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ANNEX 1: CHARACTERIZATION FORM AND TECHNICAL SUMMARY TEMPLATES

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CARIBBEAN ENVIRONMENT PROGRAMME

ANNEX 1: CHARACTERIZATION FORM AND TECHNICAL SUMMARY TEMPLATES

Annex 1 provides two templates - the Characterization Form (for collecting information about the study area) and a template for development of a summary of results. These templates can be used directly and can also be edited per guidance from Part II of the Resource Guide.

Characterization Form for Defining the Costs and Benefits of Domestic Wastewater Management

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STUDY SITE:

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RESPONDENT INFORMATION

This report was completed by:

Name:

Organization

Date:

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I. DEFINE THE STUDY AREA

Objective: Define and map the study area including key geographic and land use data to identify wastewater pollution and other water pollution pathways and populations of interest.

Possible data sources: National environmental, water, and/or marine agencies; non-profit organizations (NGOs); Academic institutes with marine/environmental centers that conduct research within the study site.

1. Please define the study area by providing a detailed description.

The study area should include the sewage catchment name(s) and geographic area, the populated area to be served by improved wastewater treatment, the area downstream which is expected to be influenced by the change in wastewater management (including receiving water bodies (e.g., rivers, lakes, oceans) and water catchments), and the upstream catchment (which might be contributing pollutants to the water body of focus).

2. Can you put it on a map? (with GIS; Google Earth; or participatory mapping)

If possible, indicate on a map the information provided in Question 1. This can be done in GIS, using Google Earth, and/or working with stakeholders using a participatory mapping approach to highlight on a hard copy map the response to Question 1.

3. What are the major land uses (such as residential, commercial, agricultural, open space / natural) in the study area?
- **Could you do rough estimates of percentages of each major land use?**

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II. POPULATION

Objective: Population data is critical for understanding current and future wastewater supply as well as the number of people who may swim in or eat from waters contaminated with untreated wastewater.

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. How many <u>people</u> live in the study area? (Approximate if necessary.)

2. Can you disaggregate this by neighborhood / area / housing development / smaller administrative unit?

3. **How many <u>households</u> are in the study area? (Approximate if necessary.)**

4. **What is the population projection for the study area over the next 20, 30, and/or 50 years (for each period if data are available)?**

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III. ECONOMIC ACTIVITIES

Objective: Economic data are important for understanding the economic activities that are important for the local economy that rely on ecosystems (especially those potentially impacted by water pollution.)

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. **Are the following sectors important for the local economy (ideally for the study area)? Can you estimate the relative contribution from each sector to the local economy (use scale below)? If quantitative data are not available, please rate the sector's importance based on the following scale:**

   <u>Importance Scale</u>:
   - **Not important:** The sector is not relevant as it does not contribute much to local GDP (e.g., through jobs or financial contribution)
   - **Moderate importance:** The sector is important, but is not the main contributor to local GDP.
   - **Very important:** The sector contributes substantially to local GDP.
   - **Critical:** The sector contributes the largest amount of any sector to local GDP

   - **Tourism? (Note types of tourism)**
   - **Agriculture? (Note types of agriculture)**
   - **Fisheries? (Note major fish species)**
   - **Industry? (Note what industry/ies)**
   - **Other?**

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IV. KEY ECOSYSTEMS

Objective: To understand potential benefits to ecosystem health from wastewater management improvements, it is necessary to identify a) key ecosystems in the study sites, b) their economic contribution in terms of key goods and services they provide, c) their contribution to key economic sectors. This will help to characterize the dependence of these sectors on healthy ecosystems, and as a result, the value of these ecosystems to the study population and the nation.

Possible data sources: Government environmental/water/natural resource agencies or ministries; Academic institutes and environmental NGOs conducting research or working towards the protection or conservation of ecosystems; Peer-reviewed and grey literature on key ecosystems both within and outside of the study area; Government reports including environmental impact statements, water quality permits, or benefit-cost analyses;

1. **What are the <u>key ecosystems</u> in the study area (e.g., coral reefs, mangroves, seagrass beds, beaches, forests, wetlands), especially downstream from population, sewage discharge, or treated wastewater discharge? Key ecosystems are those which are important to the local economy or those which provide important cultural services.**

2. **Please rank (using the scale below) how important these ecosystems are to the economic sectors previously listed in Section III (within the study area) (e.g., is tourism in the area dependent on healthy ecosystems?). Please indicate in Table 1 below the relative importance based on this scale:**

   <u>Importance Scale</u>:
   - **Not important**: The ecosystem has no relevance to the economic sector.
   - **Moderate importance**: The economic sector is dependent on resources/services provided by the ecosystem but substitutes for natural resources are available (e.g., forest ecosystems provide water filtration services that can improve the health of fisheries, but water filtration systems are also available to filter water).
   - **Very important:** The economic sector is dependent on the resources/services provided by the ecosystem and substitutes are <u>not</u> available or are exorbitantly expensive (e.g., mangroves provide important coastal protection services, guarding some shoreline industries from flooding and hurricanes. While options exist to improve coastal protection like dikes jetties, this type of infrastructure can be costly to build and maintain).
   - **Critical:** The ecosystem is vital to the economic sector in that the sector would not profit or exist without the ecosystem (e.g., tourism in a coastal community may be completely dependent on coral reefs for scuba diving, snorkeling, and sand creation as these activities provide the most income to the local economy).

Table 1: Ranking of ecosystem(s) important to key economic sectors

ECOSYSTEM	AGRICULTURE	FISHERIES	INDUSTRY	TOURISM	COMMERICAL	
Example: Coral reefs	*Not important*	*Critical*	*Moderate*	*Very important*	*Very important*	

3. **What goods and services do these key ecosystems provide (i.e., what are each of the ecosystems <u>used by people for</u>?). Please fill out Table 2 below and add or delete ecosystems as needed. You may refer to Table 3, which provides a general list of ecosystem services for major Caribbean ecosystem types, for guidance.**

Table 2: Ecosystem goods and services

Ecosystem Goods and Services	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES	
Provisioning services					
Food					
Raw materials					
Medicinal resources					
Genetic resources					
Other…					
Regulating services					
Flood/storm/erosion regulation					
Climate regulation					
Other…					
Cultural services					
Tourism and recreation					
History, culture, traditions					

Science, knowledge, education					
Other…					
Supporting services					
Primary production					
Nutrient cycling					
Species/ecosystem protection					
Other…					

Table 3: Examples of coastal ecosystem goods and services

ECOSYSTEM GOODS AND SERVICES	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES
Provisioning services				
Food (e.g., fisheries)	X	X	X	X
Raw materials	X	X	X	X
Medicinal resources	X	X		X
Genetic resources	X	X		X
Regulating services				
Flood/storm/erosion regulation	X	X	X	X
Climate regulation	X	X	X	X
Cultural services				
Tourism and recreation	X	X	X	
History, culture, traditions	X	X	X	X
Science, knowledge, education	X	X	X	X
Supporting services				
Primary production	X	X	X	X
Nutrient cycling	X	X		X
Species/ecosystem protection	X	X	X	X

Source: WRI Coastal Capital Guidebook (Waite et al. 2013)

4. **Are there any <u>existing estimates of the economic values</u> of these uses of ecosystems for this study area or nearby (e.g., through peer-reviewed or grey literature)? If so, please list these values, describe the methodology used to develop them, and provide a citation.**

5. **Do you have statistics on visitation/tourism (both foreign and national) to key ecosystems and/or statistics on visitation/tourism for the country for eco-tourism? For example, do you have data on the number of tourists (including cruise ship passengers, national and international tourists, and others) that visit the key ecosystems identified above?**

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V. CURRENT WASTEWATER MANAGEMENT SITUATION

Objective: To understand how wastewater is currently treated within the study site to allow comparison against future wastewater management alternatives in terms of population served, untreated wastewater, pollution removal effectiveness for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits; Wastewater experts; Historical costs; National price books.

1. **On-site wastewater treatment coverage:**
    - **Please estimate the percentage of the total domestic wastewater sector within the study that uses each type of on-site system below. For example: 30% of the total population uses on-site treatment. Of this 30%, 10% uses septic system, 10% uses pit latrines, and 10% uses soakaway systems).**
        - **Septic systems**
        - **Pit latrines**
        - **Soakaway systems**
        - **Other?**
    - **What percentage of on-site systems (septic systems, pit latrines, soakaway systems, etc.) are properly maintained (i.e., regularly pumped out, drain fields not clogged, etc.)?**

2. **Wastewater collection system (i.e., sewerage):**
    - **Please describe the coverage of the current sewage collection system in terms of length of pipelines and the ultimate treatment point.**
    - **Please estimate the percentage of the total population and commercial and industrial establishments within the study that are connected to a centralized sewerage system.**

3. **Wastewater treatment plants:**
    - **Please describe the number and type of wastewater treatment plants (WWTP) currently in place in the study area.**

    - **For each WWTP, please fill in Table 4 to the best extent possible. Please see Annex 2 for a glossary of wastewater terminology. Please copy and paste this table as needed if more than one treatment plant exists within the study site:**

Table 4: Wastewater Treatment Plant information for current situation

Data need	**Data**
Design	
Location	
Design capacity - Nominal design capacity for dry and wet weather flows.	
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	
Effluent limits	
Sludge treatment and disposal	
Discharge location (receiving water body). If coastal, identify the outfall locations.	
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Current flows (annual average flow, monthly average peak flow)	
Annual energy usage (kW hours, total cost)	
Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause, and estimated bypassed volume for each event).	

Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	
Annual average discharged concentrations and loads of:	
BOD_5 (mg/l, kilograms per year)	
Dissolved oxygen (mg/l)	
Total Nitrogen (mg/l, kilograms per year)	
Ammonia Nitrogen (mg/l, kilograms per year)	
Total Phosphorus (mg/l, kilograms per year)	
Total Suspended Solids (mg/l, kilograms per year)	
Faecal coliforms (units as reported)	
Enterococci (units as reported)	

4. **What is the estimated annual percentage of total wastewater generated that is <u>untreated</u> and released into water bodies? What is the estimated annual volume?**

5. **If there is <u>untreated sewage</u>, where does this go? If possible, please also note on a map the receiving water bodies and ecosystems that receive the untreated sewage – either directly, or via an outfall.**

6. **Is there an interest in improving, upgrading, or expanding the current wastewater management system in the area? If so, please describe who is interested and why.**

7. **Current wastewater treatment costs - What capital and annual operating and maintenance costs are associated with the current wastewater management situation? Please fill in Table 5 to the best extent possible. If you do not have specific cost data, please provide a description of the *likely* costs associated with the current scenario by referring to Annex 2, section D.**

Table 5: Current wastewater scenario costs

Data need	Current wastewater management situation
Year of installation	
Life expectancy (years)	
Total land area occupied by the plant (hectares)	
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced within the next 20 years and the total capital cost, including likely year of replacement and the frequency of replacement)	
Annual recurring expenses: -Salary/wages for all personnel plus personnel of any contracts associated with operation of the WWTP. -Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)	
External services costs (if applicable, net value of total costs of external services including outsourcing, costs for construction)	
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)	
Other costs?	
Net present value over infrastructure's lifetime	

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VI. WATER QUALITY

Objective: To identify and list water quality standards and requirements that are applicable to the wastewater sector and identify and provide historic data (over the past five years) on water quality within wastewater receiving bodies and key ecosystems in the study area.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants or engineers that work with the wastewater authority

1. **What water quality standards/requirements apply for the study area?**

   - **National/Regional and Local water quality standards?**
     - **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
     - **Numeric criteria?**

   - **Bathing/swimming standards**

   - **International standards (e.g., LBS Protocol)**
     - **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
     - **Numeric criteria?**

2. **What data or information do you have about water quality in the study area? Can you provide:**
   - **Ambient water quality monitoring data in freshwater bodies?**
   - **Ambient water quality monitoring data in coastal waters?**

3. **Please compare these data to water quality standards/requirements:**
   - **Are any water quality standards being violated in lakes, non-tidal streams and rivers, and coastal areas? Please provide frequency and severity.**
   - **What are the pollutants causing the violation and what are their sources (e.g., untreated wastewater, WWTP effluent, onsite septic systems, soakaways, pit latrines, sources from other sectors such as mining or agriculture)**

4. **If any water quality standards are being violated, have the violations been linked to wastewater discharges? If so, please provide specific information on the linkage.**

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VII. ECOSYSTEM IMPACTS

Objective: To understand if there is a demonstrated link between wastewater pollution and ecosystem health.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants/engineers working with the wastewater authority; Environmental impact statements; Environmental/marine NGOs and government agencies; Academic and grey literature.

