ASSESSMENT OF WASTEWATER INFRASTRUCTURE AND GO-FORWARD OPTIONS FOR THE VILLAGE OF CANARIES, ST. LUCIA

Island Water TECHNOLOGIES

1/20/2016

CANARIES: WASTEWATER ASSESSMENT AND FUTURE PLANNING

The community of Canaries is located in a steep sided river valley on the West Coast of St. Lucia. The existing wastewater infrastructure is inadequate for the local population. Increasing tourism in Canaries has the potential to boost the local economy and in turn help improve the quality of life for local residents. As well as affecting tourism, open defecation and untreated wastewater discharged to open gutters pose significant health risks to the local population. A go-forward strategy incorporating low-complexity, cost effective solutions for improved wastewater management have been suggested, that would drastically reduce the risk associated with fecal borne illness and allow for improved tourism based activities.

ACKNOWLEDGEMENTS

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Executive Summary

The community of Canaries is located in a steep sided river valley on the West Coast of St. Lucia. Increasing tourism in Canaries has the potential to boost the local economy and in turn help improve the quality of life for local residents. Currently, tourists are not able to participate in any water based activities close to the village due to the high pollution in the bay. As well as affecting tourism, open defecation and untreated wastewater discharged to open gutters pose a significant health risks to the local population.

The combination of regular storm water events and poorly developed wastewater management and infrastructure, has created a high risk environment with regard to the potential health implications of fecal water borne illness for the Canaries community.

The existing wastewater infrastructure is inadequate for the local population. Of particular concern are the community members serviced by community washrooms located in Canaries northern valley. These facilities require frequent pumping and are routinely closed due to full holding capacity.

This report assesses the impact of climate change on the existing infrastructure and incorporates future planning considerations. Key stakeholders are identified, and go-forward strategies incorporating low-complexity, cost effective solutions for improved wastewater management are suggested. These have been divided into those that can be enacted in the short-term, as well as a longer term vision of decentralized treatment integrated to a centralized network of piping that would drastically reduce risk associated with fecal borne illness, and allow for improved tourism based activities. The components and outputs of the four proposed options suggested for the Canaries community are shown below in *Figure 1*.

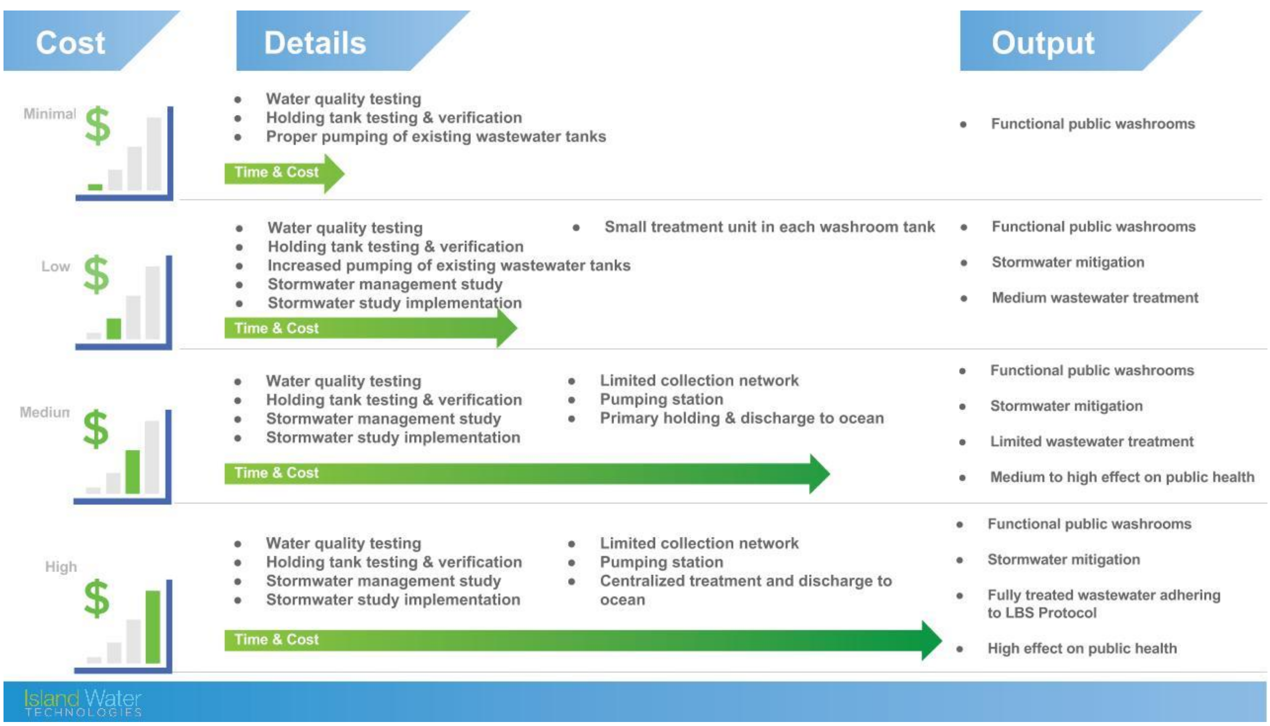

Figure 1: Four proposed move forward strategies to successful wastewater practice implementation in Canaries

1. Introduction

1.1. St. Lucia Overview

St. Lucia is an eastern Caribbean island. It is part of the Windward Islands, which are composed of the southern islands within the West Indies. It is 616 square kilometres and has a population of 174,000. There is little variation in the average temperature which ranges from 26 °C to 32 °C. It has a tropical, humid climate with annual rainfall amounts of approximately 2,000 millimeters. Most precipitation occurs from June to December (Government of St. Lucia, 2011).

Mount Gimie forms the central mountain range on the island. This formation helps form many rivers flowing from central St. Lucia to the coast. Due to the landscape and tropical location of St. Lucia there is a wide range of terrestrial and aquatic habitats: dry cactus scrubs, rainforests, mangroves and coral reefs. Due to its small size and increased human activity, there has been a significant negative impact on the terrestrial environment. As written in the GEF CReW report: "Between 1977 and 1989, 22.5% of the forest was lost and it is estimated that 40% of mangroves have been lost. In addition, over 12% of St-Lucia's beach length is being mined for sand and 50% of the wetlands have been converted for cultivation" ("GEF CReW Project Baseline Assessment Study: Saint Lucia", 2012).

Tourism and agriculture are the two main industries which rely heavily on St. Lucia's natural resources. Although helping drive the economy, they can also have adverse effects such as loss of natural habitat or degradation of the environment. Tourism is the single largest industry in St. Lucia, bringing in an estimated 65% of the annual GDP. Wastewater management plays a key role in a sustainable tourism industry. Currently tourists and local populations are unable to fully appreciate or enjoy certain coastal and marine areas of the island due to the existing levels of untreated wastewater contamination (Central Intelligence Agency, 2014).

1.2. Wastewater Impact in the Wider Caribbean Region

Impacts of poor wastewater management is felt in many countries in the Caribbean region and is having a significant impact on the surrounding environments as described by the UNEP Regional Seas program. "The discharge of untreated domestic wastewater is a major source of environmental pollution. Over 70% of coral reefs are affected by discharges of untreated sewage, habitats are disappearing, biodiversity is decreasing, fishing and agriculture opportunities are being lost, poor water quality is adversely affecting incomes from tourism, and declines in real estate value are being experienced in the impacted areas. Additionally, besides the negative impacts in the environment and economic sectors, inadequate management of wastewater has serious consequences for human health. Contaminated water supply increases the risk of infectious diseases. The global burden of human disease caused by sewage pollution of coastal waters has been estimated at 4 million lost man-years, every year" ("GEF CReW Project Baseline Assessment Study: Saint Lucia", 2012).

1.3. Wastewater Management in St. Lucia

The current absence of wastewater management in select St. Lucia communities results in high levels of environmental contamination with open defecation and raw sewage discharged directly into waterways. Industrial wastewater is either partially treated and discharged into a natural water course or untreated and discharged into open drains. This pollution ends up on the coast, often near villages and towns. Poor wastewater management leads to partially or untreated wastewater discharged directly to natural water courses. This results in high levels of bacteria in coastal regions, causing waterborne diseases which effect human health and the surrounding environment, and have affected children with parasitic worms (Caribbean Environment Programme, 2015).

Castries, the capitol city and largest in St. Lucia, has a wastewater collection system and carries out primary settling/screening before discharging to the ocean. A discharge pipe previously carried this wastewater out past the bay. The piping has since failed and the wastewater is currently discharged to a location in the bay (Anthony, 2015).

Gros Islet is the only area receiving wastewater treatment which is serviced by an Advanced Aerated Integrated Pond System. The sewage is screened and fed to four lagoons, with the first two lagoons receiving aeration. The effluent is discharged to a ravine on the east coast and was assessed and described as 'good quality' by the Caribbean Environmental Health Institute. The CEHI also noted that the system was under capacity. Approximately 13.2% of the country's population are serviced by this system ("GEF CReW Project Baseline Assessment Study: Saint Lucia", 2012).

Other systems around St. Lucia in small communities or rural areas include septic tanks and outhouses. Septic tanks with leach fields can be appropriate for rural areas, but most villages along the coast don't have any treatment and are discharging wastewater straight to natural watercourses.

WASCO has the mandate to provide services Island-wide. Island Water Technologies (IWT) met with the WASCO organization and were impressed with their technical knowledge and commitment to future infrastructure development, however they face significant financial hurdles to implement public works Island-wide.

