WATER SECTOR RESILIENCE NEXUS FOR SUSTAINABILITY IN BARBADOS (WSRN S-BARBADOS)

Environmental and Social Assessment

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Acronyms and Abbreviations

BADMC	Barbados Agricultural Development and Marketing Corporation (BADMC)
BSDP	Barbados Sustainable Development Policy
BWA	Barbados Water Authority
CARICOM	Caribbean Community
CITES	Convention of International Trade in Endangered Species
CCCCC	Caribbean Community Climate Change Center
CCORAL	Caribbean Climate Online Risk and Adaptation Tool
CERMES	Centre for Resource Management & Environmental Studies
C.R.C.	Convention on the Rights of the Child
EHD	Environmental Health Department
EIA	Environmental Impact Assessment
ENV SP	Environmental Sustainability Professional
EPD	Environmental Protection Department
ESIA	Environmental and Social Impact Assessment
ESA	Environmental and Social Assessment
ESMP	Environmental and Social Management Plan
ESS	Environmental and Social Screening
FTC	Fair Trading Commission
GCF	Green Climate Fund
GHG	Green House Gas
IFC	International Finance Corporation
IGDS	Institute of Gender and Development Studies
IPPs	Independent Power Providers????? Should this be Independent Power Producers
IUCN	International Union for Conservation of Nature
MGD	Million US Gallons per Day
MOU	Memoranda Of Understanding
MW	Megawatts
NCC	National Conservation Commission
NDA	National Designated Authority
NGO	Non-Governmental Organisation
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
POPs	Persistent Organic Pollutants
PPP	Public Private Partnership
PRU	Project Resilience Unit
PS	Performance Standards
PV	Photovoltaic

QEH	Queen Elizabeth Hospital
RAFF	Revolving Adaptation Fund Facility
RAMSAR	Convention on Wetlands of International Importance
SHaW	Safety and Health at Work Act
TBD	To Be Determined
TCDPO	Town & Country Development Planning Office
TCPA	Town & Country Planning Act
TI	Total Impact
TOR	Terms of Reference
UNFCCC	United Nations Framework Convention on Climate Change
USF	University of South Florida
UWI	University of the West Indies
WLR	Water Loss Reduction
WSRN-S	Water Sector Resilience Nexus for Sustainability in Barbados

Introduction

This document is an Environmental and Social Assessment (ESA) for the project titled, 'Water Sector Resilience Nexus for Sustainability in Barbados (WSRN S-Barbados)'. It includes an Environmental and Social Screening (ESS). This document is essential to complete the funding proposal requirements for the project submitted to the Green Climate Fund (GCF) for consideration and approval for funding. The proposed project is assessed against the eight Performance Standards (PS) of the GCF: PS1: Assessment and Management of Environmental and Social Risks and Impacts; PS2: Labor and Working Conditions; PS3: Resource Efficiency and Pollution Prevention; PS4: Community Health, Safety and Security, PS5: Land Acquisition and Involuntary Resettlement; PS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources; PS7: Indigenous Peoples, and PS8: Cultural Heritage.

The main findings of this assessment can be summarized as follows:

1. The project is a category B project having "activities with potential mild adverse environmental and/or social risks and/or impacts that are few in number, generally site-specific, largely reversible, and readily addressed through mitigation measures."
2. The project mitigates biased distribution of benefits towards a certain group, e.g. businesses or wealthier communities, gender, for human right to water.
3. The project reassures the safety and health of persons working on and in close proximity to projects, especially during preparatory and maintenance phases.
4. The project mitigates adverse impacts on gender equality based on distribution of jobs required to implement the project and handle monitoring and operation.
5. The project has limited potential to release hazardous contaminants to the environment, and avoids unsustainable practices that increase waste generation and greenhouse gas emissions throughout the project lifecycle.
6. The project mitigates adverse impacts to habitats and/or ecosystems and ecosystem services from project activities, in particular due to changing land use for PV installations, rainwater harvesting for agriculture, and infiltration well rehabilitation.
7. The project mitigates impact from hurricanes, and other natural disasters, theft and sabotage.
8. The project considers cultural heritage in materials developed for training, education, and outreach to promote climate resilience in the water sector.
9. The project considers solutions for creating a more enabling legislative and regulatory environment in Barbados specific to building climate change resilience in the water sector.
10. The project mitigates contribution to water-borne or other vector- borne diseases like dengue and zika due to water storage and rainwater harvesting.
11. The project limits contentious land tenure scenarios for PV and other project installations.
12. The project integrates stakeholder engagement throughout to exchange knowledge, build capacity, and promote climate resilience in the water sector.
13. The project mitigates for significant consumption of raw materials, energy, and/or water.

Project Description

The Government of Barbados through the Caribbean Community Climate Change Center (CCCCC) is seeking a grant from the Green Climate Fund (GCF) to transform Barbados' society into one that is more aware of the water cycle and climate change impacts threatening the island's drinking water supply, create resilience to severe weather impacts, reduce greenhouse gas emissions, reduce consumption, promote appropriate uses of diverse water sources and legislations to support climate smart development and water sector resilience. This initiative will also transform the Barbados Water

Authority (BWA) into a resilient utility of the future that integrates renewable energy into the water supply system in Barbados to mitigate greenhouse gas emissions, integrate gender and stakeholder considerations into design, support climate change adaptation strategies, build technical capacity in the Caribbean region and share lessons learnt with other member countries of the Caribbean Community (CARICOM). This project builds strategic partnerships between the Barbados Water Authority (BWA), the Caribbean Community Climate Change Center (CCCCC), the University of the West Indies (UWI) and the University of South Florida (USF).

The 6 "Water Sector Resilience Nexus for Sustainability in Barbados (WSRN S-Barbados)" objectives are:

1. build greater resilience to extreme storm events and drought conditions by utilizing cleaner energy sources, decentralising water storage, promote rainwater harvesting at the household and community level, and improve the efficiency with which rainwater runoff replenish aquifers in Barbados.
2. further advance adaptation and mitigation initiatives in the water sector of Barbados by redirecting and mobilising local funds through a revolving adaptation fund.
3. reduce the greenhouse gas emissions intensity of water provision by integrating renewable energy with back-up natural gas turbines and sustainable Water Loss Reduction (WLR) initiatives.
4. contribute to capacity building via knowledge sharing and lessons learnt platforms within communities, educational organizations, private sector, civil society, BWA and the Government of Barbados to manage and monitor water resources.
5. support the review and development of a legislative framework to supports climate smart development and water sector resilience.
6. collate and disseminate lessons learnt for use in developing further adaptation and mitigation initiatives and raising public awareness about climate change, water conservation, recycle and reuse, the revolving adaptation fund, Green Climate Fund and in general this project.

These objectives will be achieved through 4 strategic components and associated activities (See Appendix A for a summary of activities with associated costs). These are:

1. Improving/Increasing resilience to storm events and BWA's carbon footprint reduced;
    a. Design, Purchase and Installation of 2.0 MW Grid-tied PV (solar) plant, Switchgear, Transformer, and a 2.0 MW Microturbine (Natural Gas) at Belle Pumping Station
    b. Design, Purchase and Installation of 0.5 MW Grid-tied PV (solar) plant and a 0.8 MW Microturbine (Natural Gas) at Bowmanston Pumping Station.
    c. Design, Purchase and Installation of 2.0 MW Grid-tied PV (solar), Switchgear and Transformer at Hampton Pumping Station.

2. Establishing Revolving Adaptation Fund Facility
    a. Establish fund administration.
    b. Establish Memoranda of Understanding (MOU), protocols and guidelines for the fund
    c. Open bank account(s)

3. Improving resilience to climate change and disruptions in water supply
    a. Development of Climate Resilient Water Master Plan Replacing defective mains and installing a climate smart distribution network with real time decision making tools

b. Execute Needs Assessment and Installation of Potable Water Storage Systems
c. Install Rainwater Harvesting Systems at Public Facilities (Schools, Community Centers), Farms and Private homes
d. Retrofit infiltration (suck) well
e. Develop a groundwater model for Barbados

4. Increasing capacity building, public-private-partnerships (PPP) and innovation for climate resilience in the water sector of Barbados.
    a. Develop educational materials and a mechanism that builds BWA and local capacity for climate resilient decisions and climate proofing; and, trainings related to the installation, operation, maintenance and monitoring of photovoltaic systems, leak detection technology and techniques, water storage systems, and rainwater harvesting.
    b. Share lessons learnt to spur greater public and entrepreneurial involvement in climate change adaptation and mitigation; and, promote and encourage the public to utilise RAFF and take action to mitigate, and adapt to climate variability and change.
    c. Develop policy suggestions for Barbados' water sector resilience and Public Private Partnership (PPP) to combat climate change.

The BWA recently completed installation of smart water meters across the island and have also created a centralized management information system (MIS) for customer and financial information. They have also installed SCADA systems at their facilities and are replacing some of their leaking reservoirs. Public education and outreach on new meters has resulted in many persons addressing leaky pipes and toilets in their homes. Unfortunately, with a distribution network that has pipes dating back to the 1850's, they have a high rate of pipe bursting, 2.4/km. BWA's non-revenue water (NRW) level estimated for the entire island is 43% of potable water supplied with 7% commercial losses and 36% real losses (Stantec, 2016).

While the BWA's NRW approach is comprehensive and addresses the various aspects provided by IWA/AWWW guidance documents (AWWA, 2003; 2012), studies have emphasized that they prioritize mains replacement while still addressing other activities to reduce NRW. The majority of the NRW activities supported through this project will be supported through BWA funds and hence details of these are not included in Appendix A which summarizes GCF funded project components. They were, however, considered in this assessment with the main environmental and social risks arising from actual mains replacement.

Duration

This project spans 5 years 3 months.

Methodology

The ESS was conducted using GCF Environmental and Social Screening tools as well as a numeric methodology to analyse the environmental and social implications of this project. Field studies were carried out to identify and assess impacts of the project based on direct observations, interviews, and professional judgment. In addition, stakeholder consultations were carried out to capture public views and concerns about the proposed projects. Previous BWA project documents were also reviewed to complement or supplement field data (see Appendix B for summary). Each of these studies has contributed valuable information to BWA like ways to improve institutional planning and

communication, measures to take to increase the efficiency of drinking water provisions, assessment of the water quality impacts of various wastewater sources, and the critical importance of flood mitigation measures in light of the projected increase in severe storm events. This project would synthesize all of these recommendations and formulate a cohesive project that responds to the existing knowledge base.

Environmental, Regulatory and Administrative Framework

The purpose of this ESS was to identify potential impacts, propose mitigation measures for negative impacts, ensure compliance to national and international laws and regulations, and ensure that all interested and affected parties are given an opportunity to express their views and concerns about the project while being kept informed of the crucial project decisions and progress.

The Town & Country Development Planning Office (TCDPO) issues permits for all development on the island. The BWA will have to obtain approval from the TCDPO for its PV installations. In the past, BWA has gotten approval to implement PV systems at Bowmanston and smaller PV pilots at its Bridgetown Sewage Treatment Plant, Carlton and Golden Ridge pumping stations. The application needs to be properly timed provided funding is secure as there exists a limit on the number of permits distributed and the period of for which that permit is valid; therefore, securing one without the funding to complete implementation would be counterproductive for Barbados. Once this project is approved and funding is secured, the application will be submitted to the TCDPO. It is expected that the permits will be granted. Barbados recently released an updated energy policy with 75% reduction on total heavy fossil fuel consumption and 15% solar energy integration by 2037 (Ince, 2018) and this project aligns with that goal. If further environmental and social assessment is needed by the TCDPO, this will be carried out either independent of the procurement of the PV systems or as a part of those procurement activities.

Similarly, this analysis finds no damming environmental and social implications for the rainwater harvesting systems identified; however, if further assessment is needed after the needs assessment identifies those most suited for the agriculture sector partners, e.g. a pond, it will be conducted. Given the focus on small scale farmers, it is likely that during the stakeholder discussions to determine the final interventions, this would not be needed. As a statutory body, the BWA is exempted from seeking TCDPO approval to install or replace water mains and, under the BWA Act, can enter any property for the purposes of laying water mains for public water supply, subject to providing necessary compensation for damages resulting from the implementation of such works.

Due to the 2013 Electric Light and Power Act, the PV installation will require permission from the Barbados Light and Power Co. Ltd. and the Barbados Government Electrical Engineering Department.

Any building erected after 1996 has to provide a rainwater storage tank to capture water for secondary or non-potable uses. The rainwater harvesting systems will be implemented using best practices from the Caribbean (The Caribbean Environmental Health Institute, 2009).

As an accredited agency to the GCF, the CCCCC's Environmental and Social Safeguards Policy aligns with the eight Performance Standards of the Green Climate Fund. Capacity building activities in issues related to health and safety, and gender are integrated throughout the project. BWA staff and contractors will undergo ENVISION™ training and certification to become Envision Sustainability Professionals to improve sustainability of project (Georgoulias, 2016) and complete OSHA 18001 CVQ Training.

Environmental Setting

Land Use, Tenure and Rights: The main lands to be used for the installation of PV systems are BWA's and crown (Government of Barbados) property. These lands are located close to the pumping stations and there is legislation in place to limit these lands for use for agricultural purposes. There are policies in place that provide guidelines for the BWA to rehabilitate mains without cabinet approval. Some of the sites for the installation of storage tanks and rainwater harvesting systems are properties of the Government of Barbados. These include the hospital, schools and community centers. Some systems will be installed on private properties of households with vulnerable populations and/or differently abled persons, but contractual agreements between the owner of the property and BWA will be established to clear ownership and purpose for the systems.

Geology: Approximately 85% of the island is underlain by carbonate sedimentary rock that overlies low permeability sediments of clay and marl (Jones and Banner, 2003). The remainder of the island, where the coral cap has been eroded is referred to as the Scotland District Gullies are formed from the erosion of the limestone cap or the collapsed roofs of sinkholes, caverns and underground streams. These may follow cracks of tectonic origin within or below the coral cap (Machel 1999). The island has over 100 caves, hundreds of gullies, and more than 2,800 sinkholes (Kambesis and Machel, 2013). The Scotland District is known for land slippage and only minor project activities will occur there.

Meteorology: The project site is classified as a dry sub-humid tropical environment with an average temperature of 27 °C, direct normal irradiance ranging from 5.71 and ~6.03 (kWh/sq.m/day), and average rainfall of 1414 mm/yr.

Water: The regional unconfined aquifer that lies within this limestone cap is Barbados' main source of potable water. Chlorination is the only treatment intervention. A desalination plant contributes to potable supply. Some hotels reuse treated wastewater effluent for below ground irrigation. Infiltration rates vary across the island from ~250 mm/h above the second high cliff (30 m) to an average of 50 mm/h below that, and up to 1400 mm/h at some locations (Jones et al. 1998; Tullstron, 1964). Siltation in recharge locations results in reduced aquifer recharge. The Pleistocene limestone is up to 100 m thick, has porosities ranging from 20–60% and averaging 45%, and has a specific yield of 12.5–15% (Tullstrom, 1964). Recharge occurs by rapid infiltration with little evaporation prior to recharge and is associated with the wet season and monthly rainfall thresholds of 190–200 mm, (Jones and Banner, 2003).

Biodiversity: Hardly any native forests exist in Barbados and there are four plants listed by IUCN as endangered under the category of "least concerned" (IUCN, 2016). Agricultural lands adjacent to the Hampton, Belle, and Bowmanston sites are becoming secondary forests. The mammalian fauna of Barbados is dominated by exotic or introduced species. Barbados is on the migratory route for birds with some small sites listed as key biodiversity areas (Birdlife International, 2016).

Glint and Glare: The sites for PV installation are not within the zone required for airport consultation.

Natural Hazards: Climate change is one of the main natural hazards in Barbados, including coastal inundation from sea level rise and changing rainfall patterns (Department of Emergency Management, 2014; Scott et al., 2012). Droughts impact water security and floods impact water quality (Gohar and Cashman, 2016). Landslides, usually associated with rainfall intensity, are common in the Scotland District (Priot and Ho, 1972). The island is also vulnerable to extreme storm events, which disrupt the

production and distribution of water to the population of Barbados. Historically, earthquake and tsunami events are limited in terms of occurrence and magnitude (Guha-Sapir et al., 2016; NGDC, 2016).

Stakeholder Engagement

Consultations

The WSRN S-Barbados project team includes 4 core partners, the Barbados Water Authority (BWA), Caribbean Community Climate Change Center (5Cs), the University of the West Indies Cave Hill Campus (UWI), and the University of South Florida (USF), who have met in person and virtually to conceptualize and complete the GCF proposal since September 2015. UWI departments represented include Centre for Resource Management & Environmental Studies (CERMES), Management Systems, Chemistry, Institute for Gender and Development Studies. USF departments represented include Environmental Engineering. Representatives from all partnering institutions/organizations contributed to the writing of the GCF application. The group decided to complete the Stakeholder Analysis, Gender Analysis, Environmental and Social Impact Assessment (ESIA), and Feasibility Studies using its own expertise, including the authors of this ESS. The rationale for this was to build capacity and pilot the academic/utility/accredited agency partnership that is also integrated into the proposal for a paradigm shift on knowledge exchange, creation, and sharing for resilient water infrastructure in Barbados and the Caribbean. Key in person meetings of these stakeholder representatives were:

- September 2015 (BWA Headquarters). Partners agree to relevance of GCF support to climate change adaptation needs of water and wastewater sector in Barbados. Concept note prepared and submitted to GCF with emphasis on: Non-Revenue Water (NRW), PV integration, and pilot systems for building educational capacity related to wastewater reuse and rainwater harvesting.
- July 2016 (UWI). GCF feedback on concept note recommended that since solar PV and water loss reduction measures have income generating activities, a fund should be developed with those profits to support climate resilient innovative projects (reuse and rainwater harvesting). Team agrees to move ahead with proposal and USF and UWI agree to complete studies.
- November 2016 (BWA Headquarters). Initial baseline gender and stakeholder analyses done.
- May/June/August 2017 (BWA Headquarters). Meeting with new general manager and leadership team to discuss and complete proposal with GCF recommendations for increased PV integration for resilience, increased support for water storage and rainwater harvesting components, removal of wastewater reuse and Non-Revenue Water from GCF funding.