1. **Within the study area, are any of the following causing ecological impacts, such as algal blooms or damage to coral reefs:**
    - **Discharge of untreated or partially treated sewage?**
    - **Discharge of treated wastewater effluent?**
    - **Irregular release of wastewater from a WWT system due to overflow, rainwater events, or power failure, etc.?**

2. **Have any studies been conducted within the study site or your country or region that link wastewater pollution to ecosystem health? If so, what are the findings?**

3. **Is there evidence of the following in any of the key ecosystems present in the study area: (e.g., freshwater, wetlands, mangroves, beaches, coral reefs, forests, wetlands):**
    - **Is it unsightly due to pollution? Are there algal blooms or obvious evidence of pollution?**
    - **Is there odor due to pollution?**
    - **Are there impacts to fish or other aquatic life (e.g., fish kills, overgrowth of algae on coral reefs)?**
    - **Are you seeing a change in ecosystem health and/or growth?**

4. **Beyond wastewater, are there any other sources of water pollution contributing to these problems? If so, please indicate the relative contribution to total water pollution using the following scale:**

    No contribution – Minor contribution – Moderate contribution – Significant contribution

    - **Runoff from croplands?**
    - **Runoff from livestock?**
    - **Runoff from aquaculture?**
    - **Industrial discharge?**

- **Cruise ships/yachts?**
- **Others?**
- **Do you have a sense of the relative contribution from wastewater to overall pollution of key ecosystems compared to these other sources? If so, please describe.**

5. **Are there any economic or cultural uses of the key ecosystems that are in decline due to wastewater discharge issues (from untreated or improperly treated wastewater)? Please refer to Annex 2, section B for examples of Caribbean coastal ecosystems and impacts that have been documented from exposure to untreated or improperly treated wastewater.**

6. **Do tourists have any awareness of water quality issues and do they modify activities / visitation? Are you able to quantify or describe the change in visitation (e.g., reduced annual snorkeling rates or reduced number of visitors to recreational beaches)?**

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VIII. HUMAN HEALTH IMPACTS

Objective: To understand if there is a link between wastewater pollution and key human health illnesses including gastroenteritis, ear and eye infections, and other illnesses (as listed in Annex 2, section C); and to estimate the impacts on the local economy due to human health impacts (e.g., from hospitalization, medication, time taken off work, and death).

Possible data sources: Health agencies or ministries; Hospitals or doctor's offices; National statistics/census data; International statistics from multilateral, intergovernmental or NGOs (e.g., World Bank or World Health Organization); Peer-reviewed or grey-literature.

1. **Please describe any known human health impacts, such as gastrointestinal illness, respiratory illness, ear infections, eye infections, or skin rashes/lesions that are occurring in the study site that relate to wastewater. Please see Annex 2, section C for a list of human illnesses related to swimming in, drinking from, or eating seafood from water contaminated with wastewater.**

   - **Are health data recorded on any of these key illnesses? If so, who collects this data? What can you say about the average frequency and duration of occurrence for each type of illness (e.g., 50 cases per year; 1 case per resident person per year)?**

   - **Do reported incidences of these illnesses result in doctors' visits, hospitalization, or death? Do you have statistical data on illnesses and hospital data?**

- **What activities seem to be contributing (e.g., swimming; eating contaminated seafood)?**

- **How specific can you be about location?**

- **Is wastewater pollution the main cause of these health issues? If not, what are the main causes of these diseases?**

2. **Have any studies been conducted within the study site or your country or region that link wastewater pollution to human health?**

3. **Do any of these studies estimate a dose-response relationship between a given wastewater pollutant and a human health illness (e.g., gastroenteritis)? (See the BCA methods section for more detail.)**

4. **Beyond wastewater, are there any other sources of water pollution contributing to these problems? (If so, please note how large of a contribution.)**
   - **Runoff from agriculture?**
   - **Runoff from livestock?**
   - **Runoff from aquaculture?**
   - **Industrial discharge?**
   - **Cruise ships/yachts?**
   - **Others?**

5. **Do you have a sense of the relative contribution from wastewater to overall health impacts compared to these other sources? If so, please describe.**

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IX. FUTURE WASTEWATER MANAGEMENT SCENARIO(S)

Objective: To identify and define at least one future wastewater management scenario to compare against the current infrastructure situation in terms of population served, untreated wastewater, pollution removal efficiency for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Wastewater consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits.

1. **What option or options are under consideration for improving wastewater management in the pilot area? Please provide a description and fill in Table 6 for each major wastewater treatment**

plant or infrastructure element. Please add columns as necessary if more than two alternatives are being considered.

Table 6: Future wastewater management scenarios description

Data need	Alternative 1	Alternative 2
Design		
Location		
Design capacity - annual average and peak (if actual capacity is lower, that will be covered below under performance)		
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)		
Will effluent and water quality standards be met?		
Sludge treatment and disposal		
Discharge location (receiving water body). If coastal, is there an outfall(s)?		
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)		
Performance		
Flows (annual average, peak)		
Annual energy usage (kW hours, total cost)		
Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause, and estimated bypassed volume for each event).		
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)		

Annual average discharged concentrations and loads of:		
• BOD_5 (mg/l, kilograms per year)		
• Dissolved oxygen (mg/l)		
• Total Nitrogen (mg/l, kilograms per year)		
• Ammonia Nitrogen (mg/l, kilograms per year)		
• Total Phosphorus (mg/l, kilograms per year)		
• Total Suspended Solids (mg/l, kilograms per year)		
• Faecal coliforms (units as reported)		
• Enterococci (units as reported)		

2. **What are the evaluation criteria for choosing an infrastructure option and who decides what these criteria are? For example, criteria may include cost-effectiveness, pollutant removal efficiency, and/or environmental impacts.**

3. **What sort of improvements are expected from each future wastewater management scenario?**
    - **Increased coverage in terms of population treated?**
    - **Improvement in water quality of receiving water bodies and downstream water bodies?**
    - **Reduced levels of:**
        - **BOD5**
        - **Dissolved oxygen**
        - **Total nitrogen**
        - **Ammonia nitrogen**
        - **Total phosphorus**
        - **Total suspended solids**
        - **Faecal coliforms**
        - **Enterococci**

4. **Will the new wastewater treatment technology allow any reuse of water?**
   - **Where does the treated water go – back in a river, out an outfall, or into a specific use (e.g. irrigation, industrial use, or drinking water)?**
   - **Has anyone estimated the potential cost savings associated with reuse of this wastewater?**

5. **Have any engineering or financial analyses been conducted for future wastewater management alternatives? Do they provide cost data?**

6. **Please fill in Table 7 to the best extent possible based on either engineering/financial reports from the wastewater authority and relevant consultants, OR by referring to Annex 2 which provides information on relative cost by infrastructure type.**

Table 7: Cost estimates for future wastewater management scenarios

Parameter	**Alternative 1**	**Alternative 2**
Year of installation		
Life expectancy (years)		
Total area of the plant (please list the area that will need to be purchased for the treatment facility)		
Capital/Investment expenses (This includes one-time construction, planning, and design costs; costs for new development; and cost for replacement and renovation of existing assets – including external or consulting services)		
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced sooner than the life expectancy of the treatment facility and the recurring capital cost, including likely year of replacement and the frequency of replacement)		
Annual recurring expenses: -Salary/wages for all personnel -Land rental value for land purchased (i.e., the value of land purchased to install the wastewater infrastructure)		

-Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)		
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)		
Other costs		
Net present value over infrastructure's lifetime		

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X. CHANGES TO ECOSYSTEM AND HUMAN HEALTH UNDER IMPROVED WASTEWATER MANAGEMENT SCENARIOS

Objectives: To quantify and/or describe how ecosystems and the goods and services they provide will change under each future wastewater management scenario, and the potential impacts on the local economy in terms of costs;

To quantify and/or describe how human health will be impacted under each future wastewater management scenario in terms of numbers of reported illnesses and costs.

Possible data sources: Peer-reviewed and grey literature; Government documents including environmental impact statements.

1. **Have any evaluations, studies, or environmental impact statements been conducted that estimate the impact on key ecosystems and human health under each new wastewater management scenario *compared to the current wastewater management situation*? Do you know of any experts that are currently studying potential impacts? If so, please describe these findings, including how likely management under each scenario is to:**

   - **Reduce the annual loading of pollutants on receiving water bodies?**
   - **Reduce odor?**
   - **Reduce the incidence of harmful algal blooms and/or nutrient over-enrichment?**
   - **Reduce human health risk and/or the number of cases for illnesses previously identified?**

- **Improve ecosystem health conditions for the key ecosystems identified previously?**
- **Improve the provision of key ecosystem goods and services identified previously (e.g., increased likelihood of tourist visits, increased productivity of fisheries due to improved coral reef and mangrove health)**

2. **Can you establish a quantitative relationship between an improvement in water quality due to the future wastewater management alternative and a change in provision of ecosystem services for each key ecosystem? If so, please list your assumptions and quantitatively describe these changes (e.g., by reducing the amount of untreated wastewater entering the coral reef ecosystem, total nitrogen levels will decrease by 30% surrounding the reef which will improve coral reef health such that fisheries production increased by 20%).**

3. **Can you monetize or value the change in ecosystem service provision (e.g., what is the economic value of reduced coral reef degradation in terms of fisheries improvement – this is often quantified by estimating the market value of fish sold in a marketplace)?**

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XI. OTHER INFORMATION

1. **Please list any additional data or information you think would be useful to the study that might not have been discussed previously in this characterization form.**

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XII. REFERENCES

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TEMPLATE FOR SHORT TECHNICAL SUMMARY OF MCDA RESULTS

Summary for Study Site: Insert study site name here

Site Location:	Insert map here

Key ecosystems in the area: •	**Key ecosystem services and their values:** •

Population and Wastewater treatment •	Insert pie chart here

Current WW treatment situation / technology	**Condition / Issues /limitations**	**Operating Costs**
	-	

Observed or likely impacts due to WWT situation: •	**Potential Economic loss:**

WW Improvement Option 1	**Anticipated impacts**	**Cost (Capital and annual O&M costs)**
•	•	

Comparing Wastewater Improvement Option(s) with Business as Usual

This multi-criteria evaluation matrix allows weighting and integration of a range of important factors or criteria identified by key stakeholders.

- List details of scoring and weighting system used (e.g., Scale of 1- 5?)
- Describe how/when/where the evaluation matrix was compelted.

- Summarize findings (e.g., which scenario had the highest score?; which criteria seemed to be most important to stakeholders?)

MCDA results for: Insert study site name

Criteria	Weight	Score	
		Current Situation	**Future Scenario**
List all criteria identified by stakeholders			

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ANNEX 2: SUPPLEMENTARY REFERENCE MATERIALS

ANNEX 2: SUPPLEMENTARY REFERENCE MATERIALS

Annex 2 provides supplementary reference materials that can be used for both Parts I and II of the Resource Guide, and includes the following reference materials:

SECTION A: WASTEWATER TERMINOLOGY GLOSSARY

(For Health terminology see Section C.)