The Caribbean Environmental Health Institute estimated that due to St. Lucia's limited land space and variable terrain, that the total construction cost for wastewater treatment in St. Lucia is $1,350,000,000 with an estimated 346,000,000 operations and maintenance cost *(Caribbean Environmental Health Institute, n.d.).* This evaluation was noted to be preliminary, and with significantly higher costs than other nearby Islands, likely due to the unique landscape in St. Lucia.

1.4. Regulatory Framework for Wastewater Management

The Cartagena Convention (1986) is the regional multilateral environmental agreement for the protection and development of the wider Caribbean region. The Protocol Concerning Pollution from Land-Based Sources and Activities ("LBS Protocol") of the Cartagena Convention sets forward general obligations and a legal framework for regional co-operation. It provides a list of priority source categories, activities and associated pollutants of concern and promotes the establishment of pollution standards and schedules for implementation. The LBS Protocol (Cartagena Convention) came into force on August 13th, 2010 and is the most significant agreement of its kind for the Caribbean region with the inclusion of regional effluent limitations for domestic wastewater (sewage) and requiring specific plans to address agricultural non-point sources. St. Lucia has agreed to this protocol and is working hard towards meeting these goals. However, St. Lucia's available funds to meet these standards is insufficient at this time, and as such they are at this stage attempting to increase projects to start moving towards this goal.

Effluent limits are divided in two classes, as outlined in Table 1. Class 1 waters are particularly sensitive to impacts from pollution, while Class 2 waters are less sensitive. Effluent limits are not in place for contaminants of emerging concern.

Table 1: Land-based sources and activities (LBS Protocol) standard effluent discharge limits

Parameter	Class 1 Waters	Class 2 Waters
Total Suspended Solids	30 mg/L	150 mg/L
Biochemical Oxygen Demand (BOD_5)	30 mg/L	150 mg/L
pH	5-10 pH units	5-10 pH units
Fats, Oil and Grease	15 mg/L	50 mg/L
Fecal Coliform or ***E. coli*.or** *Entrerococci*	Fecal coliform: 200 MPN/100ml *E. coli*: 126 organisms/100ml *Entrerococci*: 35 organisms/100ml	Not applicable
Floatables	Not visible	Not visible

1.5. Canaries

1.5.1 Overview

The community of Canaries is located in a steep sided river valley on the west coast of St. Lucia, between Soufriere and Castries. The population is estimated at 2,044 *(Government of St. Lucia, 2011)* with approximately 780 households. The community can be divided into 4 sections (*Figure 2*), northern valley, southern valley, northern hillside, and southern hillside. The Canaries River runs through the valley floor beside the village and discharges into Canaries Bay. A large concentration of the population resides within the northern valley, which is the main focus of this report.

Increasing tourism in Canaries has the potential to boost the local economy and in turn help improve the quality of life for local residents. At present, tourists are not able to participate in any water activities due to the high pollution in the bay. Water quality in the area must increase in order for this to be a viable tourist destination. As well as affecting tourism, open defecation and untreated wastewater discharged to open gutters pose a significant health risks to the local population. This can lead to waterborne diseases which pose a higher threat to children and the elderly population.

To help raise the quality of life in Canaries, it will need to become a more sanitary environment in which tourists are able to enjoy the local biodiversity. The money tourists spend on the local economy can have further reaching impacts as the community should expect more government funded projects in the area due to increased popularity and tax funds.

This report focuses on the issues in the northern valley.

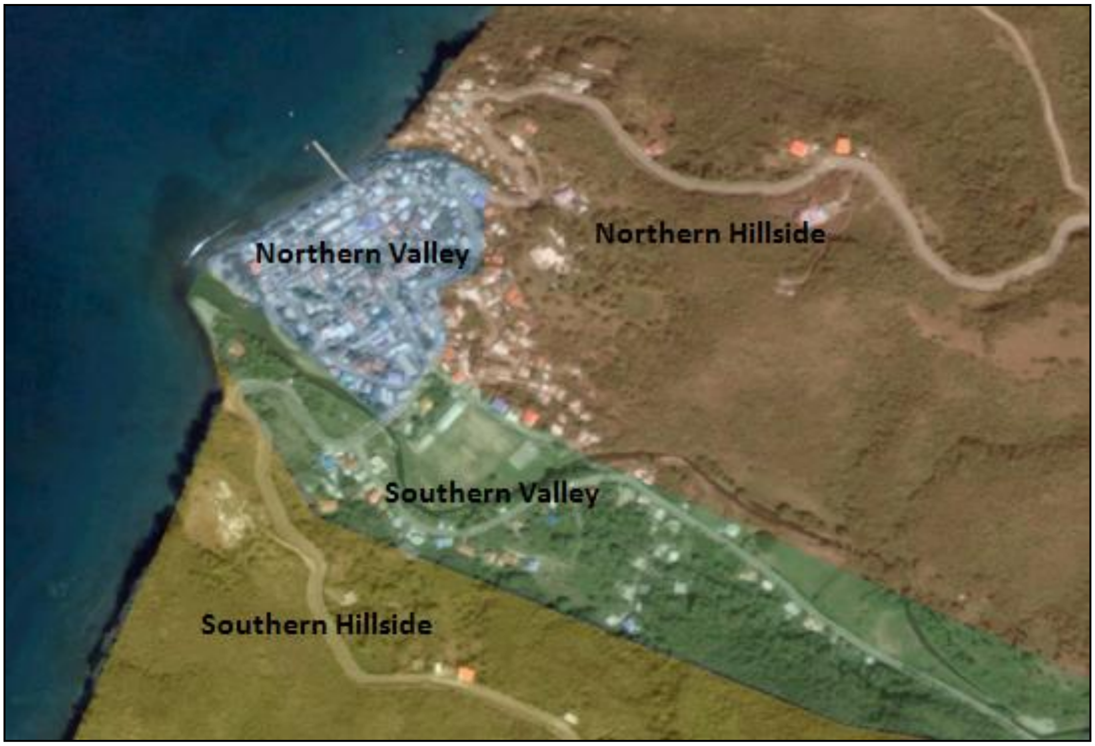

Figure 2: Google map showing the different sections of Canaries.

1.5.2 Local Initiatives – Canaries Community Improvement Foundation (CCIF)

A local community based organisation, the Canaries Community Improvement Foundation (CCIF) are currently working on a Ridge to Reef project. The goals of the project are to:

- help re-establish a healthy environment that is more resilient to the impacts of climate change and natural disasters;
- create sustainable wastewater management;
- develop a coral farm;
- develop local business.

The four main components of the project are described below:

1. **<u>Slope Stabilization:</u>** Climate change, deforestation and natural disasters have had a negative impact on the local environment. Soil erosion and slope stability is a major issue contributing to flooding, pollution in the bay, landslides, and property damage during heavy rain events.

2. **<u>Sewage Treatment:</u>** The evaluation of potential solutions from this report will determine the next steps.

3. **<u>Coral Nursery:</u>** Coral farm for rehabilitation of Canaries reefs and as a source of corals for other reefs in St Lucia. Training of coral farmers from within Canaries community will lead to income generation and sustainable employment through guided snorkel tours of the facility and replanting of other coral reefs along the nation's coast through donor funded finance mechanisms.

4. **<u>Small Business and Entrepreneurship Development:</u>** Capacity building in microenterprise and small business operation for stakeholders within the Canaries community. This will help ensure that human resources are developed in line with investments in the environment and infrastructure to the extent that the community can become self-sufficient in developing livelihoods from the opportunities that the project delivers.

1.6. Wastewater Management in Canaries

The village discharges a portion of its wastewater into the bay through open defecation and open gutters in the village. Open defecation on the beach and poorly managed wastewater is a major concern in the area as it negatively affects the health of local residents, fishing and tourism industries. Other factors contributing to the pollution of the river and ocean include: bathing & washing clothes/dishes in river, grey water and wastewater discharged to open drains, and garbage discharged to ocean.

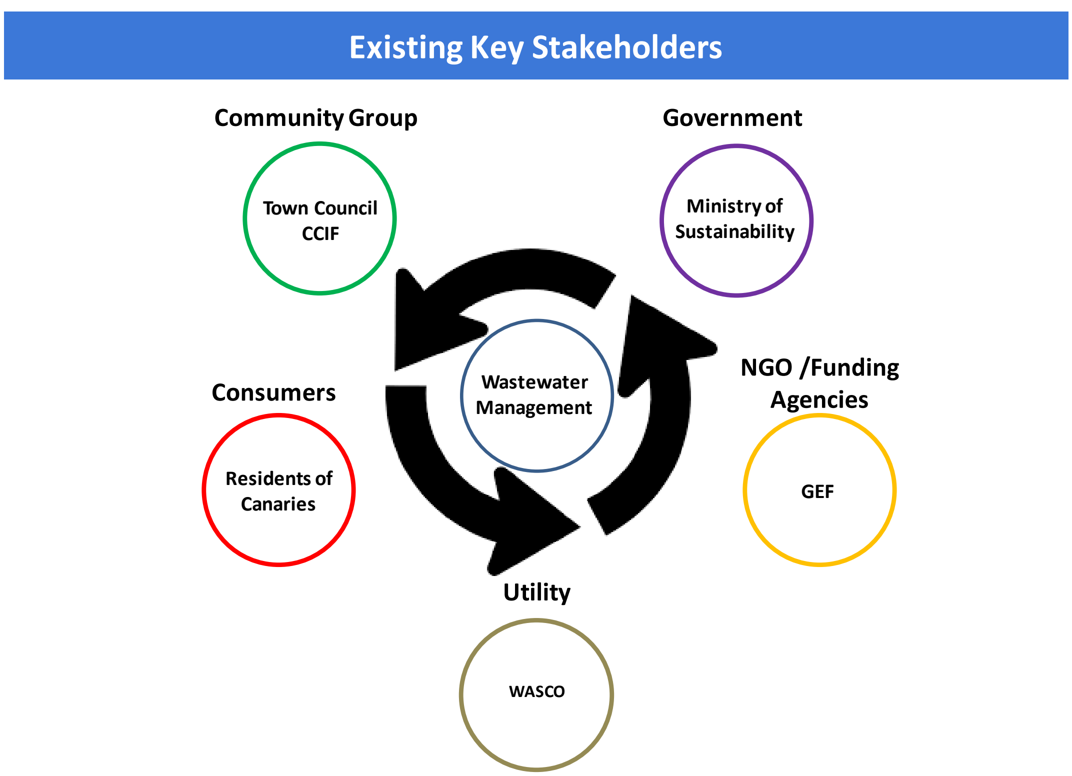

Figure 3: Key stakeholders associated with wastewater management in the village of Canaries

Existing wastewater infrastructure in Canaries involves various stakeholders. The village council is responsible for managing the washroom facilities and determining frequency of pumping for wastewater holding tanks. CCIF is leading efforts to improve the existing infrastructure through reaching out to NGO's and international funding bodies. WASCO currently manages the water delivery to the village and has indicated a willingness to operate and maintain an improved wastewater infrastructure if this aligned with cost recovery funding.