Stakeholder Engagement is critical to WSRN S-Barbados as it 1) strengthens adaptive capacity and reduce exposure to climate risks of Barbadians, 2) strengthens awareness of climate threats and risk-reduction processes, 3) increase generation and use of climate information in decision-making and, 4) strengthens institutional and regulatory systems for climate-responsive planning and development.

Baseline stakeholder consultations were conducted during October 23rd to January 5th, 2017 using focus groups, interviews, and social media overview. Focus groups included Barbados Water Authority (BWA) employees, and University of West Indies faculty, and key informant interviews with funding agencies, private enterprises, regulatory agencies, international agencies, and various groups of community members. Anonymous surveys were conducted with 229 persons across the country. A social media review was also conducted. Additional stakeholder consultations were conducted between 5/5/17 and 8/17/17 after the project scope had shifted to reflect the second set of GCF recommendations. Appendix C summarizes the key stakeholder consultations conducted for WSRN S-Barbados between

10/23/16 and 8/17/17, including the important water sector issues, potential stakeholder contribution to, and blockage of project, and strategy for engaging stakeholders. See the Water Sector Resilience Nexus for Sustainability in Barbados (WSRN S-Barbados) Stakeholder Analysis document (Prouty et al., 2017) for a complete discussion on the results from these consultations.

To summarize, respondents mentioned such the BWA hotline, website, and customer service desk as the main mechanisms for contacting the BWA. However, qualitative data from the same survey revealed those mechanisms as sometimes inefficient at addressing individuals' concerns and ineffective at serving vulnerable populations within the BWA customer base. Additionally, an overview of various social media platforms shed light on stakeholder concerns regarding reduced water supply in certain communities. Distribution of water storage containers to affected communities, digging of new water wells, increased production of water via desalination, and proposed barging of water from Suriname, were some of the topics covered in the media. Wastewater and health were continually discussed in the local newspapers during November/December 2016 due to rainfall and its impact on the South Coast of Barbados. Businesses complained of overflowing manholes and there was public outcry over discolored water in the sea. Political opposition stated that the BWA's systems were severely compromised. Media tours or reports from the facilities were non-existent, some thought "public airing" of this information would damage the beach driven tourism industry, tourists posted online asking about beach safety, comments on the enormous amount of rainfall that gets wasted and the need for more rainwater harvesting were coupled with comments on lack of "adequate" treatment for the majority of country's wastewater.

Recommendations for stakeholder engagement throughout the project cycle were:

- Give more access to information, knowledge, and shared decision-making in future projects pursued and services provided by the utility.
- Provide meaningful learning and job training opportunities led by BWA workers and partners for the benefit of diverse groups of stakeholders to promote water sector resilience.
- Engage communities using in person and online platforms that reach a broad base of persons who contribute to water sector resilience in Barbados.
- Develop venues for community members to contribute opinions to existing and future projects.

These recommendations were actually integrated throughout the proposal and will guide continued engagement with stakeholders during implementation. To accomplish this, WSRN -S-Barbados needs to adopted a Stakeholder Engagement Policy that is shared widely amongst project partners and with stakeholders, and made readily available on the BWA's and CCCCC's website. Additionally, this document is readily available via the CCCCC's regional clearing house, which is a repository for information and data on climate change and projects specific to the region. This allows for a regional reach of all stakeholders in CARICOM members. The partners need to finalize and adopt this policy as soon as possible. WSRN-S also needs to develop a Stakeholder Engagement Plan (See next section) that is flexible and informed by lessons learned as the project proceeds and stakeholders are engaged.

Stakeholder engagement plan

The list of project activities planned to engage stakeholders throughout the project life cycle is provided in Table 1. This process requires that the members of the Project Reporting Unit (PRU) develop and adopt the Stakeholder Engagement Policy, identify and establish mechanisms for stakeholder engagement, and identify the key team members responsible for stakeholder engagement associated with the project. Table 2 provides a preliminary Stakeholder Engagement Plan with main categories of stakeholders and concerns they might have, how they could be engaged, and the type of information to exchange. Throughout the lifecycle of the project, this plan will be revisited and updated.

Table 1. List of project activities planned to engage stakeholders over the duration of the proposed WSRN S-Barbados activities.

Main Activities	Description
Establish a Project Reporting Unit (PRU) responsible for stakeholder engagement.	Project partners (BWA, UWI, USF with oversight from 5Cs) establish goals, protocols, and mechanisms for operating the PRU that will be responsible for project activities, workforce development needs and university-utility and Private Public Partnerships for climate resilience, and encourages knowledge transfer.
Develop, share and apply a Stakeholder Engagement Policy throughout the project cycle. Institute mechanisms for this policy.	PRU completes policy with input from public and integrates into all aspects of project cycle. BWA's website and employee handbook updated to reflect these policies. BWA will establish a social media presence to promote knowledge exchange on project and other components. This also includes a grievance mechanism which is discussed in the next section.
Provide theoretical and practical training related to the installation, operation, maintenance and monitoring of photovoltaic systems, leak detection technology and techniques, water storage systems, and rainwater harvesting, that engages a wide range of stakeholders.	Establish a workforce development program for BWA climate resilience.
	5Cs will conduct CCORAL training with BWA Project team to mainstream climate change into infrastructure development and upgrades.
	BWA employees will obtain ISO45001 certification (Occupational health and safety management systems); health and safety manager obtains highest level.
	USF will train 30 BWA employees, contractors and key stakeholders in Barbados to receive ENVISION^{TM} certification and apply to WSRN-S components.
	BWA employees in the Renewable Energy Unit will obtain NABCEP PV Installation Professional certification and manage and maintain the PV systems.
	BWA employees in the Renewable Energy Unit will be trained on monitoring and evaluation of PV operating systems and reporting of information to public.
	USF and UWI will develop and implement a gender and infrastructure certification program and train BWA employees and key stakeholders.
	Work with Seventh Day Adventist Church to expand vocational community training program for water sector climate resilience.
	Institute research for tertiary level students based on the various demonstration projects with co-advising by various partners to contribute to knowledge exchange, creation, and sharing on climate resilience in the water sector.
Share lessons learnt to spur greater public and entrepreneurial involvement.	Develop and deliver educational materials that gain public acceptance of climate change adaptation projects and how their actions can make Barbados more resilient. Use demonstration sites of water sector resilience to engage with entrepreneurs on opportunities for job growth in their businesses. Create videos/documentary, organize event(s) within communities to raise awareness, Produce multi-media (social media, newspaper, Radio and TV) outputs that reach diverse stakeholders.
Promote utilization of RAFF to mitigate, and adapt to climate variability/change.	Make BWA's website more interactive with educational tools that integrate with social media to engage customers with climate resilient solutions for Barbados. Create videos/documentary, organize event(s) to raise awareness, etc.
Develop policies for water sector resilience to combat climate change, and for PPPs to combat climate change.	Engage government to mainstream climate change risk into development and more specifically the water sector. Bring together both the public and private sectors to dialogue and develop effective avenues and instruments to spearhead climate resilience development. Host a series of workshops to facilitate this.

Table 2. Preliminary Stakeholder Engagement Plan to be completed

Stakeholder	Concerns of Stakeholder	Engagement method	Information to disclose and report back	Information Pertinent for Project Implementation, Reporting, Monitoring and Evaluation
Government	Project information provided, financial sustainability of water supply, public education about the system, synergistic activities, TBD	Direct meetings, Period email progress report to NDA, Town hall meetings, stakeholder consultations.	All declassified information pertaining to the project. Progress reports.	Synergistic opportunities, information needed to support project.
BWA Employees	Health & Safety	Training workshops, signage at workplace with suggestion boxes that are reviewed by Health and Safety Office etc.. After initial training, recertification every 2 years.	ISO45001 certification (Occupational health and safety management systems – Requirements), with health and safety manager obtaining highest level of certification.	Health & safety concerns, violations, innovations, certifications completed.
BWA Employees	Capacity building/job security	Certification programs, internal staff programs to address workforce development and resilience needs. After initial training, some level of recertification should occur in a timeframe TBD per certification.	ENVISION^{TM} certification, NABCEP PV Installation Professional certification and training on the monitoring and evaluation of PV operating systems, gender and infrastructure certification program	Trainings completed, additional needs, critiques on what worked or did not work with training, and recommendations for improvement.
Local community	Availability of water, disruptions to daily life, TBD	Town hall meetings, stakeholder consultations, community meetings, newspaper & radio, social media platforms to discuss project and inconveniences for local community, if any. Engage prior to, during, and after project in community.	Disruption schedule, ways to learn more about project, ways to engage with project, grievance mechanism.	Vulnerable populations inconvenienced & how to address, inconveniences to community and preferred options for reducing them.
Consumers (including differently able households)	Availability and quality of potable water. Impact on household budget.	Community meetings, newspaper & radio, BWA website, social media platforms. Building community of practice of persons with WSRN funded interventions. Continual engagement.	Updates on project. Disruption schedule. Monitoring results. Maintenance guidelines. Resources for individual water quality testing.	Performance of interventions for rainwater harvesting and water supply storage systems.

Table 2 cont'd. Preliminary Stakeholder Engagement Plan to be completed

Stakeholder	Concerns of Stakeholder	Engagement method	Information to disclose and report back	Information Pertinent for Project Implementation, Reporting, Monitoring and Evaluation
Unions	Job security	Meetings and training sessions, town hall meetings.	All declassified information pertaining to the project.	How union is increasing productivity, and concerns for workers.
Contractors	Project information provided, Terms of Reference (TOR) requirements, transparency, TBD	Project information shared via project stakeholder meetings and BWA website, workshop participation for various training and education/outreach components.	Sharing of project documents, including metrics for success and new BWA policies/procedures wrt safety, gender etc., Sharing of TORs in timely manner.	Information needed by contractors wrt TORs, ways to improve project performance, things to use for training workshops and outreach.
Regulators	Water supply and quality, health impact on consumer, cost to consumers	Direct meetings, stakeholder consultations. Project reports.	Project reports with data on impact as well as grievances, concerns of consumers.	Information needed for regulator to assess project and concerns.
NGOs & Consumer Organizations	Social & environmental impact of project	Town hall meetings, stakeholder consultations, training sessions, public awareness campaigns	All declassified information pertaining to the project.	Impact of project, concerns, ways to improve delivery of education/outreach materials.
Media organizations	Communicating project components, deliverables, impact, updates with access to personnel/information	Host media informational session, invitation to various project activities, social media engagement	All declassified information pertaining to the project, educational and outreach materials.	Media reports and materials shared, questions on project.
UWI	Training opportunities, relevance to courses, business opportunities for students, integration with gender institute	Direct meetings, shared project responsibilities for training, advising, guest lectures, partnership on education and outreach activities.	Information pertaining to relevant project components, educational and outreach materials.	Resources available to support project and opportunities to build partnership and increase capacity of BWA staff and Barbadian community.
USF	Training opportunities, knowledge generation, management, & dissemination, including to international and peer reviewed publications	Direct meetings, shared project responsibilities for training, advising, knowledge generation and dissemination, partnership on education and outreach activities, including online activities.	All project component information, reports and data, including performance metrics, educational and outreach materials.	Resources available for project, opportunities to build partnership and increase capacity of BWA staff and Barbadian community, lessons learnt & ways to improve.

Table 2 cont'd. Preliminary Stakeholder Engagement Plan to be completed

Stakeholder	Concerns of Stakeholder	Engagement method	Information to disclose and report back	Information Pertinent for Project Implementation, Reporting, Monitoring and Evaluation
CCCCC	Milestones met, good management and reporting, lessons learned shared	Direct meetings, online platforms, project reports.	Project updates, project reports, any challenges or opportunities.	Progress of project activities. Effectiveness of institutional, administrative, organizational, technical, procurement and financial arrangements/agreements. Measure of achieves against targets. Potential risks and corresponding mitigate actions.
GCF	Successful implementation of Water Sector Resilience Nexus for Sustainability in Barbados (WSRN S-Barbados)	Meetings, project documents and audits, Monitoring and Evaluation Reports, Mid-term Review and End-Term Review.	Project updates, Progress reports, Financials and Mid-term Report and End-Term Report.	Progress of project and alignment with proposal and evaluation metrics. Information on institutional, administrative, organizational, technical, environmental, social, economic, and financial aspects of the project.

Grievance Mechanism

A Grievance, an official statement of a complaint over something believed to be wrong or unfair, can be filed by anyone engaged with this project, including BWA employees (internal) and communities affected by the project (public/external). Grievance mechanisms will be put in place very early for the project, detailing procedures for responding to and managing grievances. The BWA already has grievance procedures that are managed through its Human Resources department for internal grievances. These include protocols for filing complaints through all other required paperwork until the matter is resolved. The BWA is currently updating the BWA Employee Handbook and will include this information. In terms of external grievances from the public, the BWA follows procedures determined by its insurance and legal commitments. Given that this project includes both internal and public/external stakeholders, the following will be done to provide a synthesized approach to documenting and addressing grievances. Stakeholder engagement and knowledge transfer is integral to all parts of the project and will hopefully increase ownership and understanding of project components so much so that grievances are not considered.

Based on stakeholder consultations to date the following communication methods will be used to manage grievances and create a transparent platform and mechanism for grievances:

a. The BWA website will be updated to explain grievance mechanism. The site will include contact information (email, phone number, address) for the key contact persons who will respond to grievances and timeline for responses once official grievance filed. The site will provide documents/forms needed to file a grievance by either internal or external persons/entities. These forms will be available for online submission or for printing and mailing or dropping off at the BWA.
b. A poster outlining the BWA grievance mechanism and requisite forms and drop box will be placed at the counter of the BWA headquarters to facilitate persons not using the website.
c. The BWA Hotline will be given as a number for grievances and that person will direct calls to project contact for grievances. This exact procedure will have to be finalized with the stakeholders managing this project.
d. The BWA should build its online presence on social media and also provide guidelines there for grievance mechanisms.
e. Project information will be provided at project sites with contact information for grievances.
f. A chain of custody for following up on grievances filed as a result of this project will be developed.
g. Issues raised by grievances will be addressed as quickly as possible if any changes can improve performance of project and reduction of grievances filed.
h. A plan for project reporting on grievances will be instituted.

The project management team has to finalize grievance mechanism and forms and timeline for response etc. and this should be done as soon as funding is approved. Appendix D provides an example grievance form that can serve as the preliminary document used for filing a grievance. If additional grievance mechanisms are needed to take issue up with the 5Cs or GCF, that procedure will have to be flushed out. As is, the main grievance mechanism is managed through the BWA

Gender Analysis

Government of Barbados' demographic and gender statistics, national climate change and gender policies, Caribbean literature on gender, climate change and water infrastructure projects, and social media commentary on the quality of water services received from the Barbados Water Authority were reviewed to gain cultural context, and community insight on existing gender inequalities (Isaacs and Trotz, 2016). Focus groups and interviews with project partners, key agency and business sector personnel were also conducted to identify issues with the management of water and wastewater resources. Results of this analysis revealed that although there is evidence of considerable human development in Barbados, this has not translated into an associated high level of gender equality (Isaacs and Trotz, 2017a). Gender issues are referred to in places in the documents relating to these developments, however no strategies are articulated by which gender equity can be integrated beyond stating that vulnerable groups, should be targeted and participate in action to address environmental threats and damage. In the social media review two parishes, St. John and St. Joseph, were highlighted as areas of special concern due to extended and frequent water interruptions.

Literature and tools for categorization of the gender dimension of water and wastewater infrastructure projects to determine the scope, and type of gender mainstreaming activities required are limited. The UWI IGDS, Cave Hill Unit has the opportunity to build capacity in this area by leveraging expertise from the Mona Unit and Barbados Bureau of Gender Affairs. The concept of gender integration was particularly new to many of the focus group members. Organizational members could benefit from gender training that includes roles of focal points, gender sensitive budgeting and gender competency. It was suggested that social factors such as number of persons impacted, presence of schools, clinics and elderly care facilities as well as demographics of affected customer homes e.g. gender and age should also factor into the criteria for prioritizing maintenance and operational requirements.

The recommendations from the baseline gender analysis (Isaacs et al., 2017) completed for this project were:

- identify clear gender objectives and targets prior to project implementation to ensure their incorporation in the project,
- allocate budget to appoint a gender focal point who would coordinate these activities,
- mainstream gender in existing and new policies for water sector resilience in Barbados to combat climate change,
- include socio-economic information as a criterion for prioritization of locations for project interventions,
- target training for water sector resilience to increase representation of the under-represented sex in key positions.

The gender action plan (Trotz and Isaacs, 2017b) incorporates the recommendations listed above with:

- gender objectives and targets listed,
- budget allocated to gender for the creation and implementation of a certificate training program that gets incorporated into project, BWA, and local university program with international reach,
- gender policy developed for, and with BWA and gender integrated into policies being funded by project for water sector resilience and Public Private Partnerships (PPPs),
- socio-economic information integrated into decision matrix for project activities with particular attention paid to vulnerable populations and gender,
- recruitment activities included that will ensure increased representation of the under-represented sex in key positions.

Legal and Institutional Framework

Laws of Barbados

In Barbados, a number of policy documents are used to promote the sustainable development and the mainstreaming of socio-economic and environmental concerns into aspects of national planning. These include: The Soil Conservation Programmes, 1957; Emergency Drought Management Plan, 1998; The Coastal Zone Management Plan, 1998; Environmental Management & Land Use Planning for Sustainable Development, 1998; Agriculture Area Development Plan, 1999; First National Communications to the UNFCCC, 2001; The Barbados Sustainable Development Policy, 2004; Barbados National Physical Development Plan, 2006; The National Strategic Plan, 2006; and the National Biodiversity Strategy and Action Plan, 2006.