Term	Definition
Activated Sludge Process	A biological wastewater treatment process that speeds up the decomposition of wastes in the wastewater being treated. Activated sludge is added to wastewater and the mixture is aerated and agitated. After some time in the aeration tank, the activated sludge is allowed to settle out by sedimentation and is disposed of or reused as needed. The remaining wastewater then undergoes more treatment.
Aeration	Addition of air to water resulting in increased dissolved oxygen concentrations.
Aeration Tank	The tank where raw or settled wastewater is mixed with return sludge and aerated.
Aerobic Oxidation Condition	Relating to, involving, or requiring free oxygen for metabolic processes.
Algal Toxins	Organic molecules produced by a variety of algae either via Harmful Algal Blooms of phytoplankton or cyanobacteria that cause harm to organisms when present in large quantities in water.
Ammonia Nitrogen (mg/l)	Ammonia nitrogen (NH3-N), is a pollutant often found in landfill leachate and in waste products, such as wastewater and treated wastewater effluent, liquid manure and other liquid organic waste products. In surface water bodies it can be toxic to some aquatic organisms under certain temperature and pH conditions.
Anaerobic Digester (Anaerobic Tank)	A wastewater solids treatment device in which the solids and water (about 5% solids, 95% water) are placed in a large tank where bacteria decompose the solids in the absence of dissolved oxygen.
Anaerobic Oxidation Condition	Not involving, or requiring free oxygen for metabolic processes of wastewater treatment.
Anoxic	Characterized by low or zero dissolved oxygen concentrations. Anoxic surface waters have dissolved oxygen concentrations of 0.5 mg/l or lower.
Biochemical Oxygen Demand (BOD)	The amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. BOD can be used as a gauge of the effectiveness of wastewater treatment plants and the impact of their effluent discharges on receiving water bodies.
Biochemical Oxygen Demand 5 Day (BOD_5)	A measure of the amount of oxygen required or consumed for the microbiological decomposition (oxidation) of organic material in water; measured as mg/l of oxygen consumed in 5 days at a constant temperature of 20°C in the dark. BOD_5 is used to determine the level of organic pollution in a stream or lake.
Blackwater	Liquid and solid human body waste and the carriage water generated through toilet usage.
Centralized Wastewater System	A wastewater system that provide for most or all of a town's wastewater management needs, and that might be suitable for serving portions of neighboring towns.
Chemical Oxygen Demand (COD)	A measure of the oxygen-consuming capacity of organic matter present in wastewater. COD is expressed as the amount of oxygen consumed from a chemical oxidant in mg/L during a specific test.
Cluster Wastewater System	A wastewater system that can serve up to approximately 30 homes with aggregate wastewater flows of less than 10,000 gallons per day.
Coliform bacteria (Total and Faecal)	Coliform bacteria are a collection of relatively harmless micro-organisms that live in large numbers in the intestines of man and warm and cold-blooded animals. Both groups have widely been used as indicators of enteric (intestinal) bacterial

	pathogens. The total coliform group is not as specific an indicator of faecal contamination as faecal coliforms.
Constructed Wetland	An artificial wetland created for the purpose of treating anthropogenic discharge such as municipal or industrial wastewater or stormwater runoff.
Discharge	Subsurface irrigation, rapid infiltration, reuse, or discharge to surface water bodies.
Dissolved Organic Matter (DOM)	That portion of the organic matter in water that passes through a 0.45 µm pore-diameter filter.
Dissolved Oxygen (DO)(DO) (mg/l)	The level of free, non-compound oxygen present in water or other liquids. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water.
Domestic Wastewater	Wastewater from domestic sources including households, businesses (hotels, inns, restaurants), and public facilities.
Downstream	Water flow or site that is in the direction of the current and at a distance from the water or pollution source.
Ecosystem	An ecosystem is a community of living organisms in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system.
Ecosystem services	Benefits that humans obtain from ecosystems.
Effluent	Water or other liquid—raw (untreated), partially treated, or completely treated—flowing from a reservoir, basin, treatment process, or treatment plant.
Enteric Bacteria	Bacteria of the intestines; may refer to gut flora, which is always present and usually harmless. Pathogenic bacteria of bacterial gastroenteritis. The taxonomic family Enterobacteriaceae.
Enterococci (mg/l)	A subgroup of fecal streptococcal bacteria (mainly Streptococcus faecalis and Streptococcus faecium) found in the intestinal tracts and feces of warm-blooded animals. It is used as an indicator of the potential presence of pathogens.
Eutrophication	The degradation of water quality due to enrichment by nutrients, primarily nitrogen (N) and phosphorus (P), which results in excessive plant (principally algae) growth and decay. When levels of N:P are about 7:1, algae will thrive. Low dissolved oxygen (DO) in the water is a common consequence. Degrees of Eutrophication typically range from Oligotrophic water (maximum transparency, minimum chlorophyll-*a,* minimum phosphorus) through Mesotrophic, Eutrophic, to Hypereutrophic water (minimum transparency, maximum chlorophyll-*a,* maximum phosphorus).
Flow	The movement of water. Flow is usually expressed as the rate at which water moves through a cross-sectional area. Common units of expression include cubic meters per day, million gallons per day, and cubic feet per second unit time.
Greywater	Wastewater other than sewage, such as from household sink, bathtub or washing machine drainage.
Groundwater	Subsurface water in the saturation zone from which wells and springs are fed. In a strict sense the term applies only to water below the water table.
Harmful Algal Bloom (HAB)	A proliferation of algae, or phytoplankton. Severe blooms of even non-toxic algae can spell disaster for cultured animals, because blooms deplete the oxygen in the shallow waters of many marine and freshwater systems.

Individual On-Lot Systems	Wastewater systems that can serve a single property and are located on the property where the wastewater is generated.
Membrane Bioreactor (MBR)	A wastewater treatment process that uses a suspended growth bioreactor (typically found in activated sludge treatment processes) coupled with a membrane filtration process like microfiltration or ultrafiltration.
Nonpoint Source	A runoff or discharge from a field or similar source, in contrast to a point source, which refers to a discharge that comes out the end of a pipe or other clearly identifiable conveyance.
On-site system	A system relying on natural processes and/or mechanical components that is used to collect, treat, and disperse/discharge wastewater from single dwellings or buildings.
Outfall	The point, location, or structure where wastewater or drainage discharges from a sewer, drain, or other conduit area.
Parts Per Million (PPM)	A measurement of concentration on a weight or volume basis. This term is equivalent to milligrams per liter (mg/L), which is the preferred term.
Phytoplankton	Small, usually microscopic plants (such as algae), found in lakes, reservoirs, and other bodies of water.
Pit latrines	A type of toilet that collects human feces in a hole in the ground. Pit latrine designs range from simple unimproved pit latrines, through Ventilated Improved Pit latrines (VIPs) to alternating twin pit systems. A VIP is a pit latrine with a pipe fitted to the pit and a screen at the top outlet of the pipe. In a twin pit system, the second pit is only used when the first pit is filled. The first pit is left sealed for a year or more before emptying during which time disease-causing organisms are destroyed by natural processes. After such storage, without the addition of fresh wastes, the contents become safe to handle, and may be used as compost.
Point Source	A discharge that comes out the end of a pipe or other clearly identifiable conveyance. Examples of point source conveyances from which pollutants may be discharged include: ditches, channels, tunnels, conduits, wells, and landfill leachate collection systems.
Pollutant	Any substance that causes an impairment (reduction) of water quality to a degree that has an adverse effect on any beneficial use of the water.
Potable Water	Water that does not contain objectionable pollution, contamination, minerals, or infective agents and is considered satisfactory for drinking.
Primary Treatment	Removal of solid material from wastewater through mechanical screening or settling. Primary treatment removes floating and suspended solids, which comprise about 30-35% of pollutants
Receiving Water	A stream, river, lake, ocean, or other surface or groundwater into which treated or untreated wastewater is discharged.
Rotating Biological Contactor	A compact secondary treatment process that can be used following solids removal. Clarified wastewater enters a tank where a series of closely-spaced and partially-submerged vertical discs with attached microorganism populations are rotated in the wastewater. The microorganisms consume organic matter in the sewage.
Runoff	That part of rain or other precipitation that runs off the surface of a drainage area and does not enter the soil or the sewer system as inflow.
Satellite System	A system that can serve from 30 to 1,000 homes (or wastewater flows between 10,000 and 300,000 gallons per day), intended to treat and dispose of wastewater from one area of a town. Also known as community or cluster system.
Secondary Treatment	A biological process for removing biodegradable organic matter from wastewater. It follows a primary treatment step of removing settleable solids and floating materials. In the secondary process, growing populations of microorganisms metabolize biodegradable organic matter to carbon dioxide and water. Secondary

	treatment can remove up to 65 percent of the BOD and suspended solids in the wastewater.
Sedimentation	The process of settling and removing suspended matter from the wastewater. Also known as clarification.
Septic Tank	A settling tank in which solids in the incoming flow settle to the bottom of the tank and the remaining liquid portion exits the tank and typically enters an external subsurface drain system that releases the flow into the soil where it receives natural treatment as it moves downward to the water table. Septic tanks must be pumped out on a regular basis to remove the settled solids or they will cease to function properly.
Sewage	Domestic sewage is used household water from toilets, sinks, and washing machines that is discharged to sewers and conveyed to wastewater treatment plants. Industrial sewage is wastewater discharged to sewers from industrial sources.
Sewerage	A collective term for systems that collect, convey, and treat wastewater or stormwater runoff. They are comprised of collection sewers, large interceptor sewer, pumping stations (if needed) and treatment works.
Sludge	Solid matter that settles to the bottom of sedimentation tanks in a sewage treatment plant and must be disposed of by digestion or other methods or recycled on land. Activated sludge is mainly the mass of the biological organisms that provide the secondary treatment by metabolizing organic matter in the wastewater. Given their excess food supply, these populations grow rapidly and their excess mass must be removed on a continuous basis (waste activated sludge). The wasted sludge typically is then dewatered and or dried, and stabilized by various methods to reduce pathogens and odors. When properly treated, sludge can be re-used in several beneficial ways including energy production, phosphorus recovery, and as a soil amendment. Known as biosolids in the United States.
Soakaway	Also known as a soak pit. A covered underground chamber that allows water to slowly percolate into the ground. It can be used to provide partial treatment for grey water (water from sinks or washing machines) or stormwater. Blackwater (sewage) must first undergo primary treatment before discharge to a soakaway. Siting of soak pits requires proper soil and depth-to-ground water conditions.
Storm Sewer	A pipe, conduit, or open channel that carries runoff from storms, surface drainage, and street wash, but does not include domestic and industrial wastes.
Surface Runoff	The water that reaches a stream by traveling over the land surface or falls directly into the stream channels, including not only the large permanent streams but also the tiny rills and rivulets.
Suspended Solids, Total Suspended Solids	Small solid particles in colloidal suspension in water. The particles can be from a variety of sources including slit, sediment, algae, plankton, and other organic matter. Total suspended Solids (TSS) is closely associated with turbidity and water clarity is a standard measure of water quality in surface waters. Particles below 2 microns in size are considered dissolved and are not included in TSS.
Tertiary Treatment	Tertiary treatment is any treatment beyond secondary. It can include additional BOD and TSS removal and nitrogen and phosphorus removal.
Total Nitrogen (mg/l)	The total nitrogen concentration in a water sample. It is the sum of organic nitrogen, ammonia-nitrogen, and nitrates-nitrites, which all must be measured separately. Nitrogen is a key nutrient for algae, especially in marine waters and can be a major cause of eutrophication.

Total Phosphorus (mg/l)	The total phosphorus in a water sample. It is the sum of dissolved and particulate phosphorus. Like nitrogen, it is a key nutrient for algae, especially in fresh waters and can be a major cause of eutrophication.
Trickling Filter	A fixed-bed biological treatment system in which pre-settled wastewater is continuously sprayed on the surface of a filter medium. A biofilm of microscopic organisms forms on the filter media and aerobically degrades organic material in the wastewater as it slowly moves downward through the media.
Turbidity (Nephelometric Turbidity units or NTU)	Turbidity is a measure of water clarity, or how much the material suspended in water decreases the passage of light through the water. Turbidity is caused by suspended materials such as clay, silt, sand, algae, plankton, microbes, and other substances. Turbidity can also affect the color of the water. Higher turbidity has multiple adverse impacts on a water body. It increases water temperatures because suspended particles absorb more heat, which in turn reduces the concentration of dissolved oxygen. It reduces the amount of light penetrating the water, reducing photosynthesis oxygen production.
Upstream	The direction against the flow of water; or, toward or in the higher part of a river or sewer collection system.
Waste Stabilization Pond / Wastewater Lagoon	Natural or man-made lagoons used to treat domestic wastewater in which organic matter is decomposed by natural processes, and algae. Lagoons can be unaerated (known as facultative lagoons) or mechanically aerated. Ponds can be used individually, or linked in a series for improved treatment. Also known as Waste Stabilization Ponds.
Wastewater	A community's water that has been for various purposes such as toilet flushing or washing and then discharged, or wastewater discharged from an industrial source.
Wastewater catchment	The wastewater area draining to a point of interest, such as monitoring site or other watercourse (stream, wetlands, etc.).
Wastewater Collection System	The pipe system for collecting and carrying water and water-carried wastes from domestic and industrial sources to a wastewater treatment plant.
Wastewater Treatment	Biological, mechanical and/or chemical processes used to remove pollutants from wastewater in order to make it suitable for discharge to surface waters or reuse. It includes primary, secondary, and tertiary treatment.
Wastewater Treatment Plant	A facility and its associated processes of treating wastewater and generating effluent of a suitable quality.
Water catchment area	The geographical area drained by a river or stream or river. Also known as watershed or basin.
Water Table	The upper surface of the zone of saturation of groundwater in an unconfined aquifer.
Watershed	The geographical area drained by a river or stream or river. Also known as water catchment area or basin.