1.7. Additional Environmental Concerns for Canaries

1.7.1 Climate Change

IWT used the online risk assessment and climate resilience decision tool, Caribbean Community Climate Change Centre (CCORAL). A series of questions and answers were undertaken to help assess risk management and ethics in decision making. The outputs focused on four areas regarding the wastewater assessment and future planning of Canaries wastewater infrastructure:

- Identification
- Preparation
- Analysis, negotiation and approval
- Implementation, monitoring and evaluation

Any proposed wastewater solution is considered at high risk to climate change and would need to be evaluated on the basis of climate change. The CCORAL exercise can help decision makers determine the level of risk, understand climate influence, and apply climate risk management processes.

See

Appendix A for a CCORAL output for climate change risk management.

1.7.2. Sediment Transfer

Additional environmental issues for Canaries include drinking water storage, flooding, and erosion. During a 2010 hurricane (Tomas) St. Lucia sustained an estimated $336.15 million USD worth of damage (Pasch & Kimberlain, 2011).

Heavy rains contributed to flooding and landslides, causing large amounts of damage. Canaries was hit particularly hard by hurricane Tomas. Extensive flooding deposited large amounts of sand and silt into the riverbed (8-10 ft), as well as in the northern valley community. The riverbed is now at an equal height as many of the streets, causing frequent flooding during sustained rainfall events of 3-4 hours or more. Yearly efforts are made to move some of the sand to the side of the river, forming an embankment shown in *Figure 4 (a)*. These embankments are at risk to erode during rainfall events and at the time of the site visit they had been deposited back onto the riverbed or mouth of the river. As can be seen in *Figure 4 (b),* once the sediment re-erodes into the river, there is no longer a defined riverbed, which contributes to increased flooding events.

Figure 4: (a) Sediment bank on the Canaries River formed when sediment was removed from the river with a backhoe, 2013. View is form the river mouth. (b) Sediment deposited into the river, 2015. View is from the river towards the river mouth.

Drinking water infrastructure and supply was also affected by hurricane Tomas. Sediment has deposited into the upriver dam used to collect drinking water, now leaving it with significantly reduced retention time. During high rain events, drinking water collection is stopped due to the amount of sediment in the water. This leaves the community with an insufficient amount of drinking water and on occasion requires the local community to get their drinking water directly from the river.

2. Methodology

2.1. Project Objectives

The objectives of this study are:

- <u>Review wastewater infrastructure and management practices in the village of Canaries.</u>
- <u>Suggest low-complexity, short-term and long-term solutions for reducing wastewater contamination in the village of Canaries.</u>

2.2. Assessment of Current Wastewater Issues in Canaries

Historical approaches to successful and unsuccessful wastewater management in St. Lucia were reviewed. Local contacts in St. Lucia described what type of issues are present and in what areas they are persistent. Site visits to Canaries were performed by IWT VP of Engineering Jack Ambler, and EIT Mike Deighan from November 15-22, 2015 to observe the current situation. Meetings were conducted with stakeholders, local residents and community leaders.

Site visits included locating, sizing, estimating flowrates and concentrations of existing wastewater, and wastewater infrastructure. This was performed by taking measurements of local septic/holding tanks and using population size and density to estimate flowrates and wastewater concentrations. Information such as pumping frequency was gathered from the local residents.

The purpose of this assessment was to understand the wastewater issues in Canaries and record steps that have been previously taken to solve these issues. The local environment was considered when assessing effective and practical solutions for the area. This review summarized previous work performed in the area, as well as current issues from which management and technology options were evaluated.

2.3. Assessment of Wastewater Management and Technology Options

This section describes potential options for wastewater management approaches and identifies potential technology solutions. The options were developed based on the first part of the study described above. Several high level options are discussed including short-term and long-term wastewater management solutions. The output is a recommendation on the approach to wastewater management in Canaries.

2.4. Recommendations

This section recommends the preferred approach to wastewater management and associated technologies. Short-term and long-terms goals (or implementation pathways) are outlined along with a high level cost breakdown. All monetary values ($) in this report are reported in United States Dollars.

The energy costs in the recommendations section use local electricity costing rates. St. Lucia is close to the equator and as such is a prime candidate for solar power, as it alleviates operational costs by an increased capital cost. This setup works nicely for communities relying on external funding sources for upgrades. Typical payback periods for solar panels in the Caribbean region are between 4-10 years, including assembly/install. For the purpose of this set of recommendations, a payback period of 7 years was chosen.

3. Review of Existing Wastewater Infrastructure and Management Practices

3.1. Local Assessment and Inspection

Listed below were participants available to meet and discuss the study with Dr. Patrick Kiely, Mr. Jack Ambler, P. Eng and Mr. Michael Deighan, EIT:

- James Crockett (Community Consultant - CCIF)
- Marcus Antoine (CCIF)
- Marguerite Edward (Canaries resident)
- Kevan St Omer (local guide) (Canaries resident)
- Ali Anthony (WASCO)
- John Chester Joseph (World Water and Wastewater Solutions)
- Valerie Jenkinson (World Water and Wastewater Solutions)
- Chris Corbin (UNEP)
- Sylvester Clauzel (Ministry of Sustainable Development, Energy, Science and Technology)
- Noorani M. Azeez (St. Lucia Hotel and Tourism Association)
- Keith Nichols (Caribbean Community Climate Change Centre)

Through on the ground inspection, all public sites containing holding tanks or septic tanks in the lower Canaries are were identified. The location, estimated size, and estimated usage (if available) were noted. Local representatives were able to provide valuable information as to the type of issues they are experiencing.

3.2. Sources of Pollution

Several sources of pollution contribute to the poor water quality in Canaries Bay, of which wastewater is a major contributor and the main focus of this report. Consideration of other types of pollution are noted but outside the scope of this report. Wastewater is being discharged straight into the bay through open defecation on the beach and wastewater effluent being discharged to storm drains. The storm drains are open gutters located beside roadways which discharge both straight to the river and bay (*Figure 5*). Open defecation is mainly concentrated in a certain area near the mouth of the river

Figure 6*).* Other sources of pollution include greywater and organic waste discharged to storm drains, phosphate detergents from washing laundry and cutlery, bathing in the river, and up-stream sedimentation from the river. Houses located above the ravine have either septic tanks with soakaways or directly drain into the ravine. The ravine is also used to dispose of garbage and drains directly to the bay *(Figure 15)* despite regular trash collection being available. These types of disposal can lead to water borne illness in the community from fecal bacteria.

There is not a significant amount of pollution from livestock or agriculture affecting the bay, although any agricultural farming will contribute soil erosion and sediments discharged to the bay.

3.3. Existing Infrastructure

3.3.1 Stormwater

The majority of the streets in the Canaries have a stormwater drain on either one or both sides of the street (*see Figure 5*). These rectangular drains are approximately 1.5’ deep and 1’ wide. These systems collect stormwater and directly discharge it into the river or ocean. The village of Canaries, like many in St. Lucia (e.g. Soufriere, Anse la Raye), sits in a steep sided valley. The village is located alongside the Canaries River bed. Specific environmental and geographic features result in Canaries being especially susceptible to flooding. Hurricane Tomas in 2010 greatly redistributed sediment from upstream and deposited it downstream, filling the river bed with up to 10-12’ of sediment. IWT personnel investigated a region up to 1.75 miles upstream (inspecting the water treatment facility 1.2 miles upstream and an additional 0.5 miles up from there to the dam) and found the sediment conditions to persist the entire way.

Figure 5: Stormwater, greywater and wastewater draining to river (a) and ocean (b) via street stormwater drains

This sedimentation has caused a number of ecological and societal impacts in Canaries. The most important as it relates to this study is the fact the deep river bed running past the village of Canaries has filled with sediment, to approximately the same grade as the village road network. During high flow events the water treatment facility must shut down as there is no storage capacity in the dam and the water running through the river is too heavy in sediment to process. Since 2010, 3-4 hours of rain causes the community to flood from the low point (shown in *Figure 6,* near #1 on map to approximately 75% of the way to the new church, #7). This can happen as often as every 2 weeks. While this causes high levels of discomfort and property damage for the locals, it also further exacerbates the potential health implications of a poorly developed wastewater treatment infrastructure with elevated opportunity for water borne fecal borne illness in the community (St. Omer, 2015).

As such, the implications of inadequate stormwater infrastructure will be referenced as a key hurdle to the development of wastewater solutions.