The Barbados Sustainable Development Policy (BSDP) ensures the optimization of the quality of life for every person by ensuring that economic growth and development does not occur to the detriment of ecological capital (National Commission on Sustainable Development, 2004)). The Action Plan makes policy recommendations supporting sustainable development in many areas including, fresh water resources, agriculture, energy, research & development, the built environment, land resources, natural resources, education & training, waste management, human health, well-being & poverty, gender. Some specific items that resonate with WSRN S-BARBADOS, many of which are still a work in progress, are:

- Obtaining and analysing information and maintaining up-to-date records of the total available fresh water resources of Barbados;
- Considering the establishment of a joint working agreement with the University of the West Indies (UWI) and/or any other appropriate institution, to facilitate the development and execution of an effective and comprehensive ground water research programme;
- Conduct public education and awareness building programs to inform about the importance of employing water conservation practices in daily life;
- Continued support for the policy requiring new dwellings of a particular size to construct rain water catchment and storage tanks, including the possible revision of the policy to include existing dwellings and new dwellings of smaller sizes;
- Maintaining human, financial and technical commitments towards ensuring a firm foundation for managing water use in a sustainable manner as well as for devising methods for augmenting the fresh water supply appropriately;
- Conducting research into the effects of the climate change phenomena including the specific effects on fresh water resources and the influence of expected rainfall reduction and increased evapotranspiration due to temperature rise. This research will include an exploration of the most appropriate procedures to prepare for climate change and mitigate its adverse effects;
- Reducing the percentage of unaccounted for water from leaks in the distribution system from an estimated 60% to 30% by the year 2016, via an integrated approach including: Leak detection and repair program Review, monitoring and modification of the distribution system Assessment of total water consumption (public and private).
- Continuing to implement national programs and activities that address Barbados' national obligations as Party to the United Nations Convention to Combat Desertification and drought.

Table 3 lists laws relevant to the main WSRN S-BARBADOS project activities. Descriptions of these follow. Mains replacement is exempt from needing an EIA in Barbados. Similarly, the personal tank programme and rooftop rainwater harvesting activities do not require an EIA. Depending on the size of the rainwater harvesting systems installed in collaboration with the agricultural community, further environmental and social analysis might be required, not necessarily an EIA.

Table 3. Relevant acts and project activities

Act	PV	Mains Replacement	Personal Tank Storage/ Rainwater Harvesting
Electric Light & Power Act 2013	X		
Town & Country Planning Act (TCPA) CAP.240	X	X	X
Wild Bird Protection Act	X		X
National Conservation Commission Act	X		X
Safety and Health at Work (SHaW) Act 2005	X	X	X
Civil Aviation Act 1983	X		
Fair Trading Commission Act 2002	X	X	X
Protection of New Plant Varieties Act	X		X
Trees Preservation Act	X		X
The BWA Act, 1980, the Underground Water Control Act, 1953	X		X
The Marine Pollution Control Act (1998)	X		X
Better Security Act 1920	X	X	X

The Electric Light and Power Act 2013 makes provisions for independent power providers (IPPs) to supply power into the existing national grid. It incentivizes the generation of electricity from renewable energy.

The National Physical Development Plan provides a vision for Barbados' future growth within a sustainable development framework and is based on land use, community facilities and physical infrastructure. This is actually a draft plan that was amended in 2002. Electricity is listed as a "specialty industry", i.e. one whose processes are potentially noxious or dangerous to health and detract from general amenity by reason of excessive smell, fumes, smoke, dust, grit, ash, noise, and vibration.

The Town and Country Planning Act (TCPA) CAP.240 applies to any development that builds, engineers, mines, or pursues any other operations in, on, over, or under any land within limits of Barbados's territorial waters. Development should only occur if 1) given a specific grant of planning permission from either the Chief Town Planner, or the Minister responsible for town planning; or 2) permitted for development through the Town and Country Development Order (1972).

As a statutory body, the BWA is exempted from seeking Town and Country Development Planning Office (TCDPO) approval to install or replace water mains and, under the BWA Act, can enter any property for the purposes of laying water mains for public water supply, subject to providing necessary compensation for damages resulting from the implementation of such works.

Wild Birds Protection Act protects 46 species of wild birds with fines for any person who knowingly kills or wounds or attempts to do any of those things. Fines are also imposed for anyone found in possession or export of the skin or features of any of these species. They can only be sacrificed for natural history under certain licenses.

National Conservation Commission Act addresses conservation of natural beauty of Barbados, control and development of public spaces, and regulation of commercial activities in public spaces. The National Conservation Commission (NCC) is in charge of these activities.

Safety and Health at Work (SHaW) Act 2005 standardizes health and safety in the workplace. Employers must provide a safe workplace and employees should conduct activities in a safe manner and report any unsafe procedures to supervisors.

Civil Aviation Act 1983 defines the airport traffic zone as having a 3 km boundary. The Grantley Adams International Airport has the authority to control activities within the airport zone that interfere with airport operations. Their management must review any project within that zone.

Fair Trading Commission Act 2002 established a Fair Trading Commission (FTC) to safeguard consumer interests by determining principles, rates and standards of service for regulated service providers; monitor general business conduct, investigate possible breaches of the Acts administered by the FTC, and maintain effective competition in the economy. The BWA is one of the three utilities monitored by the FTC.

Protection of New Plant Varieties Act addresses the rights of plant breeders, their entitlement to protection, licenses and criminal liability. This act seeks to protect property rights with respect to flora, and therefore can be used as a tool to regulate and control biodiversity access.

The Trees Preservation Act says that the killing of any tree one meter or more in circumference is an offence unless a permit has been obtained from the Chief Town Planner.

The 1980 BWA Act, the 1953 Underground Water Control Act, and the Groundwater Protection Zoning Policy, give the BWA the legal responsibility of managing, controlling and protecting the water resources in the public's interest. Water is currently protected at 3 levels: the National Groundwater Protection Zoning Policy protects the groundwater resources; the water at the pumping station is disinfected to ensure biological safety; and the Minister of Health under the Health Services Act has legal responsibility for protecting the health of all residents inclusive of ensuring a safe drinking water supply. The Environmental Protection Department (EPD) and BWA lead source monitoring. The Environmental Health Department (EHD) and the BWA monitor potable water supplied to consumers via distribution systems. The EPD and EHD act as water quality regulators of the BWA. The Barbados Agricultural Development and Marketing Corporation (BADMC), responsible for providing irrigation services, also monitors water quality for agricultural purposes.

The 1998 Marine Pollution Control Act was designed to establish discharge standards for all wastewater into the groundwater as well as into the marine environment. In compliance with the Act a draft list of Prohibited Concentrations was prepared in 2004. The EPD is responsible for approving and monitoring wastewater reuse and is currently drafting the Water Reuse Act. To use treated wastewater from the existing plants which already have permission to operate will only require for the BWA to inform the EPD of the area to be irrigated and the method of application.

The Better Security Act of 1920 seeks to ensure uninterrupted access to water, gas and electricity by providing criminal penalties for the willful and malicious breaking of a contract to provide these services. The Act, its penalties and definitions are outdated, and could be said to contravene the right of freedom of association guaranteed in the Constitution. However, its effect may be interpreted as rendering water, gas and electricity essential services.

Local regulations and requirements

The Town & Country Development Planning Office (TCDPO) issues permits for all development on the island. Any building erected after 1996 has to provide a rain water storage tank to capture water for secondary or non-potable uses. Residential structures with 139 to 279 m^2 (1,500 to 3,000 ft^2) of roof area require a 13,638 L (13.6 m^3/ 3602 US gal/) tank; a residence greater than 279 m^2 (3,000 ft^2) of roof area requires a tank of 27,300 L (27.3 m^3/ 7,205 US gal) and all commercial and industrial buildings require a tank with a volume computed on the basis of 193 L/m^2 of roof area (Hutchinson, 2010). Rainwater harvesting will adhere to these guidelines.

The Emergency Drought Management Plan was approved by the Planning and Priorities Committee in 1997. It identifies parameters for monitoring, forecasting and predicting the impacts of drought like rainfall measurements, groundwater measurements, and salinity and weather data from the Meteorological Office as well as reservoir levels. This information will be integrated with management of water storage systems.

The Emergency Management Act of 2006 “provides for the effective organization and management of disasters and other emergencies” and the BWA is mandated to prepare an emergency management plan each year that must be submitted to the Director of the Department of Emergency Management. The safety training supported by this project and will contribute to this requirement.

The Pesticide Control Board deliberately restricts or bans products that are likely to have a deleterious effect on the environment, particularly with respect to the contamination of the potable water supply; and the Barbados National Standards Institution has legislative responsibility in collaboration with the Ministry of Health, in instituting strategies aimed to guarantee the general environmental safety. The WSRN S-BARBADOS components that require the use of chemicals will comply with this requirement as no materials will be used that are not legal in Barbados.

Mechanisms of public and civic participation consultation

The Town and Country Department and Planning Office (TCDPO) establishes a committee to review and comment on a project’s planned activities. First, the TCDPO must determine if further environmental and social analysis is needed and if so approve the Terms of Reference (TOR) document of the work scope to complete this analysis. The applicant for a permit must be submitted with supporting documentation including environmental and social assessments to TCDPO after which it is reviewed by the established committee that includes various government agencies. The applicant must also conduct a public information session to present the project to the public along with the results of the environmental and social assessments and this requires public notice at least a week prior to the session. The WSRN S-BARBADOS project is designed considering mitigation actions for all identified adverse environmental and social impact and will engage with the public and key stakeholders throughout the project and beyond in a paradigm shift for the utility and how it makes decisions on where to locate project components.

Relevant international and regional legislation and policies

Barbados has also signed, ratified, acceded to, accepted or adheres to many different international conventions, including those listed in Table 4. These actions demonstrate a level of commitment that Barbados has made to uphold many globally endorsed environmental and social practices like those linked to climate change. Institutionalization, enforcement, and accountability, remain challenges to support some of these conventions/agreements. Various reports have highlighted the challenges with local implementation with a most relevant case being the RAMSAR convention and a current court challenge over the Graeme Hall Swamp that abuts the BWA's South Coast Sewage Treatment Plant. This project, through its education and outreach activities, can emphasize how its components link to these conventions and support national discussions/actions to ensure they are met through project activities.

Table 4. International and Regional Legislation and Policies, years created and/or implemented, and thematic areas of focus.

International and Regional Legislation and Policies	**Year**	**Areas of Focus**
Convention of International Trade in Endangered Species (CITES)	1972	biodiversity, wildlife
Convention on Wetlands of International Importance especially as Waterfowl Habitats (RAMSAR)	1971, 2005	biodiversity, wildlife
Protocol Concerning Specially Protected Areas and Wildlife to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean	1983	biodiversity, wildlife
International Plant Protection Convention, Rome	1951	biodiversity, wildlife
Convention on Biological Diversity	1992	biodiversity, natural resource management
Convention on the Protection and Development of the Marine Environment in the Wider Caribbean (Cartagena Convention)	1983	biodiversity, natural resource management
Protocol to the International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	1972, 1996	pollution
Basel Convention on the Control of Transboundary Movement of Hazardous Waste	1989	pollution
Stockholm Convention on Persistent Organic Pollutants (POPs)	2001	pollution
United Nations Convention to Combat Desertification	1997	climate change
United Nations Framework Convention on Climate Change	1992	climate change
Paris Climate Change Agreement	2015	climate change
Sendai Framework for Disaster Risk Reduction 2015-2030	2015	disaster management, climate change
Convention for the Protection of World Culture and Natural Heritage	1972	cultural heritage, migration

Location

Barbados is a small island developing state that is the most easterly of the islands of the Lesser Antilles. Located at 13° 4' north latitude and 59° 37' west longitude, it extends ~34 km north-south and ~23 km at its widest point east-west, has a coastline of 97 km and an area of 431 km^2 and is bordered by the Caribbean Sea on the west coast and the Atlantic Ocean on the east. Barbados has 11 parishes with

population densities ranging from 261 to 2145.7 persons/km^2 for a total population of 277,821 (Barbados Statistical Service, 2013). The Barbados Water Authority (BWA) provides water to 98% of the local population, all of whom would directly benefit from this project. The indirect beneficiaries include 100% of tourists as the BWA supplies potable water to hotels, cruise ships and attractions. It currently operates 41 pumping and repumping stations that extract a total of 158,987 m^3/d (42 MGD) of water and entered into a public-private partnership (PPP) contract for a 29,905 m^3/d (7.9 MGD) brackish water reverse osmosis desalination plant which started operating in 2000. The water network is connected by over 2,500 km of transmission and distribution mains and supplies over 100,000 connections. The utility also manages two wastewater treatment plants. The South Coast Sewage Project is a preliminary treatment plant located in Christ Church that was designed for average flows of 11,356 m^3/d (3.0 MGD) and maximum flows of 29,526 m^3/d (7.8 MGD). The Bridgetown Sewage Treatment Plant is a secondary treatment facility located in St. Michael that was designed for a maximum flow of 36,339 m^3/d (9.6 MGD).

Figure 1 provides a map of groundwater based development zones designed to protect the potable water quality of the underlying aquifers upon which BWA currently depends with only chlorination used as a form of treatment. Table 6 summarizes the rules for building, sewage, and waste handling across the different groundwater protection zones in Barbados. Table 5 provides a list of BWA's water supply facilities, distributed across the island. Figure 2 provides a map of Barbados with locations of the BWA and UWI marked as well as key project installations for PV (Belle, Bowmanston, Hampton) and water storage (Queen Elizabeth Hospital, QEH).

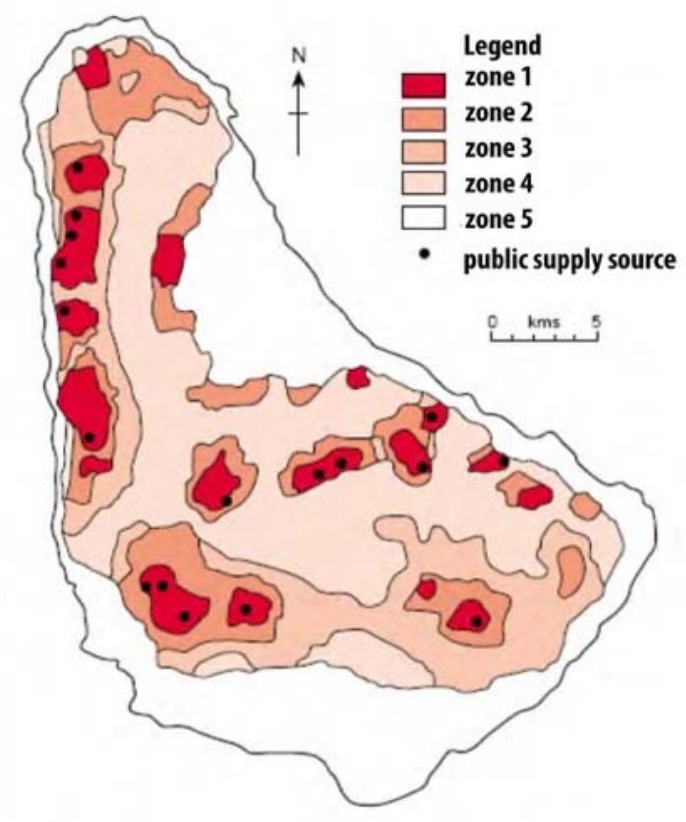

Figure 1. Groundwater based development control zones of Barbados.

Table 5. Groundwater protection zones of Barbados with travel time to aquifer.

Zone	Rules for building, sewage and waste handling
Zone 1 300 day travel time	• Owners of existing properties in Zone 1 area are allowed to rebuild their houses and to install water closets and showers under the following conditions: Houses should remain as single-family dwellings; Where a water closet is installed waste disposal should be by means of a septic tank, filter bed of activated carbon and a soak away no deeper than 15 feet; There should be no change in the use of existing buildings; and There should be no subdivision of land where vacant lots will be created • Existing uses shall continue to use existing sewage disposal systems, however, if any alterations or additions to existing uses are permitted, the existing sewerage system must be upgraded so that there is no direct disposal of waste water into the ground. By way of a holding tank and disposal of untreated wastewater outside of the Zone 1 and Zone 2 Ground Water Protection Areas; or • By means of a septic tank to filter bed to sewage disposal suck well. The design specifications for the filter bed must address grain size, particle chemistry, durability and long-term permeability to ensure safe disposal. No sewage disposal suck well shall exceed 6 meters in depth. • No additional residential, institutional, commercial or industrial development will be permitted. • Through public education and other programs, the Government will encourage farmers to use the Best Management Practices for fertilizer, pesticide and herbicide application, set out in the Environmental Management Plan, in order to minimize contamination of groundwater supplies in the Zone 1 Water Protection Areas.
Zone 2 600 day travel time	• All sewage disposal shall be by means of a septic tank. • Wastewater from the septic tank shall be disposed of by means of a sewage disposal suck well. • All sewage disposal systems must be inspected, certified and approved. • No new petrol or fuel oil facilities will be allowed including service stations. • At existing industrial operations, no suckwell discharge of priority pollutants should be allowed. • There shall be no outside storage of process wastes.
Zone 3 5-6 year travel time	• For new development on lots of a minimum size of 900 square meters, disposal of sewage and grey water via standard sized separate suckwells will be allowed • For new development on lots less than 900 square metres, special regard must be paid to the separation of sewerage and grey water • New industrial areas may be established provided that: no suckwell discharge of priority pollutants should be allowed (e.g. toxic organics, toxic heavy metals, solvents, pesticides etc). • process wastes should be disposed in approved landfill sites; • cooling water may be discharged to a standard depth suckwell; • sewage from the operations may be disposed of via suckwells.
Zone 4 Extends to all highland	• New petrol and petroleum product handling facilities will be allowed provided that dual tankage, appropriately sized impermeable reservoirs and leak detection equipment are provided. • New industrial areas may be established provided that: source control of priority pollutants is practiced and waste treatment and recycling of recovered material is implemented; process wastes should be disposed in approved landfill sites; cooling water and surface site drainage may be discharged to standard depth suckwells; sewage from the operations may be disposed of via suckwells.
Zone 5 coastline	• sewage and grey water from new development may be disposed of via suckwells unless the area is within a sewer system boundary; • industrial process wastes may be disposed of via suckwells • No new petrol or oil facilities will be allowed on the coastline

Table 6. List of BWA Reservoirs (R), Pump Stations (PS), Repumping Stations (RP), Groundwater Wells (GW), Springs (S), and quantity of water pumped per day MGD.