This glossary draws from glossaries and other resources available on the websites of the following organizations, networks and projects (Accessed between June 2015 and August 2015):

- American Rivers: http://www.americanrivers.org/green-infrastructure-training/2013/08/27/example-gray-infrastructure-wastewater-and-pollution/
- Australian Government, Australian Water Information Dictionary: http://www.bom.gov.au/water/awid/

- U.S. Environmental Protection Agency, 2002. Onsite Wastewater Treatment Systems Manual Systems Manual Systems Manual Wastewater Treatment Systems Manual. Office of Water Office of Research and Development U.S. Environmental Protection Agency: http://water.epa.gov/aboutow/owm/upload/2004_07_07_septics_septic_2002_osdm_all.pdf
- MIT, Water and Sanitation: http://web.mit.edu/urbanupgrading/waterandsanitation/resources/definitions.html
- Sacramento State, Office of Water Programs, Glossary of Water and Wastewater Terms: http://www.owp.csus.edu/glossary/index.php
- Texas Commission on Environmental Quality, Glossary for Surface Water Quality: https://www.tceq.texas.gov/waterquality/monitoring/glossary_viewer.html
- UNEP, Water Quality for Human and Ecosystem Health, 2008 United Nations Environment Programme Global Environment Monitoring System/Water Programme. http://www.unwater.org/wwd10/downloads/water_quality_human_health.pdf (Accessed July 17 2015)
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- Winnipeg, Glossary of Wastewater Terms: http://winnipeg.ca/waterandwaste/pdfs/sewage/projects/glossary.pdf

SECTION B: ECOSYSTEM IMPACTS FROM EXPOSURE TO WASTEWATER POLLUTION

This Section provides an overview of how ecosystems may be impacted by pollutants found within domestic wastewater, and an overview of recent studies that have estimated these impacts. In general, wastewater pollution enters ecosystems either directly or indirectly via untreated wastewater effluent, partially treated wastewater effluent or sludge. Secondary wastewater treatment does not always remove nutrients sufficiently (Lapointe et al. 2010).

Domestic wastewater pollution effluent and sludge is known to carry a variety of pollutants that directly and indirectly impact ecosystem health, including pathogens, nutrients, sediment, heavy elements, toxic chemicals, pharmaceuticals, and other organic and inorganic substances (e.g., faecal matter). Nutrient pollution (primarily nitrogen and phosphorus) is a concern for freshwater and coastal ecosystems as it can deplete water bodies of oxygen (i.e., eutrophication), result in algal blooms, can lead to the release of hydrogen sulphide and ammonia, which are toxic to some organisms. Excess nutrients can lead to enhanced plant growth which can alter ecosystem function and structure. Sediment and other suspended solids can smother ecosystems and deprive of light need for photosynthesis and growth. Sewage sludge is another concern as it can decrease species biodiversity and increase heavy metal concentrations in soils and plants. Pathogens can be transferred to marine and freshwater species from bacteria like *salmonella* (Islam and Tanaka 2004).

By negatively impacting ecosystem health, wastewater pollution also impacts the ecosystem services provided by ecosystems including fish production, shoreline protection, tourism, and recreation. The following table gives examples of studies estimating impacts of wastewater pollution on relevant ecosystems.

Table 1: Examples of studies of the impacts of domestic wastewater contamination in coastal, freshwater and land-based ecosystems

Ecosystem	Wastewater Contaminant (s) of Concern	Ecosystem Impact(s)	Study location	Reference
Coastal Ecosystems				
Coral Reefs	Nutrients	Eutrophication; Macro-Algae overgrowth; Low dissolved oxygen content; Coral die-off; Beach Erosion; Habitat Loss	Caribbean	DeGeorges et al., 2010
	Nutrients and suspended particles	Increased macroalgal density; Lower cover of hard corals; Decline in fish abundance	Thailand	Reopanichkul et al. 2009
	Nutrients	Higher macroalgal biomass; Blooms of chlorophytes overgrowing reefs in the Buccoo Reef complex; Turtle grass invasion of the Nylon Pool area	Tobago	Lapointe et al. 2010
	Nutrients	Decrease in live coral cover, species richness, and juvenile coral density.	China	Huang et al. 2013

Mangroves	Nutrients	Changes in biodiversity for peri-urban mangroves receiving sewage (increase in crab biomass and decrease in gastropod abundance)	Kenya and Mozambique	Cannicci et. al. 2009
Seagrasses	Ammonium and nutrients	Higher biomass due to nutrient enrichment; Decreased biomass due to ammonium enrichment; Change in population structure	Portugal	Cabaço et. al. 2008
	Nutrients	Reduced rhizome growth rates	United States	Lapointe et. al. 1994
Estuaries	Nutrients	Decreased biodiversity; Increased dominance of opportunistic species	General	Alve 1995
	Nutrients	Decrease in net photosynthetic capacity	United States	Driscoll 2003
Terrestrial Ecosystems				
Heathlands **Prairies** **Grasslands**	Nutrients	Shift in the species composition and diversity of the ecosystem; Effects on soil chemistry	Netherlands United States	Smith et al. 1999
Agriculture	Heavy metals	Soil and plant contamination with heavy metals due to wastewater irrigation	India	Sharmaa et al. 2007
Freshwater Bodies				
Lakes and Rivers	Nutrients	Eutrophication; Algal Blooms;	China	Le et. al 2010
	Pharmaceuticals	Biodiversity Loss; Reduced algal biomass production; Proliferation of antibiotic resistant bacteria.	General	Kim 2007
	Nutrients Inorganic suspended solids	Shift towards dominance of cyanobacteria which produce toxic compounds harmful to aquatic lake life; Restriction of light penetration and limitation of growth of benthic and suspended algae in rivers.	General	Smith et al. 1999

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SECTION C: HUMAN HEALTH RISKS FROM EXPOSURE TO WASTEWATER POLLUTION

This section provides an overview of common human health risks related to exposure to untreated and improperly treated domestic wastewater release into fresh and coastal water bodies. These health risks are extensively documented and well understood. There are five main pathways of exposure: consumption of fish and shellfish from contaminated waters; bathing or swimming in contaminated waters; inhalation of contaminated waters; in the case of infectious diseases, direct contact with an infectious person; and mosquito bites.

Health issues related to consumption of fish and shellfish include:

- Amnesic Shellfish Poisoning
- Azaspiracid Shellfish Poisoning
- Ciguatera Fish Poisoning
- Diarrheic Shellfish Poisoning
- Neurotoxic Shellfish Poisoning
- Paralytic Shellfish Poisoning

Health issues related to contact with contaminated water through swimming or bathing include:

- Acute Febrile Respiratory Illness
- Acute Respiratory Disease
- Cryptosporidium
- Cyanobacteria
- E. Coli Food Poisoning
- Otitis external ("swimmers ear")
- Eye, ear, and skin infections
- Febrile Respiratory Illness
- Gastroenteritis
- Staphylococcus aureus

Health issues related to inhalation of the water vapors of contaminated wastewater:

- Acute Febrile Respiratory Illness
- Acute Respiratory Disease

Infectious diseases:

- Cholera
- Hepatitis A
- Typhoid

Human health issues associated with mosquito bites include:

- Encephalitis

Table 2: Common human health risks associated with untreated and improperly treated domestic wastewater

Health Risk	Symptoms	Pathways	Cause	Source
Acute Febrile Respiratory Illness	Fever, dry cough and/or sore throat, respiratory congestion, chills, headache, myalgia, malaise and sometimes additional gastrointestinal issues	Bathing or Inhalation	Bacteria or virus	Fleisher et al. 1996; Fleisher et al. 2010
Acute Respiratory Disease	Difficulty breathing, rapid breathing or shortness of breath, low blood pressure, organ failure	Bathing or Inhalation	Virus	Dwight et al. 2005; McCann et al. 2011
Amnesic Shellfish Poisoning	Nausea, vomiting, diarrhea, dizziness, disorientation, lethargy, seizures, permanent loss of short-term memory, acute respiratory distress may be fatal within minutes to hours, debilitating chronic neurologic symptoms lasting months to years	Consumption of Shellfish	Diatom (algae)	Fleming et al. 2006; Van Dolah 2000
Azaspiracid Shellfish Poisoning	Nausea, vomiting, severe diarrhea, stomach cramps	Consumption of Shellfish	Azaspiracid (nitrogen-containing toxin)	Fleming et al. 2006
Cholera	Watery diarrhea, vomiting, abdominal cramps, in extreme cases can cause premature labor and fetal death	Bathing and consumption of fish	Bacteria	Fleming et al. 2006; McCann et al. 2011

Health Risk	Symptoms	Pathways	Cause	Source
Ciguatera Fish Poisoning	Nausea, vomiting, diarrhea, numbness of the perioral area and extremities, reversal of temperature sensation, muscle and joint aches, headache, itching, tachycardia, hypertension, blurred vision, paralysis, acute respiratory distress may be fatal within minutes to hours, debilitating chronic neurologic symptoms lasting months to years	Consumption of Fish	Dinoflagellates (such as Gambierdiscus toxicus, that adhere to coral, algae and seaweed)	Fleming et al. 2006; Van Dolah 2000
Cryptosporidiosis	Diarrhea, stomach cramps or pain, dehydration, nausea, vomiting, fever, weight loss	Bathing	Parasite (Cryptosporidium)	DiGiovanni et al. 2006; Fleming et al. 2006
Cyanobacteria poisoning	Skin irritation, stomach cramps, vomiting, nausea, diarrhea, fever, sore throat, headache, muscle and joint pain, asthma, eye irritation, rashes, blisters of the mouth and nose, liver damage	Bathing	Bacteria (Blue-green algae)	Boehm et al. 2009
Diarrheic Shellfish Poisoning	Vomiting and diarrhea	Consumption of Shellfish	Okadaic acid (biotoxin)	Fleming et al. 2006; Van Dolah 2000
E. Coli Food Poisoning	Diarrhea, urinary tract infections, neonatal meningitis	Consumption of contaminated food or water	Bacteria	Boehm et al. 2009; Mazari-Hiriart et al. 2008; Rabinovici et al. 2004
Ear infections	Congestion and swelling of the nasal passages, throat and Eustachian tubes	Bathing	Bacteria or virus	Dwight et al. 2005; Fleisher et al. 1996; Fleming et al. 2006
Encephalitis	Most people exhibit no symptoms but in cases of severe infections, symptoms include high fever with head and body aches, stiff neck,	Mosquito bites	Virus	Indiana State Department of Health 2015

Health Risk	Symptoms	Pathways	Cause	Source
	muscle weakness, disorientation, tremors, convulsions and, in the most severe cases, coma or paralysis			
Eye infections	Inflammation	Bathing	Bacteria, virus or parasite	Boehm et al. 2009; Dwight et al. 2005; Fleisher et al. 1996; Fleming et al. 2006
Febrile Respiratory Illness	Cough or shortness of breath, fever or chills	Bathing	Bacteria or virus	Fleming et al. 2006
Gastroenteritis	Diarrhea, itchy skin, fever, lack of energy, loss of appetite	Bathing	Typically a virus (e.g. rotavirus or norovirus), but can also be bacteria (e.g. E. coli or salmonella)	Alexander et al. 1992; Dwight et al. 2005; Fleisher et al. 1993; Fleisher et al. 2010; Fleming et al. 2006; Given et al. 2006; Rheingans et al. 2009
Giardiasis	Violent diarrhea, excess gas, stomach or abdominal cramps, upset stomach, nauseas	Bathing and consumption of fish	Protozoan parasites	DiGiovanni et al. 2006; McCann et al. 2011
Hepatitis A	Jaundice, fatigue, abdominal pain, loss of appetite, nausea, diarrhea, and fever.	Consumption of contaminated food and water; Direct contact with an infectious person	Virus	Indiana State Department of Health 2015; World Health Organization 2015a
Neurotoxic Shellfish Poisoning	Nausea, tingling and numbness of the perioral area, loss of motor control, severe muscular ache, seizures, unconsciousness	Consumption of shellfish	Brevetoxins	Fleming et al. 2006; Van Dolah 2000
Otitis external ("swimmers ear")	Inflammation of the outer ear canal	Bathing	Bacteria (commonly caused by streptococcus, staphylococcus or pseudomonas)	Boehm et al. 2009

Health Risk	Symptoms	Pathways	Cause	Source
Paralytic Shellfish Poisoning	Tingling and numbness of the perioral area and extremities, loss of motor control, drowsiness, incoherence, respiratory paralysis, acute respiratory distress may be fatal within minutes to hours	Consumption of shellfish	Saxitoxins	Fleming et al. 2006; Van Dolah 2000
Poliomyelitis (Polio)	Sore throat, fever, nausea, vomiting, abdominal pain, constipation, and occasionally diarrhea	Consumption of food or water from contaminated waters; Contact with an infectious person	Virus	Center for Disease Control 2015
Salmonellosis	Diarrhea, abdominal cramps, vomiting, headache, body aches, fever	Consumption of food carrying feces; Consumption of contaminated water	Bacteria	Indiana State Department of Health 2015; Mazari-Hiriart et al. 2008
Skin irritation	Skin rash, ulcers or sores	Bathing	Bacteria	Boehm et al. 2009; Dwight et al. 2005; Fleming et al. 2006; Fleisher et al. 2010
Staphylococcus aureus	Skin infections, respiratory disease, food poisoning	Bathing	Bacteria	Boehm et al. 2009
Typhoid and Paratyphoid fever	Sustained high fever, malaise, anorexia, headache, constipation or diarrhoea, rose-coloured spots on the chest area and enlarged spleen and liver	Water consumption; eating or drinking beverages handled by someone with typhoid.	Bacteria	WHO 2015b

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SECTION D: COMPARISON OF WASTEWATER TREATMENT TECHNOLOGIES APPLICABLE FOR THE CARIBBEAN

Table 3 compares wastewater treatment technologies commonly found in the Caribbean region by a number of factors (described below). This table is designed to provide economic valuation practitioners with a general sense of how technologies compare to one another in terms of wastewater technology design, costs, and externalities like odor that may be useful for completing the Characterization Form for a study site.