3.3.2 Wastewater

Collection:

There is no wastewater piping infrastructure in Canaries. Collection is done using one of five methods:

1. Houses not located in the northern valley region typically have septic tanks with soakaways for final disposal into the groundwater.
2. Houses located above the ravine in the northern hillside area have either septic tanks with soakaways or directly drain into the ravine.
3. Public washrooms in the northern valley area serve as a location for locals to use the bathroom and shower. However, as noted later, these facilities need to be pumped often and quickly fill to their capacity.
4. The stormwater drainage systems are used as the de-facto wastewater draining system. Some of the existing wastewater holding tanks or septic tanks directly overflow into this system, most houses discharge (grey water, food waste, etc.) directly into this system.
5. Open defecation on the beach/riverfront.

Estimated Wastewater Production and Wastewater Holding:

Wastewater production was estimated by counting the number of house structures. IWT counted ~315 houses, of which 15% were assumed to be abandoned or for commercial use. Using the 2010 census data of 2.6 people per house this equates to just under 700 people. With average BOD (80 g/capita-day) and TSS (90 g/capita-day) production per day and a flowrate estimated at ~95 liters/capita-day, this resulted in a wastewater flowrate of 66,000 liters per day, with a wastewater strength of 850 mg/L BOD, 950 mg/L TSS, considered high strength municipal wastewater.

Canaries wastewater infrastructure consists of three separate public washrooms, all located within Lower Canaries *(Figure 6*). These facilities consist of toilets, showers, and sinks.

Table 2: List of public holding/septic tanks in Canaries and estimated volume

	Estimated Volume (Liters)	Location
1st Washroom	36,000	Near shore in floodplain
2nd Washroom	15,000	Next to infant school
3rd Washroom	15,000	Up hill, near Floravilla
Secondary School Tank	16,000	Secondary School
Primary School Tank	16,000	Primary School
Old Church	4,900	Old Church
Health Center Tank 1	7,500	Health Center #1
Health Center Tank 2	7,500	Health Center #2
New Church	4,900	New Church
Total Public Use Tankage	66,000	
Estimated Max Available Tankage	123,000	

Figure 6: Overhead map of Canaries, St. Lucia showing the locations of major holding tanks and public washrooms

Figure 7: Washroom #1 is on the oceanfront and is commonly flooded

Figure 8: Washroom #2 is on the outskirts of the commonly flooded area

Figure 9: The primary school had a new septic tank installed within the last 2 years. It was not pumped before the tank and has not been pumped since. It appears to discharge into the open gutters.

Figure 10: Washroom #3 is on higher ground and not in danger of flooding

Figure 11: The old church is located with in the common flood area. It has no visible riser and has never been pumped before. The effluent appears to discharge into the open gutters.

Figure 12: The secondary school is pumped every 2-3 years and has a soak-away which was not visible. Previously held 200 students, but now has 93.

Figure 13: The wellness center has two tanks; one we were unable able to locate. Effluent is believed to discharge to the soakaways on site or to the gutters.

Figure 14: The new church was assumed to have the same tank size as the old church, as we were not able to get access

Figure 15: (a) The ravine is an area where garbage is dumped and eventually moves downstream and (b) makes its way to Canaries Bay

3.3.3 Description of Existing Wastewater Holding/Septic tanks

Public Washrooms:

Washroom 1:

- Located on the beachfront
- 4 men's toilets
- 4 men's showers

- 2 sinks
- Soakaway present, but not functioning

Washroom 2:
- 2 men's toilets
- 2 women's toilets
- 2 sinks

Washroom 3:
- 2 toilets
- 1 sink
- Appears to discharge to stormwater drains

The washrooms have a low capacity for the population and are pumped infrequently. After the tanks are pumped, the washrooms are used by a large percentage of the population. As they become filled, residents resort back to using the beach area. The tanks are not pumped frequently enough, this causes the tanks to be at capacity for a large percentage of the time, leading residents to utilize other means. During rain events, the effluent from Washroom 1 was said to overflow and drain to the ocean.

Pumped septage is said to be hauled up north to Beausejour where it is buried and capped. This is an expensive process and was reported to cost $1,110.00 per hauling event.

Figure 16: Overhead map showing the washrooms (red square), and the estimated usage based on house location/proximity.

Commercial Washroom:
Commercial buildings have holding tanks, some of which drain directly to open gutters running through the village. Observed locations include, but may not be limited to:

Secondary school:
- 4-5 bathrooms,
- Unable to locate soakaway
- Pumped every 2-3 years
- 93 kids attending

Primary School:
- Bathrooms
- Overflows straight to drain
- Tank has never been pumped

Health Center:
- Possibly two tanks and 2 soakaways
- Accessible diversion pipes, possible leading to open drain

Old (Renovated) Church:
- Low usage bathrooms
- Tank covered by tiles
- Discharged to open drain

New Church:
- Wasn't able to observe
- Advised by local representative that there are bathrooms and holding tank present in the church

3.4. Important Local Considerations

Cost:
The capital cost of implementing wastewater infrastructure in the Canaries typically relies upon grants and third party funding. This requires cost effective solutions and may need to be implemented as a multi-phased project. More suitable technologies may have too high of a cost or lack of appropriate funding. Maintaining infrastructure will have an on-going cost in order to continue proper treatment.

Lack of Local Expertise:
The local population does not have the training to maintain a treatment facility. WASCO believes it is too expensive for them to run any wastewater infrastructure day to day at this location. A possible solution is to train a local resident to maintain all wastewater related infrastructure and have WASCO periodically evaluate performance and oversee maintenance.

Condensed Population and Infrastructure:
Canaries is located within a steep sided valley where most of the population is clustered. There is no available land within the northern valley which can be used for adding a treatment facility. This means

that a basic collection system will require a pumping station unless some land can be purchased. Additionally, the northern valley has the housing/roads/stormwater trenches very tightly spaced. Room to improve infrastructure is limited and will increase the cost of construction efforts.

Energy Costs:
Residents in St. Lucia pay 0.34 $/kWh for power. Alternative sources of energy (solar powered solutions) will be considered to power or subsidize any energy costs. Low cost and low complexity technologies are also considered. Solar powered wastewater infrastructure holds certain enabling capabilities with increased up-front CapEx allowing for reduced operational costs of the system. This capability may be particularly suited to developing countries where funding exists for up-front capital cost, but limited resources are available for sustained O&M of facilities.

Standard of Living:
Most households within the valley do not have flushing toilets. There are no sewage lines installed in the community. Technologies utilized must be appropriate for the community, while increasing the standard of living and help to achieve their living needs.

Flooding / Natural Disasters:
Flooding is a major issue in Canaries. Hurricane Tomas (2010) has changed the river bed which is now nearly level with many streets within the village. Part of the village regularly floods due to sustained rainfall events as short as 3-4hrs. This poses a risk to infrastructure within the flood zone.

3.5. Summary

The review of the wastewater infrastructure and management practices in the village of Canaries has identified the pathways for contamination of the river and bay. The impact of contaminated water in the river and bay has been identified as a significant public health risk to the local community, as well as an ecological issue for the bay. Of particular concern are the community residents in the northern valley region where a combination of regular flooding and open defecation or direct discharge of untreated wastewater could result in illness due to fecal borne contamination.

4. Outline Potential Solutions

The village of Canaries has a number of infrastructure issues that will need to be addressed in order to create a complete solution, to an appropriate standard. The order of installations is important as stormwater issues have a tendency to affect all other infrastructure. This section is setup to present short-term (immediate) solutions, including proper diligence, low-cost and easily implemented improvements, which are less reliant on a complete infrastructure and will incrementally assist with a more complete solution. The short-term goals, given the proper funding, could be achieved in a 12-month period. These short-term goals are followed by long-term solutions that take a more complete view, and focus on providing a long-term robust wastewater infrastructure. The longer term solutions could be implemented in a 1-5 year time period.

4.1. Short-Term Solutions

4.1.1 Public Health Considerations, Increased Water Testing and Monitoring.

Public Health Awareness and Community Outreach:

The potential negative impacts relating to public health of the Canaries community due to the combination of frequent flooding, open defecation and untreated wastewater discharged to open storm drainage should be considered a top priority of local residents and at a national level through the Ministry of Health. We suggest immediate priority should be placed on educating the local community on the potential negative impacts of fecal borne illness that can be caused from the combined flood events and discharged fecal matter. A more detailed public health risk analysis should be carried out, and cases of recorded illness should be correlated with high flood events, and compared with similar communities which have a more complete wastewater infrastructure.

Consistent Water Quality Testing/Monitoring:

IWT would suggest that water quality testing of the Canaries Bay and Canaries River be performed. Getting an accurate reading of the containment levels would be a critical tool in helping determine the current levels of pollution, and the relative contribution of pollution being brought in from the river (and associated upstream activities). Complete and regular testing cycles for both the river and bay would be recommended.

Canaries River Testing:

The River would only need to be tested under certain circumstances to develop an accurate baseline, with additional sampling required if upstream activities are known to be changing. Testing would be recommended to be done at least once per month during regular flows, for a year, to determine typical concentrations of key pollutants. IWT would also suggest taking another 6 samples during high rain events during the same year, to determine pollutant loading during storm events (increased sediment loading and runoff from human activities could be significant during these events). During our site visit, the local community confirmed to us that during high rain events, their water treatment facility cannot be used. This is due to the fact that they are drawing water directly from the river (the dam that was used to collect water was filled with sediment during Hurricane Tomas in 2010) and during these storm events the water is too filled with sediment to filter properly at the existing facility. During high rain events the local population will use the river water directly for their activities and understanding what the contaminant loadings during these events could further help understand the risk to public health.