Facility	R	PS	RP	GW	S	MGD	Facility	R	PS	RP	GW	S	MGD
Alleynedale		X		X		1	Indian	X		X			0.05
Apes Hill	X	X	X[a]			0.75	Joe's River	X					
Applewhaites		X		X		1.75	Lakes		N/A				
Applewhaites Wellfield		X		X		0.75	Lamberts	X		X			0.25
Applewhaites Tenantry		X		X		0.5	Lancaster			X			0.5
Ashton Hall	X	X		X		1	Lears			X			0.5
Battaleys	X						Lodge Hill	X		X			
Belle		X		X		8.5	Lodge Hill	X					1
Benn Spring					X	0.8	Molyneux		X		X		1
Bissex Hill 1 & 2	X						Mt. Prospect			X			0.09
Boscobelle	X						Mt. Stepney	X		X			0.09
Bowmanston	X	X		X		2.6	New Market		X		X		3.5
Brittons	X						Ozone			X			0.25
Carlton	X	X		X		0.75	Providence	X					
Carrington		X		X		0.5	Rising Sun	X					
Castle Grant	X						Rock Hall	X					
Cave Hill	X						Shop Hill	X					
Codrington		B	X			1	St. Andrews	N/A					
Codrington College					X	1	St. Stephens	X		X			6
Constant		X		X		0.5	Trents		X		X		0.5
Ellerton	X		X			1	Sweetvale 1		X		X		0.5
Everton		X				1	Sweetvale 2		X		X		0.9
Ft. George	X		[c]				Sweetvale		X		X		0.5
Golden Ridge 1	X	X	X			1.5[c]	Sweetvale		X		X		0.5
Golden Ridge 2	X	X[d]					Villa Maria		X		X		0.75[e]
Grand View	X						Vineyard	X					
Groves Wellfield &	X	X		X		N/A	Warleigh			X			2.0[f]
Half Acre	X		X			0.25	Waterford		X		X		1.5
Haggatts			X			0.25	Whim		X		X		1
Hampton		X		X		7.5	Woodland			X			0.5
Hanson	X		X			N/A							
Haymans		X		X		1							

a - Normally 0.5, recently increased to 0.75 with intention to increase to 1.0 MGD

b - Decommissioned station. Recommissioned November 24/25, 2016. It was a pumping station, which means it has a well but due to low water levels the well was decommissioned in 2007/2008. It has been recommissioned as a repumping station.

c - Future repumping station.

d - This is one repumping station with 2 reservoirs, so the value in the extraction/supply amount column is for the station.

e - Normally 0.5 MGD.

f - Should be 2.75 MGD, but due to suction issues it is approx. 2.0.

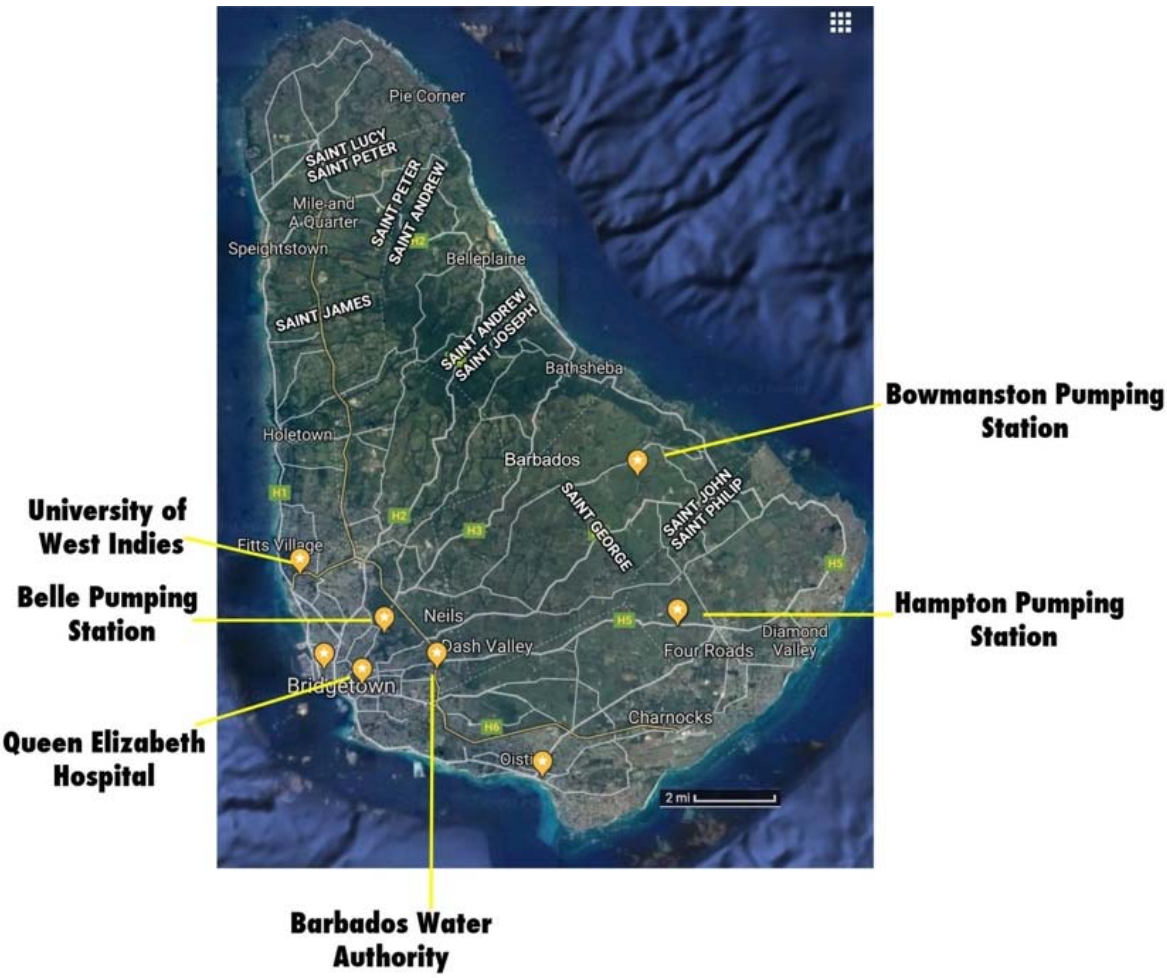

Figure 2. Map of Barbados showing main project sites for PV installation and large tank storage

The Belle, Bowmanston, and Hampton, slated for PV installation, represent the three largest pumping stations in Barbados. The proposed PV sites are in Zone 1 protection zones, as is the case with BWA groundwater well sites. The proposed PV system should not have any polluting effects as cleaning would only utilize water and not generate any detrimental wastewater. During installation, any precautions taken with a construction site to limit runoff contamination would be followed. The panels installed over what is currently pervious area will impact stormwater runoff and design would have to account for that, and likely include green infrastructure implementation to handle the runoff. The WSRN S-BARBADOS rainwater harvesting systems will not impact groundwater quality. The rainwater harvesting systems will reduce water pumped by the BWA, contribute to water conservation measures, and reduce stormwater runoff and therefore contamination to the marine environment. Mains replacement will disrupt environments during installation, however, techniques to minimize impact will be used. Other non-revenue water activities would reduce water loss from the distribution system and therefore be a benefit to the aquifer.

Environmental & Social Risks and Impacts Assessment

Risk Factors

The Environmental and Social Assessment checks for the "project's potential adverse impacts and risks, in quantitative terms to the extent possible, and defines a set of social and environmental mitigation and management measures to be taken during the implementation of the Project to avoid, minimize, or manage for risks and adverse environmental and social impacts, per the mitigation hierarchy" (UNDP, 2016). The following Performance Standards (PS) of the Green Climate Fund/International Finance Corporation (IFC) coupled with ESIA/EIA standard practices for the Caribbean (IFC, 2015, 2017) were used, with the exception of PS7 as there are no indigenous populations in Barbados. The risk factors associated with these standards are given in Table 7.

PS1 - Assessment and Management of Environmental and Social Risks and Impacts, including:

- Policy (or equivalent documents)
- Process for identifying risks and impacts
- Management programme
- Organisational capacity & competency
- External communications

PS2 - Labour & Working Conditions

- Fair treatment, non-discrimination, equal opportunity
- Good worker–management relationship
- Comply with national employment and labour laws
- Protect workers, in particular those in vulnerable categories
- Promote safety and health
- Avoid use of forced labour or child labour

PS3 - Resource Efficiency and Pollution Prevention

- Avoid, minimise or reduce project-related pollution
- More sustainable use of resources, including energy and water
- Reduced project-related greenhouse gas emissions

PS4 - Community Health, Safety and Security

- To anticipate and avoid adverse impacts on the health and safety of the affected community
- To safeguard personnel and property in accordance with relevant human rights principles

PS5 - Land Acquisition and Involuntary Resettlement

- Avoid/minimise adverse social and economic impacts from land acquisition or restrictions on land use
- Improve or restore livelihoods and standards of living
- Improve living conditions among displaced persons by providing

PS6 - Biodiversity Conservation and Sustainable Management of Living Natural Resources:

- Protection and conservation of biodiversity
- Maintenance of benefits from ecosystem services
- Promotion of sustainable management of living natural resources
- Integration of conservation needs and development priorities

PS7 - Indigenous Peoples **(NOT APPLICABLE TO BARBADOS)**

- Ensure full respect for indigenous peoples
- Human rights, dignity, aspirations
- Livelihoods

- Culture, knowledge, practices
- Sustainable and culturally appropriate development benefits and opportunities
- Free, prior and informed consent in certain circumstances

PS8 - Cultural Heritage

Table 7. Risk factors considered when assessing the WSRN S-Barbados project based on factors identified by the International Finance Corporation (2015) that were applicable to the project.

Operations	Occupational Health and Safety Impacts	Labor and Working Conditions	Community Impact
1. Raw materials consumption 2. Energy consumption 3. Water consumption 4. Wastewater quantity & quality 5. Air emissions 6. Solid waste generation 7. Hazardous waste generation 8. Usage of chemicals 9. Usage of hazardous materials 10. Noise generation 11. Land conversion	1. Fire and explosion 2. Physical hazards 3. Ergonomic hazards 4. Chemical hazards 5. Biohazards 6. Radiation hazards 7. Electrical hazards 8. Work zone air quality 9. Work zone noise 10. Eye hazards 11. Workplace temperature 12. Working at heights. 13. Working in confined spaces 14. Industrial vehicle driving and site traffic 15. Transportation of workers	1. Age of workforce 2. Gender of workforce 3. *Presence of dormitories* 4. *Differences in nationalities/ethnicities* 5. Use of security guards 6. Use of migrant labor 7. Use of temporary, seasonal and contract labor, on- or off-site 8. Use of apprentice programs 9. Use of production-quota-based pay systems 10. Use of recruiting or labor contracting agencies 11. Presence of worker representatives	1. Contamination of surface water 2. Ambient air quality/odor from industrial emissions 3. Solid waste disposal 4. Hazardous waste disposal 5. Usage of hazardous materials 6. Ground or surface water depletion 7. High ambient noise level due to industrial operations 8. Ground water contamination 9. Air emissions, transport noise 10. Traffic congestion 11. Cultural heritage/historical/ ecologically sensitive sites 12. Land acquisition and usage 13. Buildings and infrastructure development/decommissioning 14. Security personnel

Risk Analysis

An analysis on the potential impacts was conducted using a quantitative/numeric approach using Equation 1.

$$TI = D + O + E + Du + R \quad (1)$$

Where:
TI = Total impact considering the level disturbance, likelihood of occurrence, extension of reach, duration, and level of reversibility.
D = Disturbance, How large is the impact on the entity being impacted, from minor to major?
O = Occurrence, What is the likelihood that this impact will happen?
E = Extension, How far will the impact be felt from immediate surroundings to a national scale?
Du = Duration, How long will the impact last, from short term to permanent?
R = Reversibility, To what extent can the impact be reversed, from reversible to irreversible?

Table 8 provides an overview of the methodological framework that was applied to the projected impacts and how these are to be interpreted with most desirable impacts having a score closer to 5 and

least desirable impacts having a score closer to 15. The risks were categorized into High, Medium, and Low categories based on the Total Impact score. Tables 9 to 15 evaluate the risks associated with each PS using this scoring matrix and provide explanations and mitigation measures.

Table 8. Scored matrix utilized in analysing risk. Explanation of Risk Categories for individual projects was adapted from UNDP (2016) Social and Environmental Screening Procedure.

Impact Classification			
Score →	3	2	1
Disturbance (D)	Major	Regular	Minor
Occurrence (O)	Very probable	Probable	Not probable
Extension (E)	National	Local	Immediate
Duration (Du)	Permanent	Medium	Short
Reversibility (R)	Irreversible	Partial	Reversible
Total →	15	10	5
TI			
High Risk[1]		TI ≤ 12	
Medium Risk[2]		8 ≤ TI ≤ 12	
Low Risk[3]		TI < 8	

[1] - High Risk. Projects that include activities – either "upstream" or "downstream" activities – with potential significant and/or irreversible adverse social and environmental risks and impacts, or which raise significant concerns among potentially affected communities and individuals as expressed during the stakeholder engagement process. High Risk activities may involve significant impacts on physical, biological, ecosystem, socioeconomic, or cultural resources. Such impacts may more specifically involve a range of human rights, gender, and/or environmental sustainability issues.

[2] - Medium Risk. Projects that include activities with potential adverse social and environmental risks and impacts, that are limited in scale, can be identified with a reasonable degree of certainty, and can be addressed through application of standard best practice, mitigation measures and stakeholder engagement during Project implementation. Moderate risk activities may include physical interventions (e.g. buildings, roads, protected areas, often referred to as "downstream activities) as well as planning support, policy advice, and capacity building (often referred to as "upstream" activities) which may present risks that are predominantly indirect, long-term or difficult to identify.

[3] - Low Risk. Projects that include activities with minimal to no risks of adverse social or environmental impacts.

The average of the Total Impact for the WSRN S-Barbados project, 9.6, was used to categorize the overall project for the Green Climate Fund. Based on this number, the project was recommended as a category B project having "activities with potential mild adverse environmental and/or social risks and/or impacts that are few in number, generally site-specific, largely reversible, and readily addressed through mitigation measures." Of the 46 risks that were assessed, 16 risks fell in the medium impact category and 30 fell in the low impact category. An action plan was developed for the 16 medium risks identified by this analysis (Table 16).

Table 9. Assessment of environmental and social risks – management of the WSRN S-Barbados project.

PS	Risk	D	O	E	Du	R	TI	Explanation ***Mitigation***
PS1	1.1 Project fails to identify environmental and social risks.	1	1	1	1	1	5	Risks are identified and measures taken to reduce throughout project. *Environmental and Social Action plan addresses mitigation measures, inclusive of training.*
	1.2 Project does not adopt mitigation hierarchy: anticipate; avoid; minimise; compensate or offset.	1	1	3	1	1	7	*Project objectives demonstrate anticipation of future needs, GhG avoidance by renewable energy integration.*
	1.3 Project does not improve performance through an Environmental and Social Management System.	1	1	3	1	1	7	ESIA provides guidance on Environmental & Social Management System. *Project will ensure this system is developed further and implemented with the project team.*
	1.4 Duty-bearers lack the capacity to meet their obligations in the Project.	3	1	3	1	1	9	Duty bearers are committed to project and have requisite capacity to meet obligations.
	1.5 Project would have inequitable or discriminatory adverse impacts on affected populations.	1	1	3	1	1	7	*Project designed to engage and include vulnerable populations and all stakeholders.*
	1.6 Project potentially restricts availability, quality of and access to resources or basic services, in particular to marginalized individuals or groups.	1	1	3	1	1	7	Project ensures availability and quality access to basic water services provided throughout island and to all groups.
	1.7 Project excludes any potentially affected stakeholders, in particular marginalized groups, from fully participating in decisions that may affect them.	1	1	3	1	1	7	*Project designed in such a way that stakeholders engaged throughout project and systems are in place to include in decision making.*
	1.8 Rights-holders do not have the capacity to claim their rights.	1	1	3	1	1	7	Barbados laws will be followed and as such anyone will have capacity to claim their rights.
	1.9 Local communities or individuals raised human rights concerns regarding the Project during the stakeholder engagement process and has this been included in the overall Project proposal and in the risk assessment.	1	1	3	1	1	7	Baseline surveys were conducted that highlight water access challenges during seasonal drought times of the year. *Proposal designed to integrate these stakeholders as means to determine places for project implementation*.

Table 10. Assessment of environmental and social risks – labour and working conditions of the WSRN S-Barbados project.