Table 3: Wastewater Infrastructure Comparison by Treatment Technology/Design

Treatment technology	Oxidation conditions	Treatment level	BOD removal efficiency	Nutrient removal efficiency	Coliform removal efficiency	System Type	Odor nuisance	Land requirement	Investment cost	Operational complexity	Operating and maintenance Cost
Conventional/Intensive systems											
Activated Sludge	Aerobic	Secondary	>90%	Organic waste, Some Nitrogen and Phosphorus	90-98%	Centralized	None	Low	High	Complex	Medium
Membrane Bioreactor	Aerobic	Secondary and Tertiary	96-99%	Organic Waste, Some Nitrogen and Phosphorus	90%	Centralized or Satellite	None	Low	High	Complex	High
Aerated Lagoon	Aerobic	Secondary	up to 95%	Incidental	60-99%	Centralized	Can be considerable	Low-Medium	Low-Medium	Moderate	Medium
Rotating Biological Contactor	Aerobic	Secondary	94.20%	Incidental	High	Centralized or Satellite	Can be considerable	Low	High	Complex	High
Trickling Filters	Aerobic	Secondary	80-90%	Incidental	90-95%	Centralized or Satellite	Can be considerable	Medium (requires 4x amount of land as activated sludge)	High	Simple	Low
Non-conventional /Extensive systems											
Constructed Wetlands	Aerobic and anaerobic	Secondary	50-90%	30-90% N 20-50% P	80-99%	Cluster, Satellite, Centralized	None	High	Low	Simple	Low
Waste Stabilization Ponds	Aerobic and anaerobic	Primary and Secondary	>50%	Organic Waste, (passive Nitrogen and Phosphorus)	90-99%	Centralized	Some potential	High	Low-Medium	Simple	Low
On-site systems											

Treatment technology	Oxidation conditions	Treatment level	BOD removal efficiency	Nutrient removal efficiency	Coliform removal efficiency	System Type	Odor nuisance	Land requirement	Investment cost	Operational complexity	Operating and maintenance Cost
Pit Latrines	Aerobic and Anaerobic Zones	Primary	Organic Waste	Does not remove nutrients	N/A	Individual; On-lot	Can be considerable	Low	Low	Simple	Low
Soakaway	Aerobic	Primary and Secondary	Organic Waste	Does not remove nutrients	N/A	Individual; On-lot	Can be considerable	Low	Low	Simple	Low
Septic tanks	Anaerobic	Primary and Secondary	Organic Waste	Good phosphorus removal	N/A	Individual; On-lot	Moderate	Low	Low	Simple	Low

Brief overview of comparison factors (*terms underlined are defined in the Glossary)*:

- **Oxidation Conditions:** Oxidation conditions can be either aerobic anoxic, or anaerobic for metabolic processes of wastewater treatment.
- **Treatment Level:** There are three levels of wastewater treatment generally used in the Caribbean: primary, secondary, and tertiary.
- **Biochemical Oxygen Demand (BOD) Removal Efficiency:** Efficiency of a treatment technology in the removal of BOD.
- **Nutrient Removal Efficiency:** Efficiency of a treatment technology in the removal of nutrients from wastewater, most significantly organic waste, nitrogen, and phosphorus.
- **Coliform Removal Efficiency:** Efficiency of treatment technology in the removal of coliforms from wastewater.
- **System Type:** Refers to the gallons per day that can be treated and the applicable geographical area. Classified by Bedford et al. 2015 as:
    - Individual on-lot systems
    - Cluster systems
    - Satellite systems
    - Centralized systems
- **Odor Nuisance:** The degree to which mal odor associated with domestic wastewater is present near or around an application of a given treatment technology.
- **Land Requirement:** Scale of High, Medium to Low based on land requirements needed to create functioning treatment technology relative to other treatment technologies listed.
- **Investment Cost:** Scale of High, Medium to Low based on required investments to create functioning treatment technology relative to other treatment technologies listed.
- **Operational complexity:** Scale of Complex, Moderate to Simple based on level of complexity and skill required to operate and maintain treatment technology.

- **Operating and Maintenance Cost:** Scale of High, Medium to Low based on costs required to operate and maintain treatment technology relative to other treatment technologies listed.

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ANNEX 3A. CHARACTERIZATION FORM FOR DEFINING THE COSTS AND BENEFITS OF DOMESTIC WASTEWATER MANAGEMENT

STUDY SITE: Isla Colon, Bocas del Toro, Panama

UN environment
United Nations Environment Programme

CARIBBEAN ENVIRONMENT PROGRAMME

Annex 3A. Characterization Form for Defining the Costs and Benefits of Domestic Wastewater Management – Isla Colon, Panama

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STUDY SITE: Isla Colon, Bocas del Toro, Panama

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RESPONDENT INFORMATION

This report was completed by:

Name: Erin Gray, Lauretta Burke, and L. Jasmine Lambert, World Resources Institute

Organization: World Resources Institute

Date: August 12, 2015 – *Note: This document reflects the understanding of the study site through this date. Since August 12, 2015, the future wastewater management scenario has been updated for Isla Colon. The future wastewater section of this form details this new scenario as a footnote.*

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Contents:

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I. DEFINE THE STUDY AREA

Objective: Define and map the study area including key geographic and land use data to identify wastewater pollution and other water pollution pathways and populations of interest.

Possible data sources: National environmental, water, and/or marine agencies; non-profit organizations (NGOs); academic institutes with marine/environmental centers that conduct research within the study site.

1. Please define the study area by providing a detailed description.

The study area should include the sewage catchment name(s) and geographic area, the populated area to be served by improved wastewater treatment, the area downstream which is expected to be influenced by the change in wastewater management (including receiving water bodies (e.g., rivers, lakes, oceans) and water catchments, and the upstream catchment (which might be contributing pollutants to the water body of focus).

The selected study site area is the island of Isla Colon in Bocas del Toro Province. Isla Colon is the most populated island of the archipelago of Bocas del Toro. The island is divided into a northern and southern section by a small isthmus. Most development is centered in Bocas Town located in the southern part of the island. The northern part of the island is primarily forest with some development, including new residential development. The Bocas del Toro archipelago is divided into two semi-closed lagoons – the Chiriqui Lagoon and the Bahia de Almirante.

The introductory Ministry of Environment (MdA) and World Resources Institute (WRI) workshop (MdA and WRI 2014) confirmed the following as important beaches and locations:

- Beaches: Itsmito Beach (also known as La Feria), Big Creek, Bluff, Mimitibi, Bocas del Drago, Starfish.
- Other important locations: Main Park, Governor's Building, Hotel Bahia, Airport, Hospital, Cemetery, La Feria, Bluff, La Gruta bat cave, Bocas del Drago.

The Bocas del Toro archipelago is also divided into two semi-closed lagoons – the Chiriqui Lagoon and the Bahia de Almirante.

2. Can you put it on a map? (with GIS; Google Earth; or participatory mapping)

If possible, indicate on a map the information provided in Question 1. This can be done in GIS, using Google Earth, and/or working with stakeholders using a participatory mapping approach to highlight on a hard copy map the response to Question 1.

We currently do not have GIS data – but have the following maps:

Figure 1: Wikipedia (2015) image of the Archipelago of Bocas del Toro

Figure 2: Bahia Almirante Map from Seemann et al. 2014

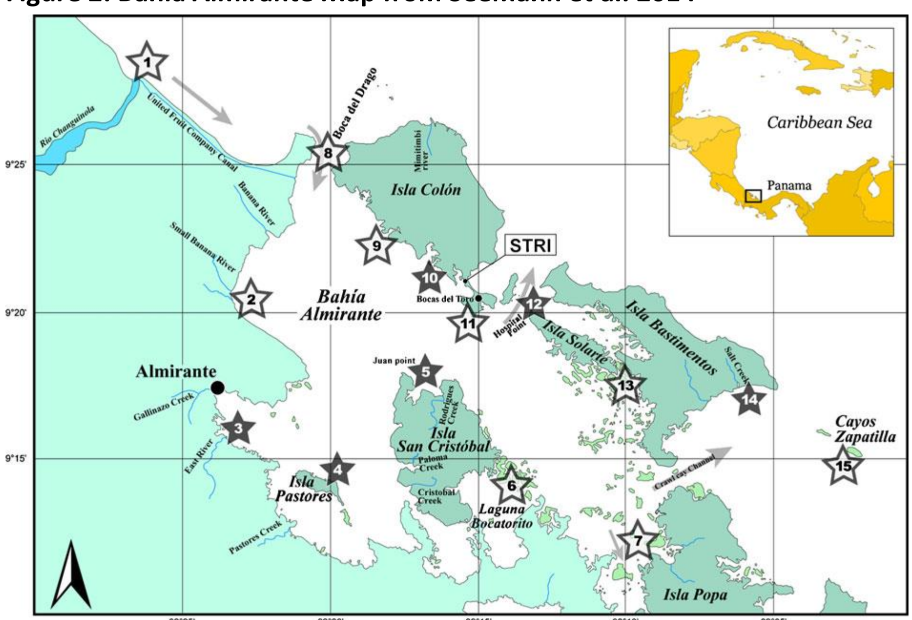


Figure 3: Google Earth image of Isla Colon (left) and Bocas town and Isla Carenero (right)

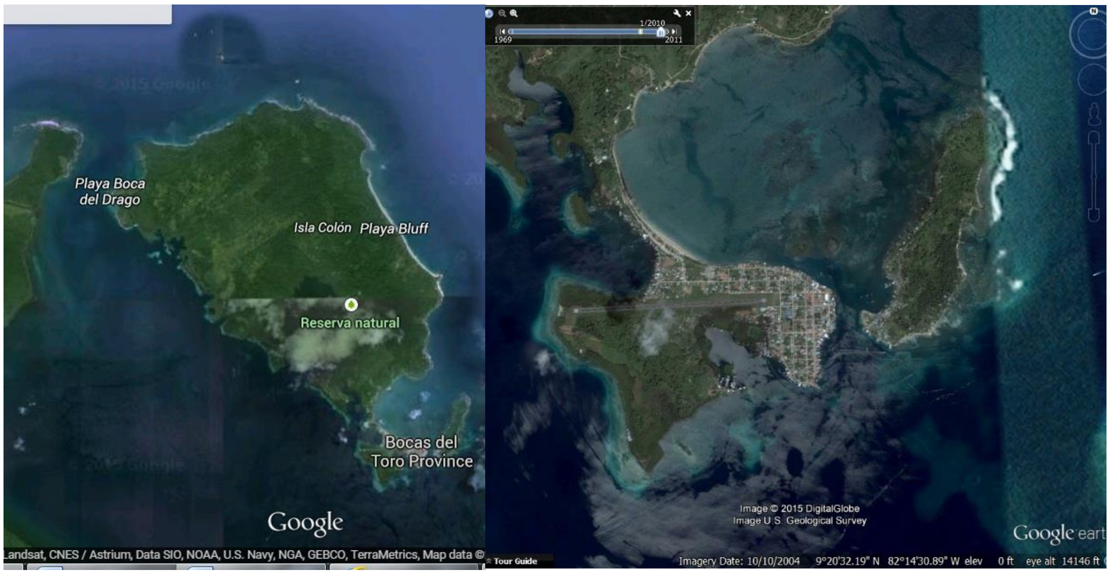
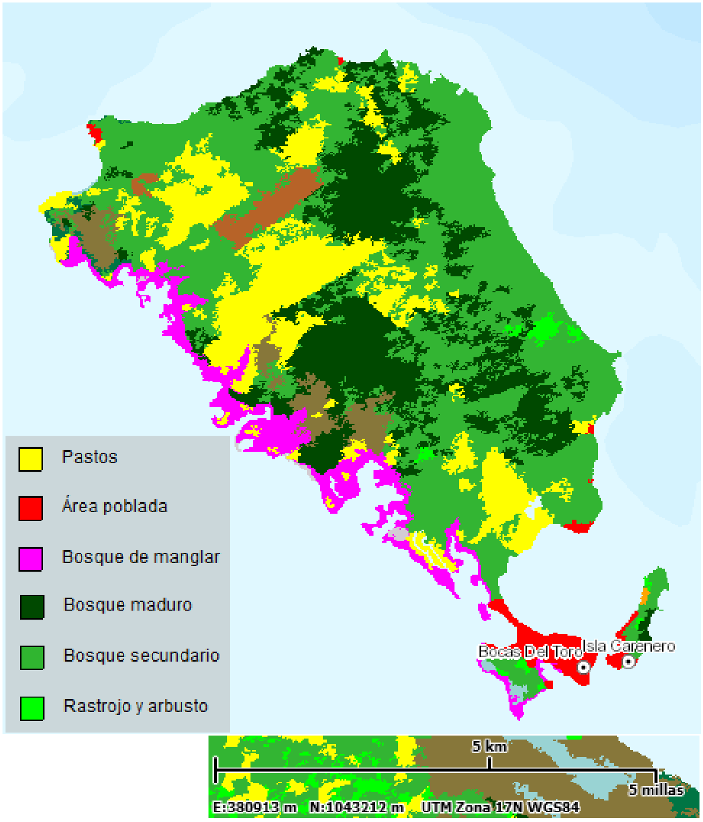


Figure 4: Spatial map of Terrain



*Adapted from 2012 Map of Coverage, Ministry of the Environment (2012)

3. What are the major <u>land uses</u> (such as residential, commercial, agricultural, open space / natural) in the study area?