Canaries Bay Testing:

Canaries Bay is a focus of the community and used by fishermen and local residents. In the past, the bay used to contain coral reefs, vibrant fishing and swimming / beach use activities. Due to the poor quality of the water, the bay usage is now limited. There are recommended and suggested water quality levels for specific activities. An indefinite monthly testing schedule for the bay would be recommended for now to get a good understanding of the typical levels of contamination. This would allow decision makers to understand the level of contamination, and understand the approximate reduction requirement of pollutant inputs for the bay. This would be required to reach an appropriate water quality standard that could result in coral reef growth, safe harvesting of fish, and safe swimming. As contamination levels dropped to the point that the Canaries Bay was safe to be used for these activities (assumed to then also have an increased tourist activities), continued testing would be needed to be assessed at that time to regularly confirm safety.

Recommendation:
IWT recommends that water quality testing begin immediately. The focus should be on understanding the pollutant load being transported to the bay by the Canaries River and understanding the current and continued water quality standards of the bay to understand its safe usage. This sampling can be performed by local trained personnel.

4.1.2 Existing Infrastructure Auditing and Validation

Existing Holding Tank Testing, Modifications and Verification:
IWT team members visited all of the known wastewater holding tanks (with available access) in Canaries. Those that were located were estimated in size, although the condition of the tanks requires further investigation. IWT would like to confirm size, pumping frequency, duration of capacity, liquid discharge, install year and tank integrity of each, to assess how these units are functioning. This assessment could be done by local representatives and recorded over time. During our inspection of infrastructure, the local population was extremely helpful in understanding the holding tank systems. Many people are living or working out of their homes, have been long-term residents, and have witnessed the installation, maintenance and are aware of associated problems. Getting to understand these parameters would help assist decision makers in knowing the state of the current wastewater collection/processing system. With further knowledge of the current system, it allows decision makers to make more accurate estimates of performance and potential viability as part of a future solution. Integration of existing technology into a more complete solution can be a valuable way of saving capital costs.

Size/Year of Install:
Local documentation may exist, or locals may know the actual size. Depth can be tested through the access hatches used to pump. Outside physical dimensions are sometimes obvious. Additionally, working with the trucks used to pump and haul the waste could help produce proper estimations.

Pumping Frequency / Time to Fill:
This is an important metric for the continued access of the locals to sanitation. This is certainly a metric which should be recorded and tabulated, of which IWT believes it is, but informally and not reported. From conversations with locals during IWT's site visit, pumping frequency is addressed during the monthly council meetings. Most tanks need pumping at least every month and the funds are not always readily available to do so. As such, the holding tanks can only be used for a period of time before they are closed due to lack of available storage. This leaves locals going to other locations, or directly onto the beach. Getting a more accurate reading on this would also help show the total quantity of wastewater being produced in the region, as well as a better understanding of the relative use of each (concentrations of the population attempting to use each). This information can also be used indirectly to help understand the liquid removal and/or the tank integrity. This kind of information should also be recorded for budgetary information for the village to have and allot money for (either local money or requesting of external funds), to properly remove the wastewater from the village in a timely manner. Getting proper estimates of the usage will greatly assist in implementation of ALL types of treatment options. Knowing the quantity of the wastewater, and population usage of each will allow a properly designed system for the minimal cost and not risk overloading proposed systems, decreasing or stopping treatment.

Liquid Discharge:

The holding tanks like those in Canaries are designed to collect sewage, provide a degree of settling of solids and floatation of FOG, with the liquid layer discharging out of the tank. This discharge was handled in a few different ways in Canaries. The liquid was either discharged to a functional soakaway, to the village's street drainage ditches, not discharged, or had an unknown discharge point. Through the use of liquid testing and dye tracing, effluent from these tanks can be quickly traced and followed, this is a simple test which is typically done in a few hours. This would also serve as a way to test the functionality of the soakaways, as some of the soakaways were said to not be working at this time.

Leak Detection:

Leaking tanks could be providing contamination to the ground water, a more direct path into the ocean and/or other seepage issues which could also cause damage to local buildings. Older tanks, improperly installed tanks and tanks closer to the ocean (depending on the tank material, the salt water can corrode the tank material) are prone to leak. Leak detection tests could be run on the tanks. It does require 24-48 hours of no usage and monitoring of the tank levels. This is easier to perform if the tank has been more recently pumped (though it should be closer to full).

Recommendation:

IWT recommends that a complete audit of the existing wastewater infrastructure be performed. The intent of this would be to figure out the current state of the infrastructure, understand the flow pattern of the wastewater, and most importantly, create a logging system that can translate to an appropriate estimation of usage/flowrate which can be subsequently used by decision makers to appropriately size and estimate the cost of new solutions going forward. The testing and modifications would need to be performed by personnel working in the wastewater industry. The proper pumping schedule can be appropriately handled by the village council.

4.1.3 Existing Infrastructure Preliminary Upgrades and Retrofit Considerations

Reduced Flow Devices and Appliances:

A significant issue with the current infrastructure is the excess liquid waste generated because, as discussed above, a significant portion of liquid waste is being discharged to unsafe locations such as the village's street drainage ditches, and potentially filling up a holding tank that may still have a solids capacity (when proper discharge is not available). The fixtures (sink, toilet, shower) in the public restrooms were regular fittings and not the reduced flow fittings. Reduced flow fittings are considered the standard in Europe and in many arid regions. Devices and appliances to be considered would be faucet aerators, flow-limiting showerheads, low-flush toilets, pressure reducing valves and toilet leak detectors to start. These type of fixtures can provide between 20-50% reduction in flow, which would help extend the capacity of the storage tanks.

Extended Availability:

The public bathroom facilities are open approximately between 8 am and 10 pm daily. The washrooms were in excellent condition and attended to by cleaning/operational personnel. While requiring showers to be done during this time is a reasonable request, access to the washroom facilities really needs to be 24 hours a day, so that the local population does not have to resort to using other locations (such as the beach or river) to accommodate this basic human need during the evening hours. Proper security concerns will need to be addressed.

Proper Operation and Maintenance of Existing Wastewater Tanks:
This solution requires no additional capital costs for Canaries is pumping and hauling the wastewater on a strict schedule. Allotting the appropriate money, and having the appropriate channels in place to schedule and proceed with hauling events would greatly reduce the issues associated with direct discharge of wastewater. However, as noted above, many of these tanks are discharging their liquid effluent directly to the stormwater ditches, while this water is removed of major solids, it still contains 30-60% of the original pollution. Drawbacks to pumping and hauling include: it is unknown where the trucks are hauling the wastewater to; and hauling of the liquid portion of wastewater (as opposed to only the solids portion) can represent a large operational cost. However, despite these drawbacks, this is the only way to manage the current wastewater situation with the existing infrastructure. At this stage IWT is suggesting an additional 3 hauling cycles per month be incorporated.

Activating the Holding Tanks to Provide In-tank Treatment:
Currently the holding tanks provide minimal primary treatment, and primarily serve as a wastewater holding tank as opposed to a wastewater processing tank. Holding tanks can provide some solids settling (if there is appropriate hydraulic retention time), FOG removal (if the effluent is taken from the right height in the vertical, so that the effluent is taken from below the floating scum layer) and minimal anaerobic organic removal. Anaerobic organic removal comes when there is a sufficient mass of anaerobic biology accumulated in the tank, and they can begin to remove some of the organic compounds (BOD/COD). Anaerobic reactions are hindered by the reaction rate, which is slow due to the poor reaction kinetics of the available electron acceptors under anaerobic conditions. Providing oxygen to a system like this, even minimal amounts, can greatly increase the rate that organics are removed from a system.

Commercial fixed film wastewater aeration technologies can be added to existing tankage to improve system performance. Drop-in, retrofit fixed film solutions are available that could be easily integrated with existing infrastructure. Drop-in, fixed film systems are used as a retrofit to a single home's septic/holding tank and they can remove 0.18 kg BOD/day and 0.19 kg TSS/day and produce effluent at <30 mg/L BOD and <30 mg/L TSS (meeting the LBS protocol). For this application, IWT would suggest building custom drop-in, fixed film packages for each tank. Choosing the three public washrooms, the two school bathrooms, and the old church bathroom as easy to access tanks owned by the public, custom packages could be installed and offer 8.1 kg/day removal of BOD and ~8.6 kg/day of TSS removed. This is approximately 14-15% of the total load estimated by IWT to be heading into the bay by the northern valley region. This would require 200 W of aeration energy at each of these locations, which IWT would propose be provided by solar panels. While solar panels would not provide 24-hour aeration, they would provide aeration during the peak hours of usage. This solution would be contingent on the holding tanks being properly operated and maintained, so as to keep a reasonable amount of solids in the tanks.

While not included in the scope of this project, additional retrofit fixed film aeration units could be added to the homes in the southern valley, northern hillside and southern hillside to further reduce the load of wastewater going to the bay. Drop-in fixed film solutions can offer a reduction of > 85% BOD/ TSS contaminants from the effluent when used with a single family home.

Recommendation:
IWT recommends that the bathroom facilities hours be extended to 24-hour availability to help promote an environment to properly dispose of wastewater. Once the existing infrastructure, auditing and validation has been completed, it will be able to be determined if reduced flow fixtures and appliances

will be able to assist in a more complete situation. This analysis will also determine the viability of adding drop-in treatment solutions to the tanks. As part of the lowest cost option, properly operating and maintaining the existing wastewater tanks is the one of the few ways to greatly reduce the contaminant load into the bay. While the operational costs may be high, the washroom facilities must be able to stay open and be pumped regularly to avoid this direct contamination. Additionally, alternative hauling companies should be investigated to try and see if a cheaper hauling company could be contracted for this work.