PS	Risk	D	O	E	Du	R	TI	Explanation ***Mitigation***
PS2	2.1 Project involves support for employment or livelihoods that may fail to comply with national and international labor standards (i.e. principles and standards of ILO fundamental conventions).	1	1	3	1	1	7	All employment associated with the project will comply with Barbados labor standards and therefore ILO conventions.
	2.2 Adverse impact on gender equality and/or the situation of women and girls.	1	2	3	3	2	11	Project includes strong gender component to address gender equality so impacts will be positive and not adverse.
	2.3 Reproduce discriminations against women based on gender, especially regarding participation in design and implementation or access to opportunities and benefits.	1	2	3	3	2	11	The project has components with disparate representation of men and women with men being more prevalent in the jobs required for PV installation, mains replacement etc. and women being more prevalent in knowledge management, education and outreach. *The project will develop and implement a Gender and Infrastructure training component that would integrate women in design phases and address gender throughout all aspects of the project cycle.*
	2.4 Limits women's ability to use, develop and protect natural resources, taking into account different roles and positions of women and men in accessing environmental goods and services.	1	1	3	1	1	7	Gender action plan for project addresses gender issues throughout project lifecycle and would expand women's ability to use, develop and protect water resources.
	2.5 Inadequate training and resources for health and safety.	2	2	1	1	1	7	The Safety and Health at Work (SHaW) Act 2005 standardizes health and safety in the workplace. Stakeholder consultations and reports from previous projects highlighted the need for updated safety and health training. *BWA employees will undergo OSHA 18001 CVQ training in chemical use and waste handling and integration of risks, including climate.*
	2.6 Uses child labour.	1	1	3	1	1	7	Barbados has ratified the Convention on the Rights of the Child (C.R.C.) and established minimum age requirements for work (16) and hazardous work (18). *The project includes knowledge exchanges and traineeships and application procedures will be put in place to ensure child labour is not violated.*

Table 11. Assessment of environmental and social risks – resource efficiency and pollution prevention of the WSRN S-Barbados project.

PS	Description	D	O	E	Du	R	TI	Explanation ***Mitigation***
PS3	3.1 Pollutant release to the environment due to routine or non-routine circumstances with the potential for adverse local, regional, and/or transboundary impacts.	1	1	1	1	2	6	Preparatory phases will require generators etc. that have potential to release air pollutants into environment. Similarly, water supply requires energy and that will release air pollutants. Project integrates some renewable energy which will reduce emissions of some of these air pollutants.
	3.2 Hazardous and non- hazardous waste generation.	1	3	3	1	1	9	During preparation, operation and maintenance phases, the project will generate both hazardous and non-hazardous waste with the majority of waste generated during preparatory phases and associated with operation of natural gas generators. *Health and Safety plan developed with OSHA training for BWA employees and contractors through project funding. Health and Safety office at BWA to verify training is current, monitor and enforce safety procedures, and update BWA Health and Safety Plan to ensure safe management of hazardous and non-hazardous waste.*
	3.3 Involves the manufacture, trade, release, and/or use of hazardous chemicals and/or materials. Uses chemicals or materials subject to international bans or phase-outs?	1	1	1	1	1	5	Project will not use chemicals that are banned or phased out. Non-hazardous materials will be used as much as possible. *Safety training and procedures developed through project will be adhered to and deal with safe management of hazardous materials, majority of which are associated with fuel during preparatory phases for PV installation.*
	3.4 Uses pesticides that may have a negative effect on the environment or human health.	1	1	1	1	1	5	Pesticides will not be applied as a part of this project.
	3.5 Requires significant consumption of raw materials, energy, and/or water.	2	3	3	2	2	12	The project is focused on water supply and so water is a material that is consumed by households and businesses. It also includes off grid renewable and clean energy solutions. *The water needed does not add to the amount of water required by households. The project seeks to reduce non-revenue water, and should therefore reduce water consumption. The PV and natural gas would offset the diesel used for power production and this would reduce GhG emissions.*
	3.6 Increases greenhouse gas emissions.	1	1	3	1	1	7	*The project includes clean and renewable energy integration and this would reduce GhG emissions. Rainwater harvesting would also minimize energy requirements for pumping groundwater. GhG emissions savings from reducing non-revenue water.*
	3.7 Inadequate sustainability training and certification for the project.	1	1	3	1	1	7	*ENVISION™ training and certification is included in the project and this will lend to the overall sustainability of the project.*

Table 12. Assessment of environmental and social risks – community health and security of the WSRN S-Barbados project.

PS	Description	D	O	E	Du	R	TI	Explanation ***Mitigation***
PS4	4.1 Safety risks to local communities – impacts traffic	3	3	3	1	1	11	During preparatory phases there will be potential impacts on the community related to increased traffic flow and movement of equipment. *Coordination with police/transportation authority, community engagement, and proper signage, to reduce risk.*
	4.1a Increases noise levels of local community.	3	2	1	1	1	8	During preparatory phases noise levels will be higher than usual. Best practices should be used, included time of operations (see Appendix E).
	4.1b Decreases air quality of local community.	2	2	2	1	1	8	Ibid.
	4.1c Decreases water quality of local community.	1	1	3	1	1	7	Ibid. *Also, water quality needs to be monitored in storage tanks & rainwater harvesting systems and routine cleaning must be done.*
	4.2 Community health and safety compromised due to the transport, storage, and use and/or disposal of hazardous or dangerous materials (e.g. fuel and other chemicals).	1	1	1	1	1	5	During preparatory phases, there will likely be some use of chemicals, including fuel and oil for machinery. *Safety and Health plan will be implemented with proper management and disposal procedures.*
	4.3 Involves large-scale infrastructure development & failure of structural elements would pose risks to communities.	1	1	1	1	1	5	Some small civil work, mostly preparatory, is identified but the project does not include large-scale infrastructure.
	4.4 Vulnerable to earthquakes, subsidence, landslides, erosion, flooding or extreme climactic conditions.	3	2	3	1	1	11	Project is susceptible to natural disasters and flooding. *Site selection, design, and preparatory approach will minimize vulnerability to impacts from hurricanes, flooding, and erosion.*
	4.5 Increases health risks (e.g. from water-borne or other vector- borne diseases or communicable infections such as HIV/AIDS).	2	2	3	2	1	10	Water storage and rainwater harvesting have potential to breed mosquitoes and impact water quality depending on storage time and quality of water. *Monitoring and a user education program for maintenance is integrated with the project to reduce these problems.*
	4.6 Poses potential risks and vulnerabilities related to occupational health and safety due to physical, chemical, biological, and radiological hazards during.	2	2	1	1	1	7	Most risks are from occupational health posed during preparatory phases, with some associated with operation and decommissioning. *BWA safety training and procedures required of all personnel and contractors working on project. Systems in place for monitoring adherence to protocols.*
	4.7 Engages security personnel that may pose a potential risk to health and safety of communities and/or individuals (e.g. due to a lack of adequate training oraccountability).	1	1	1	1	1	5	*Main PV infrastructure projects are on BWA properties that already have trained security. New installations will be adjacent or on BWA property and no new security is expected.*
	4.8 Creates a visually unpleasant scenario.	1	3	1	3	3	11	*PV infrastructure projects will be installed to minimize visual impact from loss of green space and minimize unsightly wiring etc.. Landscaping around the project should improve areas that had become overgrown.*

Table 13. Assessment of environmental and social risks – land acquisition and involuntary resettlement of the WSRN S-Barbados project.

PS	Description	D	O	E	Du	R	TI	Explanation ***Mitigation***
PS5	5.1 Project potentially involves temporary or permanent and full or partial physical displacement.	1	1	1	1	1	5	Land to be used for project would not displace any inhabitants. *A resettlement action plan or a resettlement policy framework are not necessary.*
	5.2 Results in economic displacement (e.g. loss of assets or access to resources due to land acquisition or access restrictions – even in the absence of physical relocation).	1	1	1	3	3	9	Land required for PV infrastructure or rainwater harvesting for agriculture at some sites will limit other forms of development or agriculture production in the future even though they are currently not being used by government or private land owner. *Land acquisition will take economic costs into consideration when valuing land for purchase/lease, none of which is currently being used for agriculture or other purposes. Added agricultural value will be gained from the project through better access to water for irrigation. Also, PV installation will be complemented by rearing of Black Belly Sheep to provide dual purpose for land.*
	5.3 Project leads to forced evictions.	1	1	1	1	1	5	Lands additional to what BWA currently uses will be needed for PV infrastructure. Under Barbados law, BWA has authority to acquire such lands needed for components described in project proposal. *Lands identified for PV infrastructure are currently not inhabited. Mains replacement may require disruptions in local environment temporarily to gain access to a site, but no evictions would be needed. Infiltration well rehabilitation and rainwater harvesting for agricultural production would also not lead to any forced evictions. Proper legal avenues will be taken to acquire any lands needed for project, including requisite compensation to third party or government. Project site selection made to minimize need for forced evictions.*
	5.4 Affects land tenure arrangements and/or community based property rights/customary rights to land, territories and/orresources.	1	1	1	1	3	7	See answer to 5.3. Also, possibility exists to affect community right to resources when measures taken to rehabilitate areas around infiltration wells or install storage tanks on public spaces. *Project design through community engagement would provide win-win solutions that build community asset (e.g. accessible green space, artwork as education etc.) and make BWA water resources more resilient.*

Table 14. Assessment of environmental and social risks – biodiversity conservation and sustainable management of living natural resources of the WSRN S-Barbados project.

PS	Description	D	O	E	Du	R	TI	Explanation ***Mitigation***
PS6	6.1. Negatively impacts habitats (e.g. modified, natural, and critical habitats) and/or ecosystems, ecosystem services, and/or livelihoods.	2	2	2	3	3	12	PV infrastructure will be placed on overgrown agricultural land. Storage and rainwater harvesting can potentially remove green space when installed. Preparatory activities will affect existing landscapes. *Characterize habitats thoroughly prior to component implementation and use ENVISION^{TM} approach to improve ecosystem services and reduce impacts.*
	6.2 Detrimental activities proposed within or adjacent to critical habitats and/or environmentally sensitive areas, including legally protected areas, areas proposed for protection, or recognized as such by authoritative sources and local communities.	1	1	2	1	1	6	PV is located in Zone 1 areas for groundwater protection. Other project components will be installed on existing built environment, with the exception of infiltration rehabilitation and rainwater harvesting ponds for agriculture sector. Project components will minimize disruptions through design approach & green infrastructure for stormwater management. *Through stakeholder/needs assessment, develop record of knowledge/value of area and integrate with design, monitoring, and maintenance.*
	6.3 Activities pose risks to endangered species.	1	1	1	1	1	5	Projects are being installed at on existing urban or agricultural land and this should minimize interaction with endangered species.
	6.4 Introduces invasive species.	1	1	1	1	1	5	Project should not introduce invasive species.
	6.5 Improperly harvests of natural forests, plantation development, or reforestation.	1	1	1	3	1	7	Rehabilitation of infiltration wells would entail reforestation. Agricultural activity will be encouraged using rainwater harvesting, however, this will be for small scale farmers and not plantations. *Reforestation will use best practices in Barbados.*
	6.6 Improperly produces and/or harvests fish populations or other aquatic species?	1	1	1	1	1	5	Project will work with agriculture sector on rainwater harvesting activities, some of which could lead to fish/aquatic species growth. *Through stakeholder engagement with farmers and agricultural NGOs/government agencies, implement best practices for rainwater harvesting management.*
	6.7 Involves significant extraction, diversion or containment of surface or ground water.	3	3	2	3	1	12	Project extracts groundwater which is main water supply source for Barbados. *Non-revenue component, including mains replacement, will reduce extraction. Similarly, efficient fixtures and rainwater harvesting also reduce need for extraction.*
	6.8 Utilizes genetic resources incorrectly.	1	1	1	1	1	5	The use of genetic resources are not planned for this project.
	6.9 Generates potential adverse transboundary/global environmental concerns.	1	1	1	1	1	5	All materials imported for this project will have to meet international and Barbados laws/regulations. Exports are not expected from this project.
	6.10 Results in secondary or consequential development activities.	2	2	1	2	1	8	Potential for additional activities with more reliable access to water. *Strong knowledge exchange and outreach component to reduce activities that would result in negative consequences.*

Table 15. Assessment of environmental and social risks – cultural heritage of the WSRN S-Barbados project.

PS	Description	D	O	E	Du	R	TI	Explanation ***Mitigation***
PS8	8.1 Adversely impacts sites, structures, or objects with historical, cultural, artistic, traditional or religious values or intangible forms of culture (e.g. knowledge, innovations, practices).	1	1	3	3	1	9	Project implementation sites include BWA facilities and some have historical significance. *The majority of the project activities occur on land already utilized for urban development and agriculture. Stakeholder consultations are integral to the project, and ENVISION™ framework emphasizes the importance of having them to identify culturally significant sites, structures, etc. in addition to what is found in public record for heritage etc.. Through this community based participatory approach to implementing much of the project components, any sites identified will be enhanced and protected wherever possible.*
	8.2 Inappropriate use of tangible and/or intangible forms of cultural heritage for commercial or other purposes.	1	1	3	1	1	7	Project will develop learning materials for knowledge exchange throughout Barbados and course of timeline. It is desired that these materials be culturally relevant and therefore some might incorporate cultural heritage. *The strong academic partnerships who are part of the knowledge management team, coupled with the extensive stakeholder engagement plan, will ensure cultural heritage is not exploited, but reinforced as critical for resilience in the water sector.*

Environment and Social Action Plan

Table 16. Environmental and social action plan for the WSRN S-Barbados project based on main risks (Total Impact, TI ≥ 8, maximum =15) that fall under the 8 GCF Performance Standards.

Summary of risks	Mitigation measures	Risk significance	Responsible party/person	Schedule	Expected results	Cost/Budget
Potential adverse impacts to habitats and/or ecosystems and ecosystem services from project activities, in particular due to changing land use for PV installations, rainwater harvesting for agriculture, mains replacement, and infiltration well rehabilitation. (TI = 12, PS6)	Terms of Reference (TOR) for PV projects include requirements for minimizing impacts to habitats and ecosystem services and more specific biodiversity surveys as part of the application to TCDPO. Green infrastructure will be prioritized for stormwater management at sites. Land is currently overgrown and was once mainly sugarcane. Incorporate agricultural activity with black belly sheep from community grazing there. TOR for mains replacement includes reduction in risk by contractor using lessons learnt from previous BWA projects. ENVISION™ Training and certification integrated with project and applied to all aspects that depend on stakeholder engagement to design and implement.	Medium	Director of Projects, BWA	Completed prior to preparatory cycle of any project component related to PV, mains replacement, rainwater harvesting (especially for agriculture), and infiltration well rehabilitation.	Minimal damage to habitats and/or enhanced habitats via rehabilitation projects.	Included in budget for PV installation. $35,000 budget for ENVISION™ Training and certification
Requires significant consumption of raw materials, energy, and/or water. Involves significant extraction, diversion or containment of ground water. (TI = 12, PS3 & PS6) *NB. This project supplies water.*	ENVISION™ Training and certification integrated with project and applied to all aspects. Criteria for resource use minimization used as an evaluation metric for TORs. Integrated plan to improve resilience in water sector that includes reducing non-revenue water activities, and public education to promote conservation practices for water supply.	Medium	BWA, UWI, USF	ENVISION™ training begins as soon as project starts & applied to decisions being made on other project components with real time adjustments for improvement. Completed in alliance with stakeholders and in conjunction with given project activities.	Reduced consumption/waste of raw materials. Acceptance, ownership, and understanding of water sector resilience projects by Barbadian public.	$35,000 budget for ENVISION™ Training and certification + $362,500 for public outreach

Table 16 cont'd. *Environmental and social action plan for the WSRN S-Barbados project based on main risks (Total Impact, TI ≥ 8, maximum = 15) that fall under the 8 GCF Performance Standards.*

Summary of risks	Mitigation measures	Risk significance	Responsible party/person	Schedule	Expected results	Cost/Budget
Adverse impact on gender equality and/or the situation of women and girls. Reproduce discriminations against women based on gender, especially regarding participation in design and implementation or access to opportunities and benefits. (TI = 11, PS2)	Targeted recruitment to reach persons underrepresented in given job positions associated with project will be completed. Development of a gender training program in conjunction with the UWI Institute of Gender Studies that builds capacity to address gender and infrastructure across the island and beyond.	Medium	UWI, USF, BWA Gender point Person	Process begins as soon as project starts and continues throughout the project lifecycle. Gender and infrastructure training material developed first amongst partners and then implemented across BWA and with key stakeholders contributing to WSRN-S.	Gender mainstreamed in project to support gender equity and equality.	$160,000
Safety risk to community due to traffic, noise levels, air pollution. (TI = 11, PS4)	Coordination with police/transportation authority, community engagement, and proper signage and public relations, to reduce risk. Updating of BWA's Safety and Health plans and dissemination across utility and online. OSHA training of BWA employees and contractors to meet ISO45001 certification and provision of safety equipment needed to properly manage project activity.	Medium	BWA Health and Safety	Process begins as soon as project starts and continues throughout the project lifecycle.	Risk to communities minimized, low grievances filed.	$200,000

Table 16 cont'd. *Environmental and social action plan for the WSRN S-Barbados project based on main risks (Total Impact, TI ≥ 8 , maximum = 15) that fall under the 8 GCF Performance Standards*.