- **Could you do rough estimates of percentages of each major land use?**

Based on stakeholder input from the introductory MdA and WRI workshop (2014), primary land uses include residential, commercial (including tourism), agriculture, forest, and informal indigenous settlements. There are about 523 indigenous families living in Bocas Town and their settlements have been constructed in the mangroves adjacent to the wastewater treatment facility (MdA and WRI 2015). The majority of development has happened south of the isthmus around Bocas Town. The northern section of the island above the isthmus appears to be primarily forest, some of which is primary forest, but there is also some residential development in this area.

Workshop participants stated that since the 1990s, there has been a sharp increase in tourism and associated infrastructure. For example, participants noted that the number of hotels on the island has risen from 6 to 40 over the past decade.

==

II. POPULATION

Objective: Population data is critical for understanding current and future wastewater demand as well as the number of people who may swim in or eat from waters contaminated with untreated wastewater.

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. How many <u>people</u> live in the study area? (Approximate if necessary.)

The province of Bocas del Toro has a population of 125,461 (INEC Panama 2010). Isla Colon is the most populated island in the Bocas del Toro archipelago. The main population center is Bocas Town, which as of 2008 had a population of 12,996 people (Wikipedia 2015). Additionally, according to 2010 Census Data there are 227 people living in Big Creek, 19 people living in Bluff, and 290 people living in Boca de Drago (INEC Panama 2010), giving an estimated total population of 13,532 for Isla Colon. Anecdotally, we have heard that the population of Isla Colon is closer to 15,0000.

Bocas Town has become a popular tourist destination with approximately 80,000 visitors per year (with 79,788 tourists in 2014 and 77,714 tourists in 2013 and a 3 % annual growth rate in tourism in the past two years. Tourists are mostly coming from Europe, the United States, Panama, and Asia (MdA 2015b).

2. Can you disaggregate this by neighborhood / area / housing development / smaller administrative unit?

No.

3. How many <u>households</u> are in the study area? (Approximate if necessary)

The average size of household in Panama is roughly 4.4 people (UN Stats 1995), so a rough estimate of the total number of households in Isla Colon would be ~3,400 assuming a population of 15,000 people.

There are approximately 523 indigenous families living 2-3 families per house) living in Bocas Town (MdA and WRI 2015).

4. What is the population projection for the study area over the next 20, 30, and/or 50 years (for each period if data are available)?

The annual population growth rate for Panama is two percent (World Bank 2015), so the population projection based on this figure is:

- Current (2015): 15,000
- In 20 years (2035): 22,289
- In 50 years (2065): 29,998

However, the rate is likely lower for Isla Colon as many nationals live on the mainland and travel by boat to Isla Colon for work. Participants of the Mda and WRI workshop (2015) stated that the expatriate population, however, is growing on the island.

==

III. ECONOMIC ACTIVITIES

Objective: Economic data are important for understanding the economic activities that are important for the local economy that rely on ecosystems (especially those potentially impacted by water pollution).

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. Are the following sectors important for the local economy (ideally for the study area)? Can you estimate the relative contribution from each sector to the local economy? If quantitative data are not available, please rate the sector's importance based on the following scale:

Importance Scale:

- **Not important:** The sector is not relevant as it does not contribute much to local GDP (e.g., through jobs or financial contribution)
- **Moderate importance:** The sector is important, but is not the main contributor to local GDP.
- **Very important:** The sector contributes substantially to local GDP.
- **Critical:** The sector contributes the largest amount of any sector to local GDP

- **Tourism? (Note types of tourism)**
- **Agriculture? (Note types of agriculture)**
- **Fisheries? (Note major fish species)**
- **Industry? (Note what industry/ies)**
- **Other?**

Historically, the economy of Isla Colon was based largely on agriculture, namely, banana plantations. Today, the island's economy is based mostly on tourism – primarily ecotourism. Eco-tourism activities include (MdA and WRI 2014 & 2015; Frommers 2015):

- Recreational beaches (Starfish Beach, Sandfly Beach, Big Creek Beach, Boca del Drago, and Bluff Beach)
- Boat tours to surrounding tourism spots
- Bird Island – a small rocky outcropping off the northern tip of Isla Colon, famous for birdwatching. It's the only place in Panama to see the Red-Billed Tropicbird.
- Surfing
- Scuba diving and snorkeling

The commercial sector has been built up around tourism and includes a local airport, local restaurants, hotels, handicrafts, bicycle rentals, and tours. Fishing and limited agriculture are still practiced on the island (small cattle, banana farming, and subsistence farming). The island is also home to the Smithsonian Tropical Research Institute, which attracts scientists, students and tourists alike.

In addition to tourism, the island hosts a significant number of yachts and cruise ships each year.

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IV. KEY ECOSYSTEMS

Objective: To understand potential benefits to ecosystem health from wastewater management improvements, it is necessary to a) identify key ecosystems in the study sites, b) their economic contribution in terms of key goods and services they provide, c) their contribution to key economic sectors. This will help to characterize the dependence of these sectors on healthy ecosystems, and as a result, the value of these ecosystems to the study population and the nation.

Possible data sources: Government environmental/water/natural resource agencies or ministries; Academic institutes and environmental NGOs conducting research or working towards the protection or conservation of ecosystems; Peer-reviewed and grey literature on key ecosystem both within and outside of the study area; Government reports including environmental impact statements, water quality permits, or benefit-cost analyses;

1. **What are the key ecosystems in the study area (e.g., coral reefs, mangroves, seagrass beds, beaches, forests, wetlands), especially downstream from population, sewage discharge, or treated wastewater discharge? Key ecosystems are those which are important to the local economy or those which provide important cultural services.**

The Bocas del Toro archipelago is a complex chain of islands, mangrove cays, peninsulas, fringing reefs, and seagrass beds (Collin 2005). The archipelago is divided naturally into two semi-enclosed lagoons; the Chiriqui Lagoon is a turbid environment highly impacted from runoff, while Almirante Bay is less impacted by runoff (D'Croz et al. 2005). Silva (2015) states there are 60 species of coral in Panama, many of which can be found in Bocas del Toro. The Bahia de Almirante is a semilagoon system that has one main inlet at Boca del Drago and outlets between Isla Colón and Bastimentos, and another at the east of Isla Popa (see Fig. 1). It is bordered by large coastal swamps and mangrove forests (Seemann et al. 2014).

The national parks in the Province are Isla Bastimentos National Marine Park (Parque Nacional Marino Isla Bastimentos) and La Amistad International Park. The Isla Bastimentos National Marine Park contains most of Isla Bastimentos and some smaller nearby islands and extends into a large nature preserve at the Red Frog Beach Island Resort. La Amistad International Park (Parque Internacional La Amistad), spans the Costa Rica–Panama border. Bocas del Toro contains most of the Panamanian section of the park and covers 400,000 hectares (4,000 km2; 1,544 sq mi). La Amistad International Park is a designated UNESCO World Heritage site (UNESCO 2015). It is not clear the extent to which pollution activities from Isla Colon impact these two national parks and ecosystems.

Beaches are important ecosystems for Isla Colon. For example, Playa Bluff, located on the east side of Isla Colon, is an important site for marine turtles during nesting season and is therefore a habitat that has the potential to be impacted by untreated wastewater effluent from the island (Chacon et al. 2015). Starfish beach, Sandfly beach, and Big Creek beach are popular for swimming and important habitats as well. Bocas del Drago is a popular snorkeling spot (Bocas del Toro Travel 2015).

Bird Island Isla Colon is a popular habitat for sea birds.

There are coral reefs and mangrove forests directly off the coast of Isla Colon, however, specific spatial information about the borders and extents of these ecosystems is still lacking. The mangroves are known for having a diverse ecosystem structure (CONADES 2008a).

2. **Please rank how important these ecosystems are to the economic sectors previously listed in Section III (within the study area) (e.g., is tourism in the area dependent on healthy ecosystems?). Please indicate in**
3. **Table 1 below the relative importance based on this scale:**

Importance Scale:

- **Not important**: The ecosystem has no relevance to the economic sector.
- **Moderate importance**: The economic sector is dependent on resources/services provided by the ecosystem but substitutes for natural resources are available (e.g., forest ecosystems provide water filtration services that can improve the health of fisheries, but water filtration systems are also available to filter water).
- **Very important:** The economic sector is dependent on the resources/services provided by the ecosystem and substitutes are not available or are exorbitantly expensive (e.g., mangroves provide important coastal protection services, guarding some shoreline industries from flooding and hurricanes. While options exist to improve coastal protection like dikes jetties, this type of infrastructure can be costly to build and maintain).
- **Critical:** The ecosystem is vital to the economic sector in that the sector would not profit or exist without the ecosystem (e.g., tourism in a coastal community may be completely dependent on coral reefs for scuba diving, snorkeling, and sand creation as these activities provide the most income to the local economy).

Table 1: Ranking of ecosystem important to key economic sectors

ECOSYSTEM	AGRICULTURE	FISHERIES	TOURISM	ACADEMIA*

Example: Coral reefs	*Not important*	*Critical*	*Very important*	*Very important*
Coral reefs	Not important	Critical	Critical	Critical
Mangroves	Not important	Critical	Moderate	Critical
Seagrasses	Not important	Very important	Moderate	Critical
Beaches	Not important	Moderate	Critical	Critical

4. **What goods and services do these key ecosystems provide (i.e., what are each of the ecosystems used by people for?). Please fill out**
5.
6.

7. **Table 2 below and add or delete ecosystems as needed. You may refer to**
8.

9. **Table 3, which provides a general list of ecosystem services for major Caribbean ecosystem types, for guidance.**

Table 2: Ecosystem goods and services

Ecosystem Goods and Services	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES
Food	X	X	X	X
Raw materials	X	X	X	X
Medicinal resources				
Genetic resources				
Flood/storm/erosion regulation	X	X	X	X
Climate regulation	X	X	X	X
Tourism and recreation	X	X	X	
History, culture, traditions	X	X	X	X
Science, knowledge, education	X	X	X	X
Primary production	X	X		X
Nutrient cycling	X	X		X
Species/ecosystem protection	X	X	X	X
Water filtration/supply	X	X		X

Table 3: Examples of coastal ecosystem goods and services

ECOSYSTEM GOODS AND SERVICES	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES
Provisioning services				
Food (e.g., fisheries)	X	X	X	X
Raw materials	X	X	X	X
Medicinal resources	X	X		X
Genetic resources	X	X		X
Regulating services				
Flood/storm/erosion regulation	X	X	X	X
Climate regulation	X	X	X	X
Cultural services				
Tourism and recreation	X	X	X	
History, culture, traditions	X	X	X	X
Science, knowledge, education	X	X	X	X
Supporting services				
Primary production	X	X	X	X
Nutrient cycling	X	X		X
Species/ecosystem protection	X	X	X	X

Source: WRI Coastal Capital Guidebook (Waite et al. 2013)

10. Are there any <u>existing estimates of the economic values</u> of these uses of ecosystems for this study area or nearby (e.g., through peer-reviewed or grey literature)? If so, please list these values, describe the methodology used to develop them, and provide a citation.