4.2. Long-term solutions

4.2.1 Stormwater Management:

A major hurdle to providing wastewater infrastructure to the village of Canaries is proper stormwater management. Stormwater management further upstream for the water treatment plant water intake system prevents access to clean drinking water during storm events. As previously discussed, the river bed is filled with earth up to approximately the same grade as the northern valley, leading to regular flooding. While this flooding already causes issues, during more severe storm events, the floodplain will be significantly larger. This flooding frequency and intensity complicates the capabilities of a wastewater solution to be implemented as any wastewater equipment (pumps, blowers, disinfection units, electrical boxes, etc.) would have to be located in areas not impacted by floodwater. Wastewater tankage if submerged and will mix its wastewater contents with the stormwater, which can escape the tank enclosure and cause health hazardous flood waters and fecal contamination. High salinity flood water could result in additional implications and can cause additional damage.

Dredging of the riverbed is carried out on an annual basis, however the sediment is not removed from the site and quickly erodes back into the riverbed. The riverbed is full of sediment extending up the river basin. Regular sediment removal from the riverbed near Canaries (and transfer to a different location), will only solve issues on a short-term basis, as up-stream sediment can transport downstream and enter the village river bed area during even moderate storm events. Removal of this dredged material from the side banks by trucking it off site would help Canaries determine if the riverbed still fills up from upstream sediment under normal circumstances, or if a larger storm event would be required to add more sediment to the river area.

A retaining wall which kept the water from entering the village, is now mostly buried by sediment. Building a new wall/berm or expanding upon the original (assuming it was found to be in proper condition) could be considered as options for handling the storm events and preventing flooding. These structures can be made of many materials from concrete to compacted clay, but are highly designed structures which need to be put into place correctly, preventing seepage as well as be designed appropriately for the event of the flood level exceeding the design level of the structure. Improper design could lead to catastrophic failure of these types of walls, which would increase the total damage done to a region during a storm event as the water arrives in the village over a much shorter period then it would have during the storm event.

Recommendation:

IWT would recommend at this stage to have an independent survey and stormwater evaluation run to properly determine what other options could be possible and to properly determine the project cost and timeline.

4.2.2 Above Tank Decentralized, Packaged Treatment for Washroom Facilities:

While the space in the washroom facilities is limited, there is an area at each washroom facility which is currently "open". Washroom #1 has room directly on top of the tank, Washroom #2 has a small unused wooded area directly adjacent to the facilities and Washroom #3 also has room directly on top of the tank. This would allow for a small sized mobile type treatment plant to be placed at each location. This unit could pump from the holding tank, to the processing unit, and then gravity drain back to the tank or to a piped wastewater network. This would provide a reduction of the pollution. Since there would be three of these, they would need to be low tech, low energy, secure and as self-sustainable as possible. Proper tests and evaluation of the structural capacity for locating these would be required, and likely additional concrete would be required to add to each area to provide a stable bed and to not collapse the existing holding tanks. Each location would require the right footprint for the equivalent of a 20' cargo container. This solution would reduce the pollutant load to the environment in a range of 22-43%, with an energy cost of ~ 0.6 - 4.8 kW.

Recommendation:

IWT would recommend a request for proposal is submitted to environmental engineering consultants and technology companies to identify groups that could deliver packaged solutions that are suitable for this application. Typical companies that might offer these type of solutions are Bionest, BMS Blivet, Ecologix, Norweco, Island Water Technologies, Orenco and others.

4.2.3 Connection of the Holding Tanks to Form Centralized Wastewater Collection Network:

A significant issue with implementing any type of treatment is the collection of the wastewater itself. Due to the slope of the village, the majority of the stormwater and wastewater collect in the street drains and flows down near Washroom #1 (as shown in *Figure 6*), where it then spills out into the river and ocean. This natural sloping leads to an obvious collection point. For a centralized solution, a primitive collection network could be achieved by piping the main 3 public holding tanks together, as shown in (*Figure 17*). Final elevations would need to be checked, and connection to other holding tanks could be added as treatment capacity increased. This would entail ~1,500 feet of pipe.

Once the wastewater is collected, IWT was originally thinking that the construction of a wastewater facility in the village area would work. By IWT estimates there are nearly 700 people which wastewater infrastructure would need to serve. This is a considerable amount and there would be insufficient space available to construct a plant of this size in a one-house allotment. When discussing the potential purchase of such a property it was brought to IWT's attention that most houses are owned by multiple family members, often with some of the owners living overseas, so such transactions would be difficult. Also, to build a plant in this area would not be in a discrete location. If this community is to get to a point where tourists are using the bay and beach area, it would probably be better to not have the wastewater within sight and smell of this area.

Figure 17: Example of potential collection system

IWT would suggest that a pumping station be installed in this area. While this will include additional operation and maintenance costs, it would allow for the wastewater to be pumped to a more appropriate area with enough footprint to provide treatment. This also represents the sort of bare minimum amount of piping required to be laid, maximizing existing infrastructure and keeping a similar setup, so that the local population doesn't need much of a change of their typical day to day activities. It could also be done by using each existing tank as an individual pumping station, but from the sheer operations, maintenance, and security of the task one pumping station would be suggested. Though if the project was planned to be done in multiple segments, the pumping stations could be installed independently of each other.

Recommendation:
As part of any non-point of use treatment, a collection system will need to be constructed. Use of these facilities to help implement this type of solution could help reduce the costs for a more complete long term system. This type of work should either be sourced by a trusted contractor or by public bid to engineering firms operating in the area.

4.2.4 Review of Potential Centralized Wastewater Treatment Solutions

Lagoon:
Lagoons are often used when it comes to looking for a low tech solution for remote communities. As discussed previously, Gros Islet has lagoons for treatment of wastewater in the northern part of St. Lucia. There are several types of lagoons, facultative, aerobic flow through, aerobic with solids recycling and anaerobic. Anaerobic lagoons are not included in this discussion as they are typically used for industrial

wastewaters. Aerobic lagoons with solid recycling are also not considered for this application due to their higher level of technology and requirements, which make them more similar to packaged treatment units from a complexity standpoint. Depth to groundwater will need to be evaluated and taking into consideration when planning these. While these can be installed above grade, typically the cost to bring external material makes that not possible. These systems can consist of one cell, or multiple cells (typically up to 3) to provide complete treatment.

Facultative Lagoons:
Facultative lagoons are typically 1.2-2.4m deep and are not mechanically mixed or aerated. Oxygen is transferred into the lagoon at the surface through atmospheric reaeration and algal photosynthesis, which creates a facultative solution. Solids settle to the bottom of the lagoon and anaerobic conditions/degradation persist there. This treatment system relies on oxygen being delivered by passive aeration, and the resultant algae growth in the lagoon (algae photosynthesis produces oxygen for uptake by microbes). While these systems are widely used worldwide, their effluent discharge can be variable due to the large amounts of algae grown. While BOD <30 mg/L is possible, the effluent TSS levels range from 30-100 mg/L. A typical facultative lagoon can handle between 15-80 kg BOD/ha-day, even if the higher loading rate assumed for this case and a 2:1 length:width ratio, this results in a 60m x 120m sizing. The advantages to these systems as the only input energy into the process is done by pumping to the system. The system would also have very limited maintenance requirements, however, the sizing of it appears to be too large for this application.

Aerobic Lagoons:
Aerobic lagoons operate under similar parameters to facultative but use mechanical systems to provide aeration (such as surface mixers and submerged diffusers). Enough aeration and mixing would be required to bring this to completely mixed. Typical depths are between 1.8-6m with 3m being typical. Aeration energy requirements can be significant for the operation of one of these systems. Using the complete Canaries community of ~700 people, results in a considerably smaller footprint system, ~17m by 35m. Large but potentially possible to fit. Effluent requirements would again be BOD <30 mg/L, with TSS slightly improved compared to facultative, typically ranging from 20-60 mg/L. Aeration/mixing requirements would be roughly ~7-10 kW.

Wetlands:
Vegetated wetlands, with surface or sub-surface flow are also a technology which can be utilized in remote areas, especially those with the warm climates such as St. Lucia. The main varieties available are subsurface flow, vertical and free water surface flow. However, these systems require low influent wastewater concentrations (recommended <170 mg/L BOD, <150 mg/L TSS). In order to achieve this with the higher strength municipal wastewater in Canaries it would require up to an 8 times recycle flowrate, adding an additional operation and maintenance cost to the system. Energy requirements for the recirculation will add an additional 2 kW to the energy requirements. Effluent results of <30 mg/L BOD/TSS are achievable. During the trip to the Canaries, IWT visited one of the subsurface flow wetlands operating at a nearby several dozen villa resort, which was operating efficiently. The effluent was of a good quality (exceeding the LBS requirements), however there was significant maintenance costs associated with the unit, which was experiencing clogging issues and needed to be hand excavated in order to not jeopardize the quality of the liner. A system designed to treat the Canaries population would be need to be ~24 meters wide by 72 meters long.

Extended Aeration Plant:

Packaged treatment units are used on St. Lucia with success. The level of treatment plant considered at this stage, due to the high maintenance and operation costs of packaged plants, is limited to extended aeration plants. Extended aeration systems are complete mechanical plants. They are often considered the simplest version of advanced wastewater treatment plants. They can be constructed above or below grade depending on site constraints. This system is the most complex system suggested in this space and would require significant operation and maintenance. A trained operator is typically required to be on site 2-3 hours per day. Energy costs are also considerably higher than the other systems looked into for this report, likely 14-17 kW to treat the Canaries wastewater. The system requires expensive diffused aeration and recycling of the sludge to maintain reactor MLSS concentrations. While the sludge yield compared to alternative advanced wastewater treatment plants is low, it is still significant. These systems require more often pumping and hauling of their sludge then the lagoon systems. However, due to their higher treatment capacity, a smaller footprint can be expected, at ~10 x 20m for a system sized to treat Canaries wastewater.