Summary of risks	Mitigation measures	Risk significance	Responsible party/person	Schedule	Expected results	Cost/Budget
Potential impact from hurricanes, and other natural disasters, theft and sabotage (TI = 11, PS4)	Project in itself is designed to avoid risks posed by drought to water supply. CCORAL Training with 5Cs included to further identify climate vulnerabilities. TORs for project components will detail requirement that contractors minimize threats from hurricanes, earthquakes, landslide, flooding etc.. Sites identified for PV installation already have taken those threats into consideration. Water storage and rainwater harvesting systems will be designed to include straps to secure from wind, and located in places that do not flood or actions taken to implement green infrastructure with property owner to reduce flooding. Stakeholder engagement and knowledge exchange will promote sense of project ownership amongst all Barbadians to reduce threat of human induced disaster like theft or sabotage. Additionally, PV sites will be fenced and monitored by BWA security, and pumps for water storage systems will be secured in padlocked units.	Medium	5Cs, BWA for CCORAL BWA for approving and managing project components that best promise resilience to climate change and variability.	Completed early in project cycle and applied throughout.	Increased resilience of Project to climate change and variability, other natural disasters, theft and sabotage.	$7,500 for CCORAL plus budget included in TORs for designs that withstand hurricanes, reduce flooding, and reduce threat from theft and sabotage.
Visually unpleasant scenario (TI = 11, PS4)	PV infrastructure projects will be installed to minimize visual impact from loss of green space and minimize unsightly wiring etc.. Landscaping around the project should improve areas that had become overgrown. These requirements would be included in TORs as a part of the evaluation for contractual agreements.	Medium	BWA	Completed in conjunction with the PV installation timelines.	Stakeholder complaints on visual nature of installations should be minimal.	Included in budget for PV installation. BWA will maintain the grounds around PV installation.

Table 16 cont'd. *Environmental and social action plan for the WSRN S-Barbados project based on main risks (Total Impact, TI ≥ 8, maximum = 15) that fall under the 8 GCF Performance Standards.*

Summary of risks	Mitigation measures	Risk significance	Responsible party/person	Schedule	Expected results	Cost/Budget
Increased exposure to water-borne or other vector-borne diseases like dengue and zika due to water storage and rainwater harvesting (TI = 10, PS4)	Design storage system with continuous pump to reduce stagnation of BWA treated water and include backflow preventers to reduce contamination of supply if pressure is low. Design rainwater harvesting to eliminate mosquito breeding with mesh etc.. Ensure buy-in from persons/places where systems will be installed and ensure proper maintenance and operational techniques will be implemented. Randomly monitor systems after installation, perform maintenance where needed to reduce risk of disease, and continuously exchange knowledge with stakeholders to track performance/needs.	Medium	PRU	Started early in project cycle and continues throughout.	Water resilient systems are properly maintained and do not contribute to any diseases. Persons adopt habits required to ensure proper functioning of water resilient systems.	$170,000 maintenance budget + $467,500 outreach budget
Hazardous and non- hazardous waste generation. (TI = 9, PS3)	Updating of BWA's Safety and Health plans and dissemination across utility and online. OSHA training of BWA employees and contractors to meet ISO45001 certification and provision of safety equipment needed to properly manage project activity. Appropriate measures taken to inform potentially impacted persons, including proper signage.	Medium	Health and Safety Manager, BWA	Process begins as soon as project starts and continues throughout project lifecycle. Trainings/certifications expected to be complete within first two years, but scheduling needs to be coordinated with other trainings required as a part of this proposal.	Reduced adverse health and safety impacts from project on BWA employees, contractors, and those in proximity to project.	$200,000

Table 16 cont'd. *Environmental and social action plan for the WSRN S-Barbados project based on main risks (Total Impact, TI ≥ 8, maximum = 15) that fall under the 8 GCF Performance Standards.*

Summary of risks	Mitigation measures	Risk significance	Responsible party/person	Schedule	Expected results	Cost/Budget
Duty-bearers lack the capacity to meet their obligations in the Project (T = 9, PS1).	Budget is allocated to ensure duty bearers meet their project obligations. Budget is also allocated for project monitoring and evaluation, management, capacity building and accountability to ensure duty bearers meet their project obligations and targets for outputs and outcomes.	Medium	BWA, 5Cs	Process begins as soon as project starts and continues throughout project lifecycle with regular meetings, reports, and structures in place to evaluate project progress and any how to overcome any challenges encountered. Trainings/certifications are included throughout the project cycle and local capacity is expected to grow in Barbados for project components.	Project goals are accomplished, with the set targets met for successful evaluation of project.	$425,000 + $1,045,100 for various capacity building and knowledge management activities to quantify project output/outcome/impact
Result in economic displacement (e.g. loss of assets or access to resources due to land acquisition or access restrictions – even in the absence of physical relocation). (TI = 9, PS5)	Siting of PV systems on BWA or crown lands with permission given to use, or on lands not currently being used with no structures. Mutually agreed upon compensation for privately owned land (required from 2 MW installation at Hampton Pumping Station). Added community value to land (e.g. sheep rearing under PV systems).	Medium	BWA	Already started and completed with PV installations.	Non-contentious acquisition of land needed for project and win-win situations for BWA and community.	Covered by BWA

Table 16 cont'd. *Environmental and social action plan for the WSRN S-Barbados project based on main risks (Total Impact, TI ≥ 8, maximum = 15) that fall under the 8 GCF Performance Standards.*

Summary of risks	Mitigation measures	Risk significance	Responsible party/person	Schedule	Expected results	Cost/Budget
Increased exposure to water-borne or other vector-borne diseases like dengue and zika due to water storage and rainwater harvesting (TI = 10, PS4)	Design storage system with continuous pump to reduce stagnation of BWA treated water and include backflow preventers to reduce contamination of supply if pressure is low. Design rainwater harvesting to eliminate mosquito breeding with mesh etc.. Ensure buy-in from persons/places where systems will be installed and ensure proper maintenance and operational techniques will be implemented. Randomly monitor systems after installation, perform maintenance where needed to reduce risk of disease, and continuously exchange knowledge with stakeholders to track performance/needs.	Medium	PRU	Started early in project cycle and continues throughout.	Water resilient systems are properly maintained and do not contribute to any diseases. Persons adopt habits required to ensure proper functioning of water resilient systems.	$170,000 maintenance budget + $467,500 outreach budget
Results in secondary or consequential development activities. (TI = 8, PS6)	Strong knowledge exchange and outreach component to reduce activities that would result in negative consequences.	Medium	PRU	Started early in project cycle and continues throughout.	Minimization of secondary consequential development activities. Increased consumer behavior that practices water conservation etc..	1,045,100 for various capacity building and knowledge management activities to quantify project output/outcome/impact + $467,500 outreach budget

Table 17. Additional resources for environmental and social action plan for the WSRN S-Barbados project.

Summary of risks	Mitigation measures	Risk significance	Responsible party/person	Schedule	Expected results	Cost/Budget
Limited expansion of project components for water sector resilience by non-supportive laws and regulations in Barbados. (PS1)	Workshops planned to engage stakeholders, including parliamentary representatives, that would result in two policies pertaining to water sector resilience and private-public partnerships for the water sector.	Low	UWI, BWA	Expected to be early in project, but not prior to implementation of certain project components that would inform policy. Also early enough that policy can be used to support laws etc.. prior to project completion.	Policies developed that inform laws and regulations that support water sector resilience in Barbados.	$160,000
Biased benefit of project towards a certain group, e.g. businesses or wealthier communities, for human right to water (PS1)	Socio-economic factors considered throughout project decision making process. Needs Assessment conducted prior to identification of water supply storage and rainwater harvesting sites, and the results of these factored into installations supported as a part of the project. Stakeholder engagement and knowledge exchange throughout these processes to eliminate biases and ensure, vulnerable populations and gender are properly considered. These actions should avoid this risk.	Low	BWA with needs assessment led by UWI/USF.	Needs assessment will be conducted at least 3 months prior to start of installations of either water storage systems or rainwater harvesting.	Equitable access to uninterrupted supply of water across Barbados.	$71,500

The potential impacts are projected to occur both during the implementation and operation/maintenance phases of the main WSRN S-BARBADOS project components. Overall, this project improves water provision across Barbados. This will positively impact every sector of Barbadian life. A detailed Environmental and Social Management Plan will have to be completed by project partners for each project component to control and mitigate measures for all foreseeable, potential impacts and this approach will be integrated into all project components once all stakeholders are working together on this project. The BWA already has Frameworks for Environmental and Social Management based on past projects that will serve as the baseline for what becomes standard use and policy at the BWA. These documents are included with the overall project description.

Compliance with Environmental and Social Safeguards Policy

As an accredited agency to the GCF, the CCCCC' Environmental and Social Safeguards Policy aligns with the eight Performance Standards of the Green Climate Fund: PS1: Assessment and Management of Environmental and Social Risks and Impacts; PS2: Labor and Working Conditions; PS3: Resource Efficiency and Pollution Prevention; PS4: Community Health, Safety and Security, PS5: Land Acquisition and Involuntary Resettlement; PS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources; PS7: Indigenous Peoples, and PS8: Cultural Heritage.

Additional capacity building activities are integrated throughout the project in issues related to health and safety, and gender. BWA staff and contractors will undergo ENVISION™ training and certification to become Envision Sustainability Professionals (ENV SP). The Envision sustainable infrastructure rating system is a comprehensive framework of 60 sustainability criteria that address the full range of environmental, social, and economic impacts to sustainability in project design, construction, and operation. These criteria—called "credits"—are arranged in five categories: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Risk. These 5 criteria align with the 8 performance standards listed above and training early in the project will contribute to even more sustainable project approaches.

Positive Impacts and Enhancement Measures

Overall, the WSRN S-BARBADOS project will have many positive impacts for Barbadians that far outweigh the negative impacts (scores were not completed for this document as the focus was on risk and mitigation). It is expected to provide short term employment during preparatory phases, improve water supply from the BWA, reduce air emissions from non-renewable energy sources, increase adoption of sustainable rainwater harvesting practices, increase residential water security, increase groundwater recharge through green infrastructure implementation and rehabilitation of recharge wells, increase opportunities for reinvestment in climate innovative strategies for resilience, integrate gender across all adaptation and mitigation initiatives, mainstream stakeholder engagement in climate action, improve communications and build long term partnerships among major stakeholders, improve capacity building and research for informed climate action, improve safety and sustainability training of BWA employees and communities, and reduce the burden on Barbados' net international reserves.

In order to secure project benefits, the management and reporting system must integrate the comments and feedback agreed upon by all stakeholders along with well-documented procedures for operation. Gender and stakeholder engagement is integrated into all aspects of project decision-making. Communication of all aspects of the project with and to the public and stakeholders must be done in a timely manner and through diverse avenues that reflect the avenues of engagement in Barbados. This

includes sharing of information with other Caribbean countries and potential investors of future projects.

Select Negative Impacts and Mitigation Measures

There are some activities that can potentially impact the environment and human health adversely. Potential negative impacts include the following (See Appendix E for more details by project type):

(i) **Air:** Dust, particulate matter, vehicle and generator emissions will decrease air quality in the vicinity of the implementation sites, mainly for mains replacements and PV installation. Some mains are made of asbestos and if not properly handled, fibers could affect workers and others who come in contact with the uprooted pipes. Noise from construction activities will also be a problem. Potential Mitigation: Apply water where possible to reduce dust generation. Ensure equipment is working efficiently with good engine performance and rectify if this is not the case. Ensure all workers, including contractors have OSHA safety training and wear appropriate protective gear e.g. respirator dusk masks, and ear plugs. Ensure that old mains are disposed of properly. Schedule work mainly during the hours of 09:30 – 15:30 hrs in areas where ambient noise levels are not very high outside of those working hours.

(ii) **Soils:** A major source of soil contamination is expected to be the unintentional disposal of waste, i.e., chemical, liquid and oils mainly during the implementation of project components and the use of heavy vehicles working on the project sites. Mains replacement will disrupt soils, and if not replaced properly, can lead to road failures. End of cycle disposal of materials like PV panels could pollute landfill areas. Potential Mitigation: It is recommended that oils etc. be collected, stored and resold to the service stations. The chemical waste should be collected, stored and disposed of following national practices. To mitigate possible soil erosion, less disruptive mains replacement techniques like horizontal drilling and pipe bursting should be considered where feasible. An end of life cycle plan must be developed for PV panels and included in the Terms of Reference (TOR) for the contractor/s.

(iii) **Water:** Some mains replacement will disrupt roadways and increased sediment loads can potentially run into the marine environment. PV installation can increase stormwater runoff from the site. Rehabilitation of recharge wells could potentially increase pollutant loads to the aquifer. Further, spilled and leaked chemicals and oils from vehicles during implementation could increase stormwater runoff pollutant loads. Chemicals used for water quality analyses can contaminate aquatic environments and groundwater systems if disposed of improperly. Potential Mitigation: Utilize the most appropriate mains replacement technique (e..g. horizontal drilling, pipe bursting etc.) that minimizes erosion/sediment impacts to sensitive ecosystems. Schedule replacement activities to rapidly restore roadway/area. Stormwater runoff from PV systems installed on pervious areas should be properly managed, preferably by green infrastructure. Chemicals and oils collected from various projects should be disposed of properly, including the shipment overseas as was recently done for hazardous wastes.

(iv) **Biological Resources:** Minor erosion from mains replacement can potentially increase sediment discharge to the marine environment. This can also occur in the case of PV installation if those are done on currently pervious areas as opposed to roofs etc.. Potential

Mitigation: Implementation of silt barriers where possible and/or use of pipe bursting or horizontal drilling will mitigate erosion impacts on downstream environments.

(v) **Health and Safety:** Unintentionally contaminated water during mains replacement could negatively impact the health of customers as could exposure of workers and others to air pollutants etc. during construction and operations and maintenance of other projects. Contamination of rainwater harvesting systems and unintended use, e.g. for drinking, could negatively impact human health. Accidents can occur when using equipment and that could impact anyone accessing sites (e.g. mains replacement during construction phase or cleaning of PV panels during maintenance phase). Potential Mitigation: Monitor water quality after installation of new mains and provide information to customers to flush systems if needed. Properly train persons installing and using rainwater harvesting systems on appropriate measures (e.g. roof cleaning and tank cleaning) needed to reduce health risks posed from this technology. Ensure workers have OSHA health and safety training, appropriate protective gear, and follow health and safety rules established by the BWA.

(vi) **Traffic Congestion:** During implementation, mainly associated with mains replacement, there will be disruption of traffic flow due to road closure and some level of congestion due to trucks taking material to sites during peak hours. Potential Mitigation: An effective traffic management plan is needed that communicates inconveniences to residents and road users ahead of time so they can plan accordingly. Proper road signage must be on the site when work is in progress.

(vii) **Water Supply:** Disruptions due to mains replacement will interfere with daily activities and livelihoods of communities connected to the mains. Mitigation: Inform consumers ahead of time of disruptions and provide alternative sources of water to alleviate the inconvenience.

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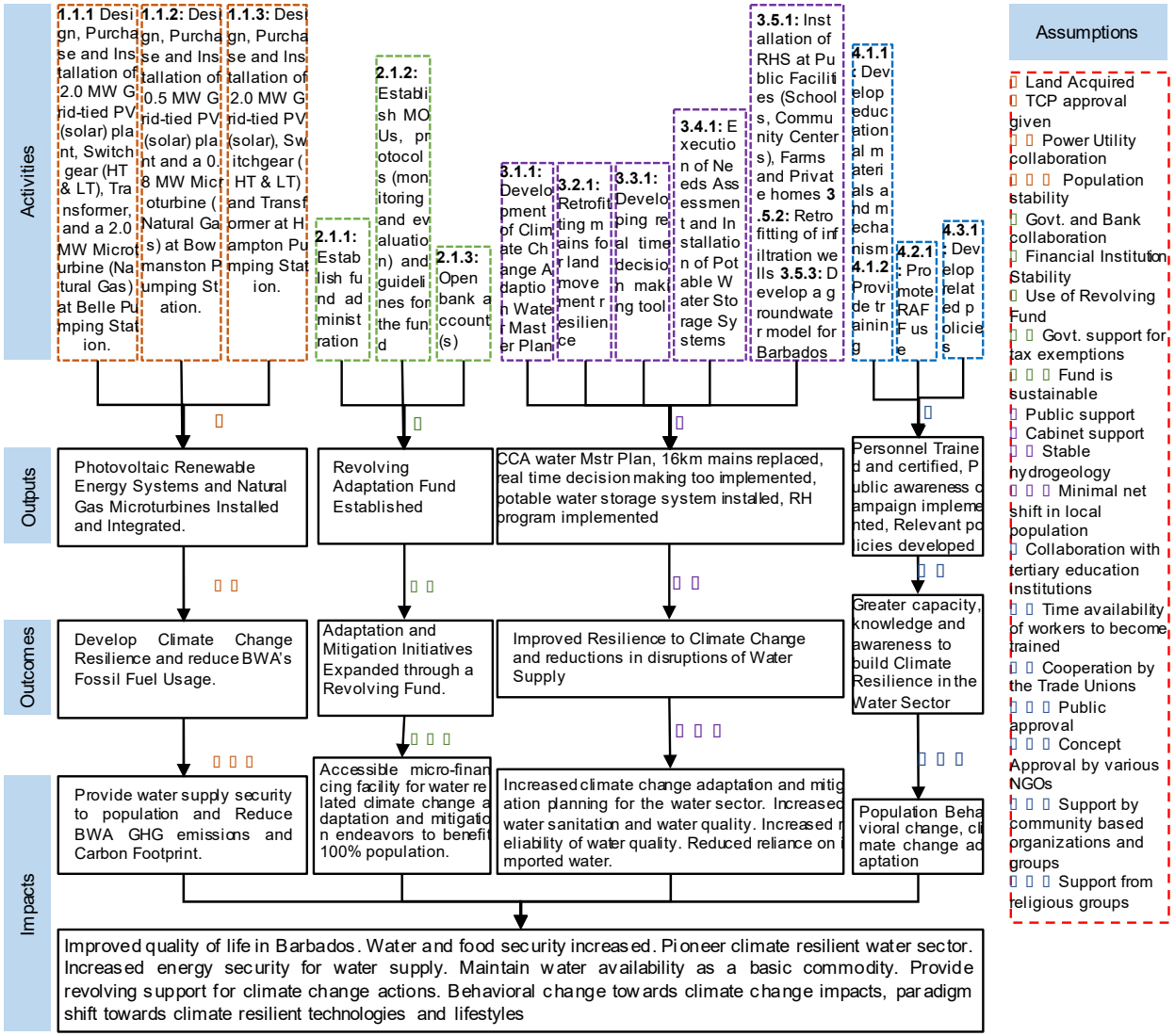
Appendix A. Green Climate Fund Components of Water Sector Resilience Nexus for Sustainability in Barbados (WSRN S-BARBADOS).