We are not aware of any existing estimates of the economic values of these uses of ecosystems for this study area or nearby areas. Based on our own calculations using data provided by the Tourism Authority of Panama (ATP 2015), the tourism industry in Isla Colon employs approximately 6,102 people on the island, which is nearly half the population, and tourists contribute approximately 1.8 million dollars in vacation spending annually.[1]

[1] Employment and spending approximations were calculated using the percentage of total tourists that visit Isla Colon as a percentage of total tourists in Panama for 2013 & 2014 based on information given by the Tourist Authority of the Republic of Panama. This percentage was then used to calculate the relative ratio of people employed by the tourism industry based on national figures. Likewise, Isla Colon tourist population data was applied to national averages on tourist spending per visit to estimate the amount of money spent by tourists over the course of one year in Isla Colon. (Indicadores de Turismo de La Republica de Panamá, 2015)

11. **Do you have statistics on visitation / tourism (both foreign and national) to key ecosystems and/or statistics on visitation/tourism for the country for eco-tourism? For example, do you have data on the number of tourists (including cruise ship passengers, national and international tourists, and others) that visit the key ecosystems identified above?**

In 2013, 77,714 tourists visited Isla Colon, and in 2014, almost 80,000 tourists visited the island (and increase of 2.7%) (Ministry of Environment 2015).

There are 3 dive operators in Isla Colon that offer visits to some 17 different sites, the majority of which are inside of the Archipelago with some also at the Isla Bastimento.

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V. CURRENT WASTEWATER MANAGEMENT SITUATION

Objective: To understand how wastewater is currently treated within the study site to allow comparison against future wastewater management alternatives in terms of population served, untreated wastewater, pollution removal effectiveness for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits; Wastewater experts; Historical costs; National price books.

1. **On-site wastewater treatment coverage:**
   - **Please estimate the percentage of the total domestic wastewater sector within the study that uses each type of on-site system below. For example: 30% of the total population uses on-site treatment. Of this 30%, 10% uses septic system, 10% uses pit latrines, and 10% uses soakaway systems).**
     - **Septic systems**
     - **Pit latrines**
     - **Soakaway systems**
     - **Other?**

Up to 20% of the population is not connected to the central wastewater treatment plant (WWTP). We remain unsure about whether the 20% of the population not connected to the treatment facility is using on-site treatment or not.

IDAAN has a five year investment plan for Panama under the 100/0 plan to bring 100% access to water and have 0 pit latrines by 2019. The 100/0 plan was established by President Juan Carlos Varela, by which a national priority was set to provide 100% of Panamian residents with access to drinking water (24 hours a day), and eliminate pit latrines. The Consejo Nacional de Desarrollo Sostenible (CONADES) helped create this plan and is working with IDAAN to realize its success.

- **What percentage of on-site systems (septic systems, pit latrines, soakaway systems, etc.) are properly maintained (i.e., regularly pumped out, drain fields not clogged, etc.)?**

Data not available.

2. **Wastewater collection system (i.e., sewerage):**
   - **Please describe the coverage of the current sewage collection system in terms of length of pipelines and the ultimate treatment point.**

There is no underground sewerage system, but rather a series of drainage networks.

3. **Please estimate the percentage of the total population and commercial and industrial establishments within the study that are connected to a centralized sewerage system.**

It is estimated that only 80% of the population in Bocas Town is connected to the wastewater treatment facility. However, the number of homes/businesses actually connected remains unknown. MdA and WRI workshop participants (2014) stated that they believe some development has been unregulated (namely Hotels), and that the number of new hotels connected to the plant is unknown. Zero of the 523 indigenous families are connected to the WWTP (IDAAN 2015).

4. **Wastewater treatment plants:**
   - **Please describe the number and type of wastewater treatment plants (WWTP) currently in place in the study area.**

In the 1980s, Isla Colon's wastewater treatment consisted of one oxidation lagoon, without an aeration system. Water was simply retained in the pond for 15-20 days and then released into the ocean. In 1991 there was a large earthquake that fractured the walls of the oxidation lagoon. IDAAN decided to divide the lagoon into two parts and only one part remained as an oxidation lagoon. In 2010 IDAAN installed an aeration system into the oxidation lagoon. Currently, only one of the two lagoons is functioning as an aeration (or oxidation) lagoon at a capacity of 3,055 m3/day and is meant to meet double the current population needs. There are a series of station pumps across Isla Colon that pump to the lagoons (IDAAN 2015). The capacity of the operational aeration lagoon is frequently exceeded during periods of high rainfall, resulting in the release of untreated sewage. In addition, the aeration pumps sometimes malfunction.

The challenges related to the state of current wastewater treatment on Isla Colon include (MdA and WRI 2014, 2015):

- The current wastewater treatment facility only treats residences and businesses up to the little isthmus and not the greater Isla Colon area (which is mostly forested, but is experiencing some development for homes and hotels). Additionally, it is estimated that only 80% of the population in

Bocas Town is connected to the facility. However, as previously stated, it is not known the number of homes/businesses actually connected.

- There could be some hotels with individual treatment plants but whether they are complying with regulations remains unknown.
- Restaurants do not have proper grease management (i.e., lack of compliance with regulations), which can get stuck and harden in pipes.
- Indigenous settlements are known to dump garbage directly into the sea and they lack fresh water and sanitation. Property prices are too high for many families to own or rent homes. It is thought that there is a high rate of infant mortality in these settlements. While the government cannot currently evacuate this population but is coming up with plans for resettlement and reforestation.
- There is no warning system for water contamination events and water quality is not monitored.
- The quality of potable water in the area is inadequate and water demand is growing with increasing tourism. There is some contamination of groundwater resources. There is currently not a drinking water treatment facility on the island (IDAAN 2014).
- There are zero ANAM lab technicians residing on Isla Colon; while water quality monitoring should be taking place, water quality monitoring is not being done.

    - **For each WWTP, please fill in Table 4 to the best extent possible. Please see Annex 2 for a glossary of wastewater terminology. Please copy and paste this table as needed if more than one treatment plant exists within the study site:**

Table 4: Wastewater Treatment Plant information for current situation

Data need	Data
Design	
Location	Bocas Town
Design capacity - Nominal design capacity for dry and wet weather flows.	3,055 m^3/day (PURITEC-GES)
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Aeration lagoons
Effluent limits	
Sludge treatment and disposal	
Discharge location (receiving water body). If coastal, identify the outfall locations.	

Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Current flows (annual average flow, monthly average peak flow)	
Annual energy usage (kW hours, total cost)	
Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and estimated bypassed volume for each event).	
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	Reported over flow occurrences during period of very heavy rainfall
Annual average discharged concentrations and loads of:	Not available
• BOD_5 (mg/l, kilograms per year)	
• Dissolved oxygen (mg/l)	
• Total Nitrogen (mg/l, kilograms per year)	
• Ammonia Nitrogen (mg/l, kilograms per year)	
• Total Phosphorus (mg/l, kilograms per year)	
• Total Suspended Solids (mg/l, kilograms per year)	
• Faecal coliforms (units as reported)	
• Enterococci (units as reported)	

5. What is the estimated annual percentage of total wastewater generated that is untreated and released into water bodies? What is the estimated annual volume?

Not sure, but there is definitely some untreated wastewater that is being released directly into water bodies. According to the Management Plan for Bocas del Toro (CONADES 2008a), the concentrations of organic material and nutrients in the coastal waters are reducing the level of dissolved oxygen and stimulating the growth of algae, i.e. eutrophication. This is creating environmental health problems and is aesthetically displeasing to tourists in sites of high tourist population density.

6. **If there is untreated sewage, where does this go? If possible, please also note on a map the receiving water bodies and ecosystems that receive the untreated sewage – either directly, or via an outfall.**

Untreated sewage is known to pass directly into the mangroves and coastal waters (CONADES 2008b).

7. **Is there an interest in improving, upgrading, or expanding the current wastewater management system in the area? If so, please describe who is interested and why.**

Yes. A new inter-institutional committee has been established to deal with water issues in Isla Colon, including wastewater, a desalinization plant, the indigenous settlements, and other topics. The Committee includes the Ministry of Environment, the Ministry of Health, IDAAN, and CONADES.

Additionally, as part of the 100/0 plan, the government of Panama (through CONADES) is currently working on a census to identify wastewater infrastructure conditions in the. The census is a household survey to identify current WW treatment efforts by all residences, commercial establishments, etc. The census must first be completed before any selection of future infrastructure is made.

8. **Current wastewater treatment costs - What capital and annual operating and maintenance costs are associated with the current wastewater management situation? Please fill in Table 5 to the best extent possible. If you do not have specific cost data, please provide a description of the *likely* costs associated with the current scenario by referring to Annex 2, section D.**

Table 5: Current wastewater scenario costs

Data need	Current wastewater management situation
Year of installation	2010 (for aeration system)
Life expectancy (years)	unknown
Total land area occupied by the plant (hectares)	
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced within the next 20 years and the total capital cost, including likely year of replacement and the frequency of replacement)	The initial investment cost for the plant has been estimated at $2.2 million dollars for a demand of 11,000 people (MdA 2015a). It is not clear what the recurring capital expenses are, however.
Annual recurring expenses:	$8000/month (MdA and WRI 2015)

-Salary/wages for all personnel plus personnel of any contracts associated with operation of the WWTP. -Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)	
External services costs (if applicable, net value of total costs of external services including outsourcing, costs for construction)	
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)	
Other costs?	
Net present value over infrastructure's lifetime	

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VI. WATER QUALITY

Objective: To identify and list water quality standards and requirements that are applicable to the wastewater sector and identify and provide historic data (over the past five years) on water quality within wastewater receiving bodies and key ecosystems in the study area.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants or engineers that work with the wastewater authority

1. What water quality standards/requirements apply for the study area?

- **National/Regional and Local water quality standards?**
  - **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
  - **Numeric criteria?**

- **Bathing/swimming standards**

- **International standards (e.g., LBS Protocol)**

- **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
- **Numeric criteria?**

The relevant wastewater standards for Panama include the LBS Protocol[2] (of which Panama is a signatory) and the national Technical Regulation DGNTI-COPANIT 35-2000: Water Effluent discharges directly into bodies of surface water and groundwater (see Table 1).

Table 1: Wastewater quality standards for Panama

POLLUTANT TYPE	Land Based Source Protocol Standard	Panama Coastal Water Body Standard (DGNTI-COPANIT 35-2000)
Five Day Biological Oxygen Demand (BOD_5)	30 mg/l	35 mg/l
Total Suspended Solids	30 mg/l*	35 mg/l
Faecal Coliforms (Freshwater)	200 MPN/100 ml;	N/A
Faecal Streptococci	N/A	N/A
Enterococci (Saline water)	35 organisms/100 ml	
Total Phosphorus	"take appropriate measures to control"	5 mg/l
Total Nitrogen	"take appropriate measures to control"	6.0 mg/l NO_3 10.0 mg/l N
Solid Waste	N/A	N/A
Fats, Oil and Grease	15 mg/l	20 mg/l

[2] The LBS Protocol is a regional mechanism assisting the United Nations Member States in the Wider Caribbean Region to meet the goals and obligations of two international agreements: The United Nations Convention on the Law of the Sea (UNCLOS) and the Global Plan of Action for the Protection of the Marine Environment from Land-Based Activities (GPA). UNCLOS calls upon States to adopt laws and regulations to prevent, reduce and control pollution of the marine environment from land-based sources

* Does not include algae from treatment ponds

Under the technical regulation DGNTI- COPANIT 35-2000 (which regulates the discharge of liquid effluents), constructors were obliged to develop their housing projects with water treatment plants instead of connecting them to septic tanks. Legally, IDAAN is responsible for collecting and accepting treatment plans for all buildings constructed by developers or individuals. While, IDAAN has financial and operational limitations, they have assumed the cost of operating and maintaining all sanitary facilities.

2. What data or information do you have about water quality in the study area? Can you provide:

- **Ambient water quality monitoring data in freshwater bodies?**
- **Ambient water quality monitoring data in coastal waters?**

Stakeholders at the MdA and WRI workshops (2014, 2015) stated that water quality data is not collected currently. There is a lot of confusion from applicable Ministries on who is responsible for what. The general understanding, however, is that:

- IDAAN should monitor water quality at wastewater discharge points
- The Autoridad de Recursos Acuáticos de Panamá (ARAP) should monitor water quality after an environmental event (e.g., fish kill)
- MdA should monitor water quality of fresh water bodies

IDAAN does not have any water quality data available for Isla Colon.

3. Please compare these data to water quality standards/requirements:

- **Are any water quality standards being violated in lakes, non-tidal streams and rivers, and coastal areas? Please provide frequency and severity.**
- **What are the pollutants causing the violation and what are their sources (e.g., untreated wastewater, WWTP effluent, onsite septic systems, soakaways, pit latrines, sources from other sectors such as mining or agriculture)**

Data not available.

4. If any water quality standards are being violated, have the violations been linked to wastewater discharges? If so, please provide specific information on the linkage.

Data not available.