Table 3: Centralized Treatment Options Estimated Sizes and Requirements

Centralized Treatment Options				
Parameters	Facultative Lagoon	Aerated Lagoon	Wetlands	Packaged Treatment Unit
Width (m) x Length (m)	80 x 120	17 x 35	24 x 72	10 x 20
Energy (kW)	0	7-10	2	14-17
Complexity / maintenance	minimum	Low	medium	high (2-3 hours/day)
Sludge management requirement	minimum	minimum	medium	high
Capital costs	high	low	medium	medium
Requires upfront EQ/solids handling	no	no	yes	yes

Recommendation:

Should a complete treatment system be constructed, IWT would recommend at this stage to construct aerated lagoons. This system is still easy to operate, with a smaller energy cost than that of the packaged treatment unit. The solids management of a system like this is also easy. The footprint is large but much more manageable then the facultative lagoon or wetlands. The best way to achieve this would be to put this project out for bid, with the known land available and site constraints, to engineering firms operating in the area. During that bid, IWT would suggest accepting bids for a multiple types of treatment facilities with a special focus on the yearly costs (energy, operation and maintenance).

4.3. Disposal

Current wastewater disposal is inadequate and due to distance from the water and sloped terrain the options for disposal are limited.

Soakaways:

Soakaways are currently used for several of the tanks in the Canaries, including some of the septic tanks in the outskirts of Canaries. Due to improper design, construction and/or high groundwater tables, many have been deemed unusable or ineffective. As such ground disposal by this method was not considered for this report.

River:

The river needs to be assessed as a possible discharge point. The normal running flow of the river is quite small and as such, the additional flow from a direct discharge by the wastewater plant would be a large percentage of the resultant flow. Effluent quality discharged to the river would need to be treated to a standard safe for direct public access as well as to not interfere with the local ecosystem. While this is technologically feasible, it would require an advanced treatment system outside the scope of this project. As such, direct river discharge was not assumed for this report.

Ocean Discharge to Bay:

This is where the majority of the current wastewater sources are discharged to. This is not ideal from an environmental sense, it has limited the health impacts on the locals to exposure to the ocean and consumption of the seafood. While not the suggested method of disposal, reducing the amount of untreated wastewater will directly result in reduced contaminant load to the bay.

Ocean Discharge Outside of Bay:

This is the best available practice for Canaries, while also being the costliest. This would allow for either untreated, partially, or treated wastewater discharging past the bay. This allows for natural ocean currents to remove residual contaminants away from the bay. This is a large undertaking, as ocean current modeling must be done to locate an acceptable discharge point. Piping must then be run safely out to this location. Castries was discharging the wastewater in a similar fashion and the pipe has since broken, greatly reducing its functionality. Full assessment of this option is outside of the scope of this project, though high level cost considerations are included.

Recommendation:

IWT recommends a full evaluation and costing analysis of the ocean discharge option.

5. Decision Matrix and Implementation Pathways

Table 4: Decision Making Matrix for Potential Wastewater Tasks & Solutions

Decision Matrix						
#	Options	Cost	Pollution Removal from Immediate Bay	Positive Effects on Human Health	Risk of Implementation	Prereqruisites
1	Water Quality Testing/Monitoring	minimum	medium	none	none	none
2	Existing Infrastructure Auditing and Upgrades	low	high	low	none	none
3	Activating Holding Tanks	low/medium	low/medium	low	minimum	2
4	Proper Operation and Maintenance of Existing Wastewater Tanks	medium	medium	medium	none	none
5	Stormwater Management Study	low	high	none	none	none
6	Stormwater Study Implementation	extreme	low	medium	low/medium	5
7	Above Tank Decentralized, Packaged Treatment	medium	medium	medium	low/medium	2
8	Connection of Holding tanks to Form Limited Collection Network	medium	low	none	low	2
9	Pumping Station Implementation	medium	low	none	low	6,8
10	Centralized Treatment Option	high/extreme	high	high	low	9
11	Discharge to River	low	low	low	high	10
12	Centralized Treatment and Discharge to Ocean	extreme	high	high	medium	10
13	Primary Treatment and Discharge to Ocean	extreme	medium	high	medium	8,9, additional solids separation capacity

Recommendations:

Depending on the available funding moving forward, IWT recommends one of the following four cost options to provide maximum health and environmental impact with the available funds. Costing below is considered preliminary at this stage, as the "Minimal Cost" option would need to be performed first to collect the appropriate data to further size and cost the following solutions.

A: Minimal Cost: #1, #2, #4

This option provides an assessment of the water quality in the river and ocean, as well as understanding exactly how the existing infrastructure is operating. It then calls for an increased pumping schedule. This assessment will help set the stage for a more complete solution, and will help structure the appropriate bid documents for requesting proposals. This option is considered the default option that should be applied. It can be used in the meantime while developing other options, and unless this option is performed it greatly limits the effectiveness of costing out other solutions. This option has added value with the fact that treatment can be added incrementally as funding is available, whereas the medium cost and high cost options do not have incremental solutions. The increased hauling amounts and the increased personnel to provide 24 hours of service significantly affect the recurring costs.

Total Estimated Cost Year 1: $100,000-150,000

Estimated Recurring Energy Cost: $0

Estimated Recurring Operation and Maintenance: $67,000-96,000

Time to Completion: 1 year

B: Low Cost: #1, #2, #3, #4 (50%) #5, #6

This option is the cheapest solution which provides a portion of treatment, but likely not complete treatment. The point of use treatment options (in tank or above tank) use existing infrastructure the most effectively. This option reduces overall loading to the bay, but does not include piping the wastewater far enough from the bay. As such, many water quality issues may linger. The in-tank options could potentially be implemented without the stormwater evaluation and implementation, though at this time it would need to be a recommendation to complete the stormwater improvements in order to protect added equipment. This option assumes that ~50% of the additional pumping schedule in the minimum cost option is included, due to the increased capacity afforded by the in-tank option. This option has added value with the fact that treatment can be added incrementally as funding is available, where as the medium cost and high cost options do not have incremental solutions.

Total Estimated Cost Year 1: $194,000-279,000 + Stormwater Improvements

Estimated Recurring Energy Cost: $2,100-3,100

Estimated Recurring Operation and Maintenance: $58,000-84,000

Time to Completion: 2-3 years

Additional capital cost to reduce 50% of energy demands by implementing solar panels: $7,000-11,000

C: Medium Cost: #1, #2, #5, #6, #8, #9, #13

This option includes the collection of wastewater and discharge to the ocean. This would match the level of treatment provided to that of Castries. While the wastewater is only settled by primary treatment, the pollutants are considered “removed” from the bay, and its impacts would no longer affect the Canaries community. This would greatly reduce the health and environmental impacts to the bay. There is some risk associated with this solution should the integrity of the discharge pipe be damaged (as happened in Castries), which would cause untreated wastewater to discharge into the bay.

Total Estimated Cost Year 1: $1,600,000-3,100,000 + Stormwater Improvements

Estimated Recurring Energy Cost: $5,000-9,700

Estimated Recurring Operation and Maintenance: $39,000-76,000

Time to Completion: 3-5 years

Additional capital cost to reduce 50% of energy demands by implementing solar panels: $17,500-34,00

D: High Cost: #1, #2, #5, #6, #8, #9, #10, #12
This option is the highest cost option, and provides complete wastewater treatment and final disposal. This would place Canaries as a leader for wastewater management moving forward on the island and achieve compliance with the LBS protocol. The reduction of pollution to the bay or ocean would be significant, and the community would not be passing their waste off to the ocean. Even if the discharge piping were to fail, there would be significantly less risk to public health releasing this quality of effluent into the bay. However, the yearly costs for this type of facility are high, and this option requires more trained personnel to operate.

Total Estimated Cost Year 1: $1,900,000-3,900,000 + Stormwater Improvements

Estimated Recurring Energy Cost: $24,000-47,000

Estimated Recurring Operation and Maintenance: $58,000-110,000

Time to Completion: 3-5 years

Additional capital cost to reduce 50% of energy demands by implementing solar panels: $84,000-164,500