Theory of Change (TOC) Diagram for Water Sector Resilience Nexus for Sustainability in Barbados (WSRN S-BARBADOS).

		Unit Cost (US$)	#	Total
1. Improving /Increasing Resilience to Storm Events and Reducing BWA's Carbon Footprint.				
1.1 Integrating photovoltaic renewable energy with back-up natural gas turbines	2.0 MW PV (Solar) Plant at Belle Pumping Station	$4,000,000.00	1	$4,000,000.00
	Electrical Switchgear(HT and LT) and Transformer(s)at Belle and Hampton	$500,000.00	2	$1,000,000.00
	0.5 MW PV (Solar) Plant at Bowmanston Pumping Station	$1,100,000.00	1	$1,100,000.00
	2.0 MW PV (Solar) Plant at Hampton Pumping Station	$4,000,000.00	1	$4,000,000.00
	2.0 MW Microturbine (Natural Gas) System at Belle Pumping Station	$3,000,000.00	1	$3,000,000.00
	0.8 MW Microturbine (Natural Gas) System at Bowmanston Pumping Station	$1,000,000.00	1	$1,000,000.00
	Total			**$14,100,000.00**
2. Expanding Adaptation and Mitigation Initiatives through a Revolving Fund				
2.1 Establishing Revolving Adaptation Fund Facility	RAFF: legal instruments, guidelines and protocols	$88,000.00	1	$88,000.00
	Administration	$10,000.00	1	$10,000.00
	Bank Account	$2,000.00	1	$2,000.00
	Total			**$100,000.00**
3. Building Resilience to Climate Change and Disruptions in Water Supply				
3.4: Enhance potable Water Storage Systems	Personal Tank (400 gallon) installation	$2,400.00	1500	$3,600,000.00
	Supertank (5000 gallons)	$200,000.00	2	$400,000.00
	Compact tank (400 gallons)	$100,000.00	2	$200,000.00
	Normal tank (1200 gallons)	$150,000.00	1	$150,000.00
	QEH tank (59,0000 gallons)	$300,000.00	1	$300,000.00
	Storage At Polyclinics	$12,500.00	9	$112,500.00
	Storage at Schools	$20,000.00	10	$200,000.00
	Needs Assessment	$37,500.00	1	$37,500.00
	Total			**$5,000,000.00**

		Unit Cost (US$)	#	Total
3.5 Rainwater Harvesting Programme	Primary School	$35,000.00	11	$385,000.00
	Secondary School Worse	$45,000.00	5	$225,000.00
	Secondary School Best	$32,000.00	6	$192,000.00
	Community Center	$23,000.00	20	$460,000.00
	Retrofit of suck wells	$40,000.00	22	$880,000.00
	Monitoring of aquifer/Model - installation of monitoring equipment	$50,000.00	10	$500,000.00
	Farmers - Pond	$100,000.00	2	$200,000.00
	Farmers - Rooftop Rainwater	$10,000.00	11	$110,000.00
	Homes	$1,200.00	800	$960,000.00
	Conservation Initiatives - fixtures for toilets & labor	$100.00	1000	$100,000.00
	Maintenance	$170,000.00	1	$170,000.00
	Needs Assessment	$34,000.00	1	$34,000.00
	Total			**$4,216,000.00**
4. Capacity Building and Public Awareness				
4.1: Training and certification	Gender & Infrastructure	$200.00	800	$160,000.00
	Knowledge Management	$414,000.00	1	$414,000.00
	ISO45001 safety training for BWA	$250.00	800	$200,000.00
	Energy Efficiency Training	$3,000.00	25	$75,000.00
	Specialized PV	$10,000.00	5	$50,000.00
	ENVISION	$300.00	30	$9,000.00
	ENVISION certification	$26,000.00	1	$26,000.00
	Vocational Training (Certification & Stipend for practicum)	$1,000.00	100	$100,000.00
	CCORAL	$7,500.00	1	$7,500.00
4.2: Public awareness campaign	Educational Signage at Major sites	$2,000.00	50	$100,000.00
	Documentary Production	$2,500.00	25	$62,500.00
	Social Media Campaigns	$10,000.00	5	$50,000.00
	Radio/TV/Newspaper	$30,000.00	5	$150,000.00
4.3: Policies for water sector resilience/PPPs	Legal Framework Workshop	$6,000.00	10	$60,000.00
	Legal Policy Development - Consultant	$50,000.00	2	$100,000.00
	Total			**$1,564,000.00**

Appendix B. Summary of previous BWA project reports.

Year	Name of study	Contributions	Source
2016	Water Supply Upgrade and Development Project (WSUDP) Feasibility Study Final Report	• Assessed reports for mains replacement, reservoir upgrades, energy efficiency, and sewage treatment improvements • Discouraged installation of a photovoltaic system	Stantec
2016	Barbados Water Authority Consultants' Services Procurement for Design & Oversight of the Replacement of Mains Close Out Report	• Reviewed new Mains Replacement methodologies • Updated project prices to current economic values • Recommended new pricing structures to include engineering fees and payment distribution clauses	Amec Foster Wheeler
2016	Environmental and Social Assessment for Institutional Strengthening	• Highlighted areas for institutional improvements • Reviewed projects focusing on non-revenue water reductions and energy efficiency • Assessed the need for an organizational-wide program for hurricane resilience and preparedness • Demonstrated the benefits of implementing tariffs that reflect the true cost of water delivery	Barbados Water Authority
2015	Proposal for Non-Revenue Water (NRW) Recovery and Control Program	• Installed and commissioned flow meters in order to address the institution's leak detection problems • Began a climate change and disaster management initiative	Matchpoint
2011	Water & Sanitation Systems Upgrade Program Operations Manual	• Produced institutional suggestions for managing the rollout of the digital water meters • Proposed the development of a Project Execution Unit (PEU) and Change Management Unit (CMU)	Halcrow
2009	Comprehensive Review of Barbados' Groundwater Protection Zoning Policy and System Water Resources and Hydrology	• Concluded that the agricultural industry, sewage disposal, and landfill activities posed threats to groundwater resource throughout the island • Acknowledged areas where illegal dumping was occurring which impaired groundwater quality	Burnside International Limited
2008	Comprehensive Review of Groundwater Protection Zoning Policy and System in Barbados Evaluation of Environmental Conditions and Risk Assessment Threats	• Reviewed environmental conditions of groundwater resources • Assessed risks that threaten groundwater resources • Produced relevant policy-related information	Burnside International Limited

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Appendix C. Key stakeholder consultations conducted for WSRN-BARBADOS between 10/22/16 and 8/17/17.

Date	Contact	What is important to the stakeholder?	How could the stakeholder contribute to the project?	Potential to block the project?	Strategy for engaging the stakeholder
10/22/16	Caribbean Hotel Energy Efficiency Action, Management	Access to energy and water efficient appliances. Supportive legislation lowering the barriers that impede the access to and widespread use of energy and water efficiency measures throughout the tourism industries, particularly in hotels and guest houses.	Identify sites for resilience implementation in tourism sector, contribute to and share project best practices.	Perpetuate misinformation about the benefits of water/energy efficiency, casting doubt on the value of the project.	Engage stakeholder at workshops for resilient infrastructure implementation, knowledge exchange, and policy development.
10/31/16	Environmental Protection Department, Management	Protection of public and environmental health. Clear, concise explanation of environmental regulations. Enforcement of existing environmental regulations. Equipment needs of government labs high to process monitoring data faster.	Stakeholder can contribute to clarification of regulations and monitoring requirements for rainwater harvesting systems.	Work against the development of supportive environmental regulations.	Engage stakeholder as integral part of knowledge exchange through workshops on resilient infrastructure & policy development. Stakeholder can co-advice university students engaged with capacity building that contribute to knowledge development for project components.
11/1/16	Barbados Water Authority, 12 persons, including upper management & engineers	National education program, water conservation, water efficient fixtures, wastewater reuse for agricultural sector & energy recovery, groundwater recharge and infiltration rehabilitation, rainwater harvesting and plumbing retrofits for household use, academic partnership for courses on water, gender and business, OSHA certification, infrastructure upgrades for changing climate, alternative plants for agriculture, impact of water scarcity on human health	Stakeholder is main implementing agency and organizational buy in is critical as project is built on paradigm shift through knowledge exchange for informed decisions wrt climate resilience. As sole provider of water on island, stakeholder sets standard/examples for best practices.	Decide to not implement project anymore or face challenges with new requirements of employees wrt certifications and trainings.	Management team representative of stakeholder employees with clear communication strategies that engage entire organization and push the concept of water resilient champions from within to lead knowledge exchange and outreach efforts. Stakeholder engagement throughout in development and implementation of training and certification programs to address health and safety, gender sustainability, climate and risk.

Date	Contact	What is important to the stakeholder?	How could the stakeholder contribute to the project?	Potential to block the project?	Strategy for engaging the stakeholder
11/1/16	Barbados Water Authority, Customer Service Division	Broad dissemination of information about the status of BWA services, including interruptions, monthly payments, new connections. Public opinion of service provisions and reliability.	Assist with knowledge exchange and messaging and public outreach.	Fail to accurately pass on the project benefits (economic, educational, and environmental) to BWA patrons.	Include as part of project management structure, have participate in training/workshops.
11/1/16	Barbados Water Authority, Financial Division	Sustainable funding to support the utility's ability to provide service to its patrons. Assuring routine fees are collected, wages are paid to employees, funds for project procurements are appropriately allocated.	Improve efficient financial management of project.	Fail to explain the economic benefits to BWA patrons.	Include as part of project management structure, have participate in training/workshops.
11/1/16	Barbados Water Authority, Health and Safety & Human Resources	Protecting the health and safety of employees at BWA while also holding the utility accountable to provide necessary training, resources, and educational opportunities to improve their workforce's ability to adapt to new technologies, policies, or service provisions.	Manage health and safety procedures to minimize impacts from risks associated with different project phases. Address workforce capacity building and address grievances.	Refuse to hold employees' training as an important form of investing in the future of the utility.	Include as part of project management structure, have participate in and lead training/workshops.
11/2/16	Innotech, Faciltities/Management	Proper use, management, and upkeep of the facilities containing the majority of the BWA staff. Uninterrupted access to water and electrical services to ensure proper function of the on-site wastewater system.	Share information on rainwater harvesting and water efficient features of building.	Refuse opportunities to partner with the project to achieve mutual goals.	Engage with education/knowledge exchange for public outreach etc..

Date	Contact	What is important to the stakeholder?	How could the stakeholder contribute to the project?	Potential to block the project?	Strategy for engaging the stakeholder
11/2/16	Retired, Farm Owner	Uninterrupted water services. Access to fertilizers. Markets for ornamental flowers and edible produce. Resources and information about water and wastewater reuse potential.	Share information on rainwater harvesting and water efficient irrigation features.	Perpetuate false information in farming community about rainwater/wastewater reuse potential.	Engage stakeholder as integral part of knowledge exchange through workshops on resilient infrastructure for agriculture.
11/2/16	SIR Water Management Limited, Management	Reliable water and energy sectors. Supportive legislation that promotes the productive reuse of water and wastewater for household non-potable and agricultural purposes. Sustainable markets for sales of decentralized wastewater systems.	Share information on water resilience with professional community, add expertise to different project components, especially water harvesting and storage.	Disregard entrepreneurial opportunities to benefit from and spread good publicity about the project.	Engage stakeholder as integral part of knowledge exchange and business opportunities through workshops on resilient infrastructure & policy development.
11/3/16	Altman Realty, Management	Uninterrupted water and wastewater services. Opportunities for economic savings from water and/or wastewater reuse. Protection of public health in the event of water and/or wastewater reuse. Positive public relations and community perceptions if "green" initiatives are to be installed on commercial/residential properties.	Stakeholder's properties could be used as sites for RAF and for adoption of resilient infrastructure. Stakeholder and staff could be champions featured in educational material/knowledge exchange.	Counter-productively instill doubt throughout the business community.	Engage stakeholder at workshops for resilient infrastructure implementation, knowledge exchange, and policy development.
11/4/16	Caribbean Development Bank, Management	Economic and social development of Barbados, particularly vulnerable communities. Water, sanitation, energy infrastructure projects that support communities' access to their basic needs.	Share knowledge on TORs and upcoming studies (e.g. gender and health impact of water shortage) & partner on water sector resilience. Utilize capacity building mechanism with academic partnerships.	Refuse to promote synergistic activities with CDB funded projects on water in Barbados.	Engage stakeholder as integral part of knowledge exchange through workshops on resilient infrastructure & policy development.

Date	Contact	What is important to the stakeholder?	How could the stakeholder contribute to the project?	Potential to block the project?	Strategy for engaging the stakeholder
11/4/16	University of the West Indies-Chemistry Department, Faculty	Providing educational opportunities to students at UWI to gain advanced knowledge, practical skills, and workforce readiness in the science, technology, engineering, and math fields.	Advise student projects, conduct water quality monitoring, contribute to knowledge exchange and management.	Discouraging students to participate in the educational components of the project.	Engage stakeholder as integral part of knowledge exchange through workshops on resilient infrastructure and as an advisor on capacity building activities.
11/4/16	RENTech, Management	Reduced energy costs in Barbados and increased use of renewable energy in Barbados, including	Stakeholder's business is built on innovative renewable energy with interest in water-energy nexus. Focus in ocean energy, but interested in energy recovery within piped water systems.	Counter-productively instill doubt throughout the business community.	Engage stakeholder at workshops for resilient infrastructure implementation, knowledge exchange, and policy development.
11/4/16	University of the West Indies-Management Studies Department, Faculty	Entrepreneurship opportunities for Barbadians to promote water sector resilience. Meeting Fair Trading Commission requirements and other requisite laws/regulations to address innovative project components.	Advise student projects, build engagement with business community, advise on policy workshops, contribute to knowledge exchange.	Withdraw support and liaising efforts between project partners.	Engage stakeholder by having on advisory board, integrated with project updates and direction. Facilitate knowledge exchange with business community through UWI Student Entrepreneurial Empowerment Development.
11/4/16	University of the West Indies-Gender Studies Department, Faculty	Building on existing traineeship program addressing gender. Working with gender trained social workers in communities on water, gender, and infrastructure, and expanding CIGAD program to integrate infrastructure more.	Partner on gender integration across all project components and contribute to developing and meeting gender goals and objectives for project and beyond.	Could minimize the effects the project could have to vulnerable communities and women.	Engage stakeholder by building capacity on gender and infrastructure, support efforts already begun to train on gender in Barbados, and budget for integration with various aspects of projects.
11/5/16	Pan American Health Organization, Engineer	Water sector resilience, rainwater harvesting, water efficiency and conservation, resource recovery from wastewater.	Share information on water resilience with professional community, add expertise to different project components, especially health and water harvesting and storage.	Disregard opportunities to share contacts for potential community partners. Could withdraw support about the public health/safety of the project.	Engage stakeholder as integral part of knowledge exchange through workshops on resilient infrastructure & policy development. Potential advisor on student projects linked with health and rainwater harvesting and storage.

Date	Contact	What is important to the stakeholder?	How could the stakeholder contribute to the project?	Potential to block the project?	Strategy for engaging the stakeholder
11/7/16	Massey's Supermarket, Marketing and Human Resources Affiliates	Economic reliability of the Barbadian public to continue purchasing goods from their supermarket. Perception of the company's public relations. Suitable beneficiaries to receive funds for community development projects.	Build business/academia/BWA alliance for water/wastewater sector resilience. Fund pilot projects that promote innovation and capacity building.	Ignore potential corporate partnership opportunities	Engage stakeholder as integral part of knowledge exchange and business opportunities through workshops on resilient infrastructure & policy development for public/private partnership.
1/4/17	Barbados Water Authority, Engineer	Uninterrupted electrical services for operations and monitoring of pumps and wells to provide reliable water services for patrons. Transitioning from fossil-fuel-based energy sources to renewables. Pilot testing renewable energy options, particularly solar photovoltaic systems, to record the output efficiencies and determine potential.	Demonstrate good leadership as project falls under department now headed by stakeholder. Complete requisite project trainings/certifications and contribute to being a champion for project within and outside of the BWA.	Retract commitment to assisting in project leadership and knowledge-sharing of best practices.	Stakeholder is part of leadership team and engagement is required throughout all aspects of proposal.
1/5/17	Torque Engineering Procurement and Preparatory Management, Management	Smart/Artificial Intelligence approaches to Water Loss Reduction with easy to integrate sensors for either flow or power requirements. Efficient methods for mains replacements that reduce environmental and human disruptions.	Apply tools and techniques to increase efficiency of identifying Water Loss Reduction strategies.	Works extensively with BWA and has vast experiential, technical and field-based knowledge. Could refuse to advise or share best practices.	Engage stakeholder as integral part of knowledge exchange and business opportunities through workshops on resilient infrastructure, gender, safety, and sustainability.
1/5/17	Town and Country Planning, Technical Specialist	Synthesis of GIS map of housing applications with rainwater harvesting requirement and enforcement and synthesis of BWA infrastructure with other infrastructural maps of island.	Use GIS tools and housing database to provide project with information that could efficiently guide rainwater harvesting and storage requirements/opportunities.	Could withhold valuable information that could be used for project planning and operations.	Engage stakeholder as integral part of knowledge exchange through workshops on resilient infrastructure.