These four options are detailed graphically below in *Figure 18.*

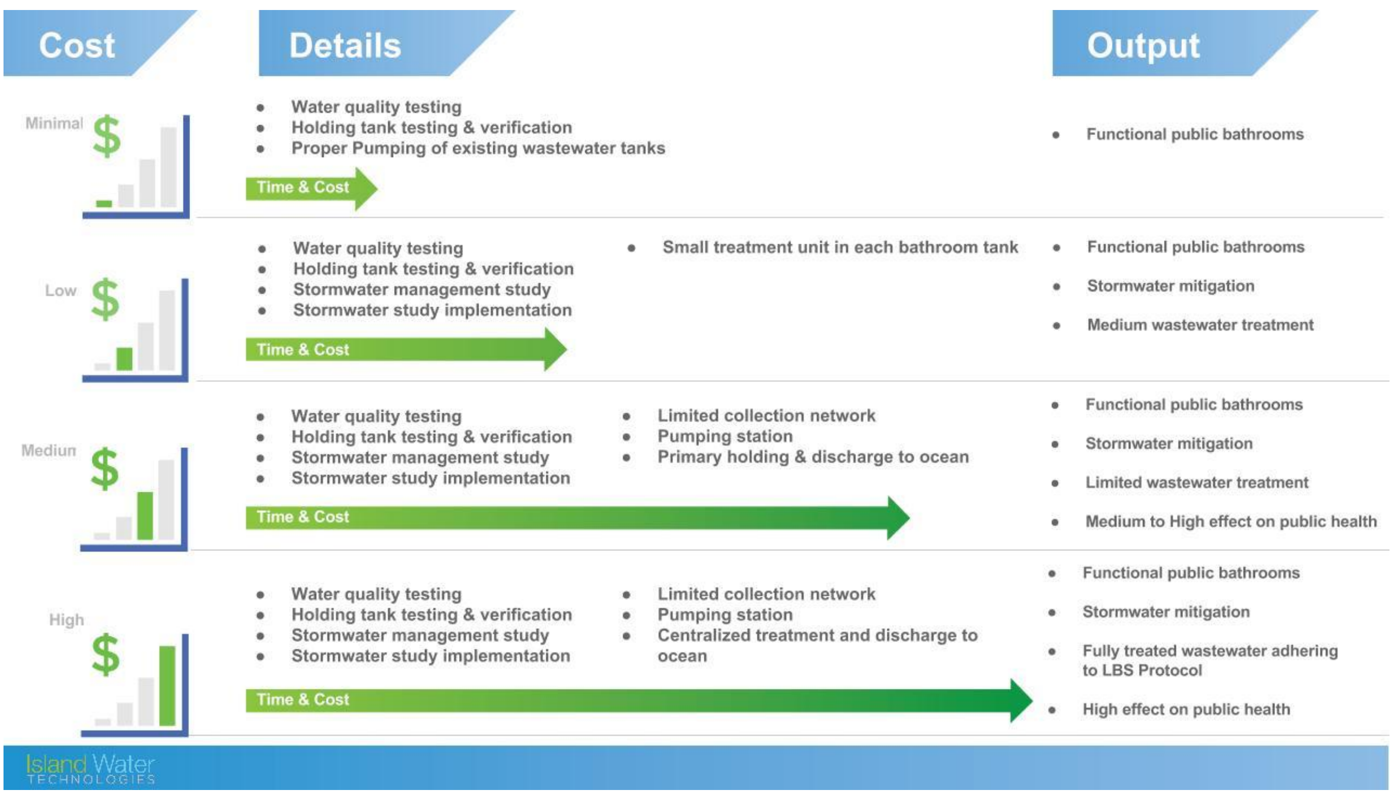

Figure 18: Go-Forward Strategy Summation

Appendix A

CCORAL Output for Climate Change Risk Management:

Aim	Process/analysis	Guiding climate question to ask yourself	Resource to help answer the question
Stage 1) IDENTIFICATION			

High level review of proposed programme/ project	Check proposal alignment with government priorities, plans, and budget. Review proposal's technical strength and logic. i.e. programme/ project justification	*What are the objectives of the proposed programme/ project?*
		
		The proposed project objectives are to assess a range of solutions that will provide:
		• The design and implementation of solutions to improve wastewater effluent from public facilities.
		• Provide effective solutions for failing holding tanks.
		• Education and Awareness with regards to sanitation and wastewater management and its effects on health and the environment.
		
		What are the indicators of its success?
		
		• The solutions presented will:
		  ○ Increase effluent water quality
		  ○ Decrease coral reef degradation
		  ○ Remediate affected areas
		  ○ Include proactive steps with regards to a changing climate
		  ○ Include the development of local skills
		  ○ Decrease open defecation
			Context tool (articulating objectives, preparing a process and establishing a baseline)

Stage 2) PREPARATION			
Lay foundation for the programme/ project	Select programme/ project manager and team, and assign responsibilities	Jack Ambler, P.E and the Island Water Technologies team or other approved engineering firms.	
	Elaborate programme/ project concept with team and/or funder (government/ external)	*Are you aware of any current social, economic or environmental issues that may affect this programme/ project's objectives?* Social:	Vulnerability Assessment tool

		• Prevalence and history of Open Defecation • No accepted correlation between wastewater issues and public health • Difficulty of ability to purchase required land for implementation of solution due to complex land owning arrangements Economic: • Requirements for low capital costs and low operational costs. • Will require money going to WASCO to train local operators Environmental: • Land around area is affected regularly by flooding. • Power outages • Limited distance to groundwater • Limited land area to implement solutions How are system is climatically vulnerability: • Designed specifically for area to overcome its harshest weather typical for the region. *Is your programme/ project climatically vulnerable?* Wastewater treatment can be impacted by heavy rainfall, and so risk mitigation strategies will be in place to reduce its vulnerability. Many factors will be looked at. Including but not limited to rainfall, flooding. Climate change specifically is making for harsher tropical storms, increased rainfall intensity and duration, causing increased flooding situations. *In what way could weather/ climate directly or indirectly affect the objectives and the success indicators of the proposed programme/ project?* Heavy rainfall can: • Reduce quality of effluent by allowing biology to flow through systems too quickly not allowing time for treatment • Introduce solids into septic systems • May have impact on corals by bringing surface pollutants overland to the ocean	

		• Potentially flood system, causing costly and ineffective downtimes. Heavy winds can: • Cause power outages	
	Engage stakeholders in preparation process	*Have stakeholders expressed any concerns regarding the impacts of climate variability and climate change on the activity/decision?* Yes, the project has been put in place due to the impacts of climate change.	Vulnerability Assessment tool (stakeholder feedback)
	Develop programme/ project document, including definition of procurement needs and expected results profile	*What are the potential climate impacts on the design and implementation of the programme/ project (e.g. on construction, operation, use)?* The solutions that will be presented will have a low carbon footprint, and will therefore have very little effect on climate change. Some of the solutions provided will even mitigate some of the impacts caused by climate change, such as the reduction of untreated waste entering the local watersheds and water bodies. The use of solar panels for energy usage will be investigated as a way to reduce greenhouse gasses, lower operational costs and sustainably develop the area. *Have similar activities been affected by recent extreme events and variable weather patterns?* The current wastewater treatment systems are heavily afflicted by the impacts of climate change. *What significant risks do these climate impacts present for the programme/ project and its beneficiaries?* The project will be assessing risks of climate change to the solutions it provides, there is no significant risk to this project. *What is the range of adaptation options to manage these risks?* The solutions will consider options including: • Surface water infiltration and redirection strategies • Water proofing • Piping upgrades • Being reactive to storm events	Risk Assessment/Adaptation tool

		• Independent power systems *Which is the preferred adaptation action(s) to implement in this programme/ project?* A thorough review and a multi criteria evaluation will allow the contractor, with help from a board of experts and stakeholders, decide which solutions to implement first. *What actions need to be taken in the procurement process to ensure that all goods, products and services are climate resilient?* This will be determined during a further review of the risks for each solution.	
Stage 3) ANALYSIS, NEGOTIATION & APPROVAL			
Thorough assessment of programme/ project feasibility; approval process	Full review and analysis of programme/ project, including further stakeholder engagement where relevant	*Has the programme/ project been designed to accommodate changes in weather and climate?* Yes. *Will this programme/ project be sustainable over its lifetime?* Yes. *How will the impacts and any adaptation options affect capital and future operational maintenance costs?* There will be a significant difference in capital costs based on the various solutions. Operational costs will be kept to a minimum with priority given to passive technologies and autonomy.	Context tool (articulating objectives, preparing a process and establishing a baseline)
	Negotiate programme/ project details and obtain approval (from Government Ministry, Cabinet, external funder, or other relevant body)	*What are the key messages to communicate about how climate affects this programme/ project?* • The increase of rainfall, has further made the land prone to flooding • The flooding increased the occurrence of sewage backup on the land, greatly increasing risk of human fecal contact, as well as impacting local ecology. *How can stakeholder support be obtained for*	Awareness Raising tool

		this programme/ project and to any adaptation actions? • Brochures • Public outreach • Connecting clean sustainable wastewater treatment with public health efforts that everyone is on board with	
	Programme/ project approval or rejection		
	Procurement of relevant assistance/support for approved programme/ project	*What actions need to be taken in the procurement process to ensure that all goods, products and services are climate resilient?* Proper design, specification and install will need to be done to ensure that all procured items meet the stresses caused by the current environment and the future climate changed environment	Adaptation option identification/appraisal tool
Stage 4) IMPLEMENTATION, MONITORING & EVALUATION			
Monitoring and reporting during implementation of programme/ project; evaluation	Develop monitoring and evaluation system Report to relevant overseeing Ministry/ organisation Evaluate implementation or programme/ project	*What should be monitored/evaluated during implementation to track that this programme/ project is climate resilient?* The highlighted solutions should be scrutinized by a local planner. *Is the programme/ project climate resilient?* The project aims to provide climate resilient solutions. *Are any changes/refinements required to respond to changing needs/information?* This is to be determined after submittal of the solutions.	Monitoring and Evaluation tool

Glossary

Aerobic – With oxygen

Anaerobic – Without oxygen

BOD – Biological oxygen demand

CapEx – Capital expenditure

CCIF - Canaries Community Improvement Foundation

CCORAL - Caribbean Community Climate Change Centre

CEHI - Caribbean Environmental Health Institute

COD – Carbonaceous oxygen demand

EQ - Equalization

Fixed film – Biological treatment process employing a medium to support biomass on its surface

FOG – Fats oils, and grease

GDP – Gross domestic product

GEF CReW - Global Environment Facility-funded Caribbean Regional Fund for Wastewater Management

Greywater – any household wastewater with the exception of wastewater from toilets

IWT – Island Water Technologies

MLSS – Mixed liquor suspended solids

NGO – Non governmental organization

Non point source - water and air pollution from diffuse sources

O&M – Operation and management

Sludge – Residual, semi-solid/slurry material produced as by-product from sewage treatment

TSS – Total suspended solids

UNEP - United Nation Environment Programme

WASCO – Water & Sewerage Company Inc.

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