Date	Contact	What is important to the stakeholder?	How could the stakeholder contribute to the project?	Potential to block the project?	Strategy for engaging the stakeholder
5/15/17	Ministry of Agriculture, Food, Fisheries & Water Resource Management, Management	Resilient water supply across Barbados. Water provision to vulnerable populations. Reduced energy expenses and non-revenue water. Increased capacity at BWA and in Barbados to make informed decisions about water sector resilience. Innovative and appropriate technology.	Champion the project and support initiatives for broad impact across island like sustainability certification, gender integration, private public partnerships, knowledge exchange and management approach, & innovation investment fund.	Could rescind government support.	Engage stakeholder by having on advisory board, integrated with project updates and direction. Facilitate PR/knowledge exchange to ensure stakeholder shares information with other members of parliament etc..
8/15/17	Seventh Day Adventist Church, Pastor	Water supplied to vulnerable populations at all times. Workforce development to assist with relief efforts. Agricultural development on SDA lands and use of rainwater harvesting to assist. Building partnership between BWA and religious organizations as was requested by BWA in 2016 to assist with drought relief efforts.	Continue approach to community based needs assessment. Organize green preparatory training in other communities across island to support and integrate with resilience projects. Provide demonstration site at SDA schools and at farm that links with agripreneurial activities. Encourage people to access RAFF. Design storage systems using pumps that minimize additional electricity and maintenance costs to residents.	Influence community and vulnerable populations to not support project.	Engage stakeholder with needs assessment to continue approach started during 2016 drought with church leaders and BWA, Support workforce development and provide stipends for trainees to learn on reject supported installations, engage with RWH for farmers as a potential entrepreneurial training for farmers
8/17/17	Ministry of Energy, Management	That BWA provides water to people at all times. Recommends solar water heaters be converted to storage units to supply emergency potable needs.	Expertise on RE (including adapted training materials for Caribbean and published books on RE for Caribbean kids and homeowners), water resilience projects can be linked with RE being done by Ministry of Energy, Integration with project to convert solar water heater design to include storage.	Makes decisions on all renewable energy projects in Barbados. Could prevent BWA installation of RE.	Collaborate on RE integration with water resilience at community centers, pilot sites (stakeholder already has demonstration site in Queen's park with RWH, RE, Conservation measures), and entrepreneurial opportunities for using solar water heaters for storage and resilience.

Appendix D. BWA Water Sector Resilience Nexus for Sustainability in Barbados (WSRN S-Barbados) Grievance Form

This form can be filled out by clicking or tapping where indicated, then typing to enter the requested information. When completed, you may print and sign, or you may upload a photo of your signature (instructions provided below) and e-mail the completed form.

1. Complainant's Information *(This information must be provided. The identity of complainants will be kept confidential if they request so. Anonymous complaints will not be accepted.)*

Names and Titles: Click or tap here to enter text.
(☐Dr., ☐Mr., ☐Ms., ☐Mrs. *Please check one* or more)

BWA Employee: ☐Yes ☐No *Please check one*

If yes, Employee Number: Click or tap here to enter text.

Positions/Organizations *(If any)* Click or tap here to enter text.

Addresses: Click or tap here to enter text.

Contact numbers: Click or tap here to enter text.

E-mail addresses: Click or tap here to enter text.

Please indicate how you prefer to be contacted (e-mail, mobile, etc.): Click or tap here to enter text.

Do you request that identity be kept confidential? *Check Yes or No below*
☐Yes **☐No**

2. Information on Authorized Representative ***(If any)***. *(If Authorized Representatives are not complainants themselves, their names will be disclosed as needed, in order to ensure transparency).*

Names and Titles Click or tap here to enter text.
Positions/Organizations *(If any)* Click or tap here to enter text.
Addresses Click or tap here to enter text.
Contact numbers Click or tap here to enter text.
E-mail addresses Click or tap here to enter text.

3. Project Information

Project name (and project number if known) Click or tap here to enter text.
Project location (Parish.) Click or tap here to enter text.

4. The Complaint

(a) What harm do you believe the WATER SECTOR RESILIENCE NEXUS FOR SUSTAINABILITY IN BARBADOS (WSRN S-BARBADOS) project caused or is likely to cause to you?

Click or tap here to enter text.

(b) Why do you believe that the alleged harm results directly from the WATER SECTOR RESILIENCE NEXUS FOR SUSTAINABILITY IN BARBADOS (WSRN S-BARBADOS) project?

Click or tap here to enter text.

(c) Please include any other information that you consider relevant.

Click or tap here to enter text.

5. Previous Efforts to Resolve the Complaint

(a) Have you raised your complaint before?

☐**Yes** If YES, please provide the following:

- When, how and with whom the issues were raised.

  Click or tap here to enter text.

- Please describe any response received from and/or any actions taken by the grievance mechanism. Please also explain why the response or actions taken are not satisfactory.

Click or tap here to enter text.

☐**No** If NO, why not?

Click or tap here to enter text.

(b) How do you wish to see the complaint resolved?

Click or tap here to enter text.

(c) Do you have any other matters or facts (including supporting documents) that you would like to share?

Click or tap here to enter text.

Signature of Complainant (if an Authorized Representative is submitting the complaint and has a separate letter providing authorization that has been signed by the Complainant, the Complainant is not required to sign below): *You may print the form and sign it. Alternatively you may click in the box below and add a photo of your signature if you prefer.*

_____

Signature of Authorized Representative: *You may print the form and sign it. Alternatively you may click in the box below and add a photo of your signature if you prefer.*

_____

Date:
Click or tap to add date or select from drop down list.

Name of the person who completed this form if different from Complainant and/or Authorized Representative:

Click or tap here to enter text.

Please send the complaint to:

Barbados Water Authority
Attn: WSRN-S Grievance

Email: TBD

Fax: TBD

Complaints may be submitted by mail, fax, e-mail, or hand delivery to the BWA headquarters.

Appendix E. Examples of Environmental and Social Impacts and mitigation measures

Environmental Impacts

Air Quality

MAINS REPLACEMENT: During the implementation process when the pipes are being replaced, there will be temporary negative impacts that directly affect the environment as old pipes are being extracted from the ground and new ones installed. Mitigating efforts must be made to address environmental impacts that stem from the excavation practices, equipment usage, chemical selection, and employees' behavior while onsite.

The excavation process will unearth approximately 16 kilometers of soil at various depths bringing a variety of particulate matter and coarse debris to the surface. Furthermore, the majority of the machinery used throughout the construction phase of the project typically burns diesel fuel which produces acute areas with concentrated amounts of harmful air emissions. These emissions increase the project's overall greenhouse gas (GHG) values and carbon footprint. Next, as the pipes are being installed, chemicals used to fit and combine joins oftentimes emit harmful fumes that have short-term impacts to the local air quality levels. Lastly, depending upon waste management practices and employee behavioral protocol, burning of excess materials or personal smoking are likely occurrences onsite which are avoidable events that also negatively impact air quality.

Water Quality

MAINS REPLACEMENT: The majority of the water quality-based environmental impacts are positive with direct and in-direct, long-term impacts associated with the O&M phase of the Mains Replacement. On the other hand, however, the construction portion of the proposed project reveals some short-term, threats that have direct negative impacts to the ecosystem.

First, the positive environmental effects associated with the O&M phase are both direct and indirect. When new pipes are installed, there is a direct water quality impact to the finite groundwater supply. In this case, the daily rate at which water is being withdrawn from the aquifer is reduced, so the water quality measure is actually reflective of a growing water quantity. The increased volume of water dilutes any existing and future contaminants (i.e. nutrient infiltration from the agriculture sector). Furthermore, the appropriate, continued O&M of the project also has an indirect positive implication to water quality because the reduced rate of total withdrawal from the aquifer prevents zones of stress along the coastal portions of the aquifer that, if overtaxed, result in areas of saltwater intrusion. Since Barbados is a water scarce nation, this project's positive contributions at protecting the country's most limited natural resource is particularly critical.

On the other hand, while much of the effects from this project do permanently benefit the environment during the O&M phase, there are still some short-term, negative impacts to consider during the construction of the project. These impacts are associated with installation practices that, if done improperly, have the potential to contaminate the drinking water supply and surface waterbodies. When pipes are replaced, if there are ineffectively sealed or have inappropriately cleaned joints, external contaminants from the surrounding area or remaining residue from the Mains Replacement could leak inside through preventable cracks. Additionally, hazardous chemicals used onsite or during

pipe installation that are improperly disposed may contaminate the vulnerable groundwater supply or nearby surface waters. Lastly, since there will be extended areas of various depths of upturned earth, during heavy rainfall events, there could be instances of turbid waters impacting groundwater quality if the storm water onsite is not managed to improve its quality and infiltration rate to the aquifer or adjacent surface water bodies.

PHOTOVOLTAIC INSTALLATION: Although the PV panels will be installed on an impervious foundation and the water quantity during heavy rain events will not be significantly impacted, it is possible that, over the course of the PV panels' lives, there may be some leaching of precious metals into the runoff. However, the quantity and associated effects of these values are not well studied. The actual nature of this environmental impact can be used as a platform for ongoing collaboration in research with the other project partners as their areas of study and expertise align well with this potential water quality concern (i.e. USF research to consider low-cost, easily installed rainwater gardens to measure and mitigate potential water quality impacts from PV panels). Furthermore, the routine O&M processes require cleaning of the panels, and some of the chemicals may be potentially toxic so these potential indirect water quality impacts must be mitigated.

WATER RESILIENCE PROGRAMMEME AND RAINWATER HARVESTING: Due to the topography of the island, many households along the southern and western coast lie outside the basin where much of the rainwater infiltration occurs. As such, installing rainwater harvesting systems has a positive, direct, and permanent impact to water quality issues that exist in the nearshore coastal areas. For instance, rainwater harvesting systems can be considered localized measures for flood mitigation because smaller volumes of water are falling from household roofs onto nearby roads, removing stress from the overburdened, often clogged storm drains. Additionally, decentralized water storage and rainwater harvesting reduces the volume of storm water runoff traveling from the island's ridges down to the vulnerable reefs, picking up contaminants from the roadways along its path. While the majority of the impacts are positive, it is also important that reasonable measures must be taken if hazardous chemicals are used to clean the rainwater vessels or patch any holes. In addition, if water is stored for long periods of time, depending upon the material of the container, the water quality may be compromised due to leaching of the tank material; reuse potential may be limited for utilitarian purposes rather than any form of human consumption.

Soil Cover

MAINS REPLACEMENT: While the exact location of the replaced pipes has not yet been determined and will be a first priority for consideration during the initial phase of the project, it is well understood that measures will be necessary to minimize the amount of unearthed soil, offsite transport of top soils, and compaction during the construction process. Impacts associated with disturbed or removed soils are nutrient imbalances in top soils that may lead to periods of infertility. Furthermore, soil disturbances have associated impacts to localized areas of erosion and potentially sink holes when large volumes are transported away from the native ecosystem. Lastly, if excessive areas of compaction occur during the construction or post-construction phase of the project, threats such as flash flooding can occur as soil types with traditionally high thresholds of moisture content can be compressed, decreasing the porosity between soil particles.

WATER RESILIENCE PROGRAMMEME AND RAINWATER HARVESTING: The environmental impact associated with the personal tanks and rainwater harvesting systems mainly entail minor, temporary soil disturbances such as excavation of top soils or removal of native soils as the foundations are put in place for the hydroponic runs and storage tanks, respectively. Removal or degradation of the soils could

impact future growth of plants, landscaping, or food crops. Furthermore, the topsoil disturbances, soil removal, or excavation procedures may influence future erosion in the adjacent areas if proper steps are not taken to manage such impacts. Next, if the heavy equipment typically used for earth moving is parked in one location for an extended period of time, issues could arise from the soil being temporarily over-compacted. Such compactions may influence the soil's normal water storage capacity, potentially resulting in areas of poor infiltration and localized ponding. Lastly, for the lifetime of the projects, the soil in the areas upon which the foundations have been laid will no longer be of productive use. However, these footprints are of relatively small sizes, and mitigation measure can be taken to appropriate other areas (brown or gray fields) or reclaim unused structures to offset any productive use that has been compromised.

Biodiversity

MAINS REPLACEMENT: Along the area where pipes will be replaced, some impacts are likely to local flora and fauna, and seasonal/migratory pathways. The construction equipment and its associated emissions, onsite tools/resins and the disposal of their rinse water, and the increased frequency of workers in the area may have temporary, negative influences on the native creatures' habitats or longer-term, negative effects on biota that is removed when pipes are replaced. This long-term impact, however, is likely minimal since the pipes will be replaced in areas that have existing, leaky pipes; virgin biologically diverse areas will likely receive little to no negative impact (in the short or long-term).

PHOTOVOLTAIC INSTALLATION: The installation process reflects few impacts on the biodiversity of the area where the PV panels are proposed for installation, however, the ongoing O&M are important because potential impacts to migratory routes for native bird species must be considered. Furthermore, chemicals used to clean the panels must be carefully considered because adjacent waterbodies or vegetation could be impacted during rain events throughout the lifetime of the project if there are spills due to the chemicals used to clean the equipment or if there are significant amounts of contaminants (i.e. precious metals or other known carcinogens) leaching into storm water runoff that is not treated prior to contact with local biota.

Noise

MAINS REPLACEMENT: As excavation of existing pipes, installation of the new piping network, and repaving of the roads take place, there will be direct, negative impacts to the surrounding stakeholders. Importantly, however, is the fact that these impacts will occur temporarily during the construction phase and are unlikely to have any long-term effects.

PHOTOVOLTAIC INSTALLATION: These projects have similar, direct, negative, temporary effects like those associated with the Mains Replacement. In this case, those stakeholders nearby the construction sites who are present during daytime working hours will also experience the noise impacts.

Land use

WATER RESILIENCE PROGRAMMEME AND RAINWATER HARVESTING: At the site for decentralise storage and rainwater harvesting pilot project unused roof space and an adjacent, modestly size area will be used for the installation of personal tanks and rainwater harvesting systems. The effects of these systems will be a direct, permanent, positive change as under-utilized area will become productive for climate resilience and development purposes.

Social Impacts

Health and Safety

MAINS REPLACEMENT: Temporary, negative health and safety threats are possible during the Mains Replacement project as potentially hazardous situations may exist from the construction processes. Such hazards are oftentimes possible to mitigate if heavy equipment, toxic chemicals, safety protocols, and efficient lines of communication are maintained in proper working order. For instance, the 20km of pipe to be replaced represents an extensive distance where local foot-traffic may be negatively impacted or construction workers could accidentally injure themselves in an open hole. There are also toxic chemical adhesives or cleaners used on the pipes which could cause respiratory problems, headaches, or other acute illnesses. Additionally, given the length of pipe to be replaced, there may be onsite congestion of construction equipment or overhanging threats from other mechanical equipment. While these issues may not cause any traffic accidents on adjacent road networks, it is still necessary to mention. Lastly, temporary disconnections will have to be made and this could affect residences and businesses if enough forewarning is not given and appropriate alternatives for water supply in order to maintain the health and safety of the impacted communities.

PHOTOVOLTAIC INSTALLATION: Depending upon the exact placement of the panels, there are permanent health and safety precautions for both the construction and operation and maintenance phases. For instance, photovoltaic panels require maximum exposure during daylight hours, so they are often placed in elevated locations which will require extreme caution during installation and cleaning. Furthermore, threats are experienced during routine maintenance either from chemicals used for cleaning the panels or from the wastewater produced from cleaning that is difficult to characterize and may have skin irritant properties.

WATER RESILIENCE PROGRAMMEME AND RAINWATER HARVESTING: The primary, negative concern for the decentralize storage and rainwater harvesting systems is the potential exposure to waterborne disease vectors. Fortunately, these disease vectors are easily controlled at the household level with minimal effort, and such efforts will be put on display along with educational material at the pilot site. Furthermore, the permanent, positive health and safety benefits of the system are in its promotion of storm water management efforts which prevent localized flooding, reduction of water quality impacts from storm water on local waterbodies, and decentralized approach water storage which improves household effects of water insecurity.

Socio-economics

MAINS REPLACEMENT/PHOTOVOLTAIC INSTALLATION: There will be permanent indirect, positive implications to stakeholders from the improvements from both the Mains Replacement and photovoltaic installations because of the economic returns to BWA. Additionally, interdisciplinary capacity building and knowledge sharing that is integrated through university-utility partnerships of WSRN S-BARBADOS, will have great socio-economic benefit to Barbados. The overall improved performance of the BWA translates to increased efficiency and effectiveness of services for water and wastewater treatment that would ultimately have a positive impact in Barbados. These economic returns come through energy savings from not pumping water that is lost to leaky pipes as well as energy savings from reduced consumption directly from the grid.

WATER RESILIENCE PROGRAMMEME AND RAINWATER HARVESTING: If these systems are installed and operated to their optimal capacity, direct positive impacts are experienced over their lifetimes. For instance, at the household level economic savings are realized when water consumption is reduced by

the rainwater harvesting system; whereas, at the national level, these systems helps to reduce the burden on the net international reserves.

Road Network

MAINS REPLACEMENT: While none of the other projects have significant impacts on public road networks (because they are all constructed on privately owned property), it is understandable that during the construction of the Mains Replacement, there will be short-term, negative impacts to the access and usability of some roads. Although the specific areas have not yet been identified, the appropriate public awareness campaigns and preventative measures to minimize impacts to stakeholders will be quickly initiated in order for community members to adapt their schedules and routes (i.e. to work, meetings, or other weekly events) for a brief time.

Visual Amenities

MAINS REPLACEMENT: Some negative impacts will occur during the construction process that will impact the visual appeal of the area. Stakeholders, however, will only temporarily experience these impacts such as remaining debris, construction equipment left onsite, and other materials around the area for Mains Replacement purposes.

WATER RESILIENCE PROGRAMMEME AND RAINWATER HARVESTING: These systems will be installed on private property and will not impact public visibility. However, depending upon the placement of the storage tanks and rainwater harvesting systems, there may be some long-term impact to the current visibility that could be negotiated through community or individual meetings with nearby stakeholders