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VII. ECOSYSTEM IMPACTS

Objective: To understand if there is a demonstrated link between wastewater pollution and ecosystem health.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants/engineers working with the wastewater authority; Environmental impact statements; Environmental/marine NGOs and government agencies; Academic and grey literature.

1. **Within the study area, are any of the following causing ecological impacts, such as algal blooms or damage to coral reefs:**
   - **Discharge of untreated or partially treated sewage?**
   - **Discharge of treated wastewater effluent?**
   - **Irregular release of wastewater from a WWT system due to overflow, rainwater events, or power failure, etc.?**

Stakeholders from the MdA and WRI workshops (2014, 2015) state that discharge of untreated domestic wastewater and irregular release of wastewater from the WWTP is likely impacting ecosystems, although not to an extent that is yet impacting tourism or livelihoods.

The 2008 Management Plan (CONADES 2008a) says that microbiological levels (i.e., fecal and total coliforms) should be being measured every three months, as these have the greatest potential to impact human health. However, there is no evidence that any of these contaminating substances have been measured or that there are limits for their amounts.

Degradation of coral reef communities due to an increase in anthropogenic impacts has been documented in reefs across the Caribbean, and within Almirante Bay (Bahía Almirante) in Bocas del Toro, Panama (Guzmán and García 2002; Collin 2005; Guzmán et al. 2005; Collin et al. 2009; Karpenter et al. 2008; Seenmann et al. 2014). It is not clear, however, the extent to which untreated wastewater is contributing to this degradation.

In 1999 the Smithsonian set up coral reef monitoring systems at their field station on the Isla Colon and as of 2008, had 33 different testing sites up and running. However, to date, no studies have specifically linked wastewater pollution to ecosystem health in this area.

We found several other studies that have looked at ecosystem impacts near Isla Colon, however, none mention domestic wastewater as a pollution source. Seemann et al. (2014) conducted a study assessing the ecological impacts of human impacts on coral reefs in Bocas del Toro. They conducted environmental and biological reef monitoring in Almirante Bay (Bahía Almirante) that assessed how seasonal temperature stress, turbidity, eutrophication and physical impacts threatened reef health and biodiversity throughout the region. Environmental parameters such as total suspended solids [TSS], carbon isotopes (δ13C), C/N ratios, chlorophyll a, irradiance, secchi depth, size fractions of the sediments and isotope composition of dissolved inorganic carbon [DIC] of the water were measured throughout the years 2010 and 2011 and were analyzed in order to identify different impact sources. The study found:

- Eutrophication and turbidity levels seemed to be the determining factor for the loss of hard coral diversity, most significant at chlorophyll a levels higher than 0.5 μg l−1 and TSS levels higher than 4.7 mg l−1. Hard coral cover within the bay has also declined, at some sites down to <10 % with extremely low diversities (7 hard coral species). The hard coral species Porites furcate dominated the reefs in highly impacted areas and showed a strong recovery after bleaching and a higher tolerance to turbidity and eutrophication compared to other hard coral species in the bay. Serious overfishing was detected in the region by a lack of adult and carnivorous fish species, such as grunts, snappers and groupers. Study sites less impacted by anthropogenic activities and/or those with local protection showed a higher hard coral cover and fish abundance; however, an overall loss of hard coral diversity was observed.
- Also, hard coral species richness has declined from 60 species reported for the Caribbean and 58 species reported for the Bocas del Toro area to 42 species
- The authors did not discuss wastewater as one of the anthropogenic impacts, however, but did link nutrients from fertilizers as well as coastal developments.

Berry et al. (2013) found that anthropogenic activities have a negative impact on coral tissues and sediments in Bocas del Toro due to heavy metals. Sources of heavy metals were cited as shipping activities from the Port of Almirante, *domestic sewage*, agricultural activities and unpredictable sources such as oil waste by tankers.

Cramer et al. (2012) found evidence of increasing environmental stress on reefs in Bocas del Toro, namely reductions in bivalve size and simplification of gastropod trophic structure. The authors list possible causes of environmental stress as: land clearing, initially for banana production but then for tourism; and fishing.

2. Have any studies been conducted within the study site or your country or region that link wastewater pollution to ecosystem health? If so, what are the findings?

In Panama, new developments and infrastructure (like WWTPs) should complete an Environmental Impact Study (EIS). IDAAN (2015) states they have completed an EIS for the aeration system in Isla Colon from 2013 but they were not able to provide it at this time.

3. Is there evidence of the following in any of the key ecosystems present in the study area: (e.g., freshwater, wetlands, mangroves, beaches, coral reefs, forests, wetlands):

- **Is it unsightly due to pollution? Are there algal blooms or obvious evidence of pollution?**

Stakeholders from the MdA and WRI workshop (2014) said they are not noticing any algal blooms.

- **Is there odor due to pollution?**

There are reports of odor in coastal mangroves (MdA and WRI workshop 2014).

- **Are there impacts to fish or other aquatic life (e.g., fish kills, overgrowth of algae on coral reefs)?**

Not sure.

- **Are you seeing a change in ecosystem health and/or growth?**

Recent water quality monitoring data from the Smithsonian Tropical Research Institute (STRI) has shown that despite the continued deforestation on the mainland and development in the islands, water quality has not shown any significant decrease over the last 10 years. However, STRI notes that clarity and chlorophyll concentration hover near the levels indicative of eutrophication (STRI 2008).

However, stakeholders at the MdA and WRI workshop in 2015 stated that they are seeing a decrease in the starfish population at Starfish beach and that mangroves around the WWTP are being negatively impacted.

4. **Beyond wastewater, are there any other sources of water pollution contributing to these problems? If so, please indicate the relative contribution to total water pollution using the following scale:**

   No contribution – Minor contribution – Moderate contribution – Significant contribution

- **Runoff from croplands?**
- **Runoff from livestock?**
- **Runoff from aquaculture?**
- **Industrial discharge?**
- **Cruise ships/yachts?**
- **Others?**
- **Do you have a sense of the relative contribution from wastewater to overall pollution of key ecosystems compared to these other sources? If so, please describe.**

Yes, evidence from the studies above show that agricultural runoff, port activities, and coastal development and land clearing are contributing to pollution. It is unclear the percentage of total contribution however from each pollution source. These environmental stressors may cloud what we know about untreated wastewater effluent pollution entering coastal areas.

5. **Are there any economic or cultural uses of the key ecosystems that are in decline due to wastewater discharge issues (from untreated or improperly treated wastewater)? Please refer to Annex 2, section B for examples of Caribbean coastal ecosystems and impacts that have been documented from exposure to untreated or improperly treated wastewater.**

Not sure.

6. **Do tourists have any awareness of water quality issues and do they modify activities / visitation? Are you able to quantify or describe the change in visitation (e.g., reduced annual snorkeling rates or reduced number of visitors to recreational beaches)?**

Stakeholders at the 2014 MdA and WRI workshop state that tourism has not yet been impacted from pollution and changes in ecosystem quality; however a recent water quality problem in May 2015 caused by contamination of Big Creek water which led to a fish die off which was cause for high alerts for tourists. The issue was temporary and water quality was approved for human consumption within a few days, but a prolonged water quality issue like this could have a profound impact on the desirability of tourists to visit the area. In a single day over 9 thousand gallons of water were delivered to the island, luckily the water was tested and found to be suitable for human consumption before it negatively impacted the tourism industry. While the cause of the fish kill in Big Creek Lake in this instance was a lack of maintenance causing over-sedimentation, the introduction of non-local Tilapia fish and not wastewater (according to MOE), the high alert that went out to tourists is indicative of the impact that wastewater contamination could have on tourism in the area if it contaminated the drinking water or became a health concern.

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VIII. HUMAN HEALTH IMPACTS

Objective: To understand if there is a link between wastewater pollution and key human health illnesses including gastroenteritis, ear and eye infections, and other illnesses (as listed in Annex 2, section C); and to estimate the impacts on the local economy due to human health impacts (e.g., from hospitalization, medication, time taken off work, and death).

Possible data sources: Health agencies or ministries; Hospitals or doctor's offices; national statistics/census data; international statistics from multilateral, intergovernmental or NGOs (e.g., World Bank or World Health Organization); peer-reviewed or grey-literature.

1. **Please describe any known human health impacts, such as gastrointestinal illness, respiratory illness, ear infections, eye infections, or skin rashes/lesions that are occurring in the study site that relate to wastewater. Please see Annex 2, section C for a list of human illnesses related to swimming in, drinking from, or eating seafood from water contaminated with wastewater.**
   - **Are health data recorded on any of these key illnesses? If so, who collects this data? What can you say about the average frequency and duration of occurrence for each type of illness (e.g., 50 cases per year; 1 case per resident person per year)?**
   - **Do reported incidences of these illnesses result in doctors' visits, hospitalization, or death? Do you have statistical data on illnesses and hospital data?**

- **What activities seem to be contributing (e.g., swimming; eating contaminated seafood)?**
- **How specific can you be about location?**
- **Is wastewater pollution the main cause of these health issues? If not, what are the main causes of these diseases?**

There are local concerns that the indigenous population may be impacted by untreated wastewater as they live adjacent to the plant and in the mangroves that receive untreated wastewater. Stakeholders from the 2014 MdA and WRI workshop stated there may be a higher infant mortality rate with the indigenous population partially due to exposure to wastewater pollution

Silva (2015) provides information on health issues related to improper sanitation. Harmful algal blooms also impact fish species, many of which are consumed by people. While the report does not list Isla Colon as an area impacted by Red Tide events (harmful algal bloom events), the following Table below shows outbreak case numbers for illnesses related to consuming contaminated seafood in Panama:

Reported Cases of Hydroalimentry (Water-Food) Related Disease in Panamá, classified by type, 2003-2007							
Year		**Total**	**Amebasis**	**Diarrhea**	**Food Poisoning**	**Salmonella**	**Shigellosis**
2003	Cases	191,729	5,542	184,529	1,073	74	61
	Rates[a]	6,138.10	177.8	5,921.50	34.4	2.4	2
2004	Cases	174,667	4,953	168,374	1,246	54	40
	Rates	5,506.90	156.1	5,307.50	39.3	1.7	1.3
2005	Cases	173,908	4,953	167,130	1,179	59	89
	Rates	5,387.20	156.1	5,177.20	36.5	1.8	2.8
2006	Cases	205,389	5,451	198,428	1,246	105	62
	Rates	6,254.30	168.9	6,042.30	37.9	3.2	1.9
2007	Cases	193,309	5,268	186,760	1,179	76	26
	Rates	5,788.10	157.7	5,592.00	35.3	2.3	0.8

The following information for Panama is taken directly from Silva (2015): "In 2007, 193,309 cases of hidroalimentary illness were reported, with diarrhea holding the highest number of cases (198.428), followed by amebiasis (5,268) and food poisoning (1.179) (Table 26). Diarrhea showed an upward trend, with more than one million cumulative cases, an average 112,287 and a monthly average of 9,357 cases during 1995-2003. Reportedly, in 2003, a national rate of 6,075 cases per 100,000 inhabitants, and the Bocas del Toro region with the highest incidence rate (from 9343 to 11449 cases per 100,000 population) followed by Chiriquí, the Metropolitan region and San Miguelito, located rates range from 7236.9 to 9343 cases per 100,000 inhabitants. Children under 5 years are the most affected by diarrheal diseases. Within this group, children under one year have between 1.5 and 2.0 times the risk of disease among children under five years and between 1.7 and 2.5 times the risk that the group of 1-4 years. By 2003, the incidence rate of diarrheal diseases in children under five years was 4 times higher than the general rate in the country; 6 times greater for patients younger than 1 year and 3.4 times higher for the 1-4 years. Acute diarrheal diseases show a seasonal pattern with higher frequencies in the rainy season.

The indigenous regions present the major causes of morbidity and mortality due to digestive diseases related to unsafe water intake and poor disposal of excreta; so the incidence of diseases like diarrhea is high (Table 27). Among the population under 5 years, the frequency of diarrhea has seen a steady increase from 24,391 in 1987 to 16,046 per 100,000 inhabitants (2006), at the expense 1-4 years group, where occurrence has doubled from 11,606 to 21,828 per 100,000 individuals.

Mortality Rates and Statistics of Gastrointestinal Disease for Nogbe Bugle, Guna Yala and the Province of Darién Counties, 2009

Principle Indicators	Nogbe Bugle	Guna Yala	Prov. of Darién	Republic of Panamá
General Rate of Mortality per 1,000 hab.	3.51	6.8	2.7	3.9
Rate of Infant Mortality per 1,000 hab. Of Live Births	19.15	22.3	22.6	11.9
Mortality in Children Linked to Poor Water Quality (ages 0-4)				
Diarrhea and Gastroenteritis of Presumed Infectious Origin	4,825	2005	3,122	-
Intestinal Parasitosis, Without Other Origin	5,011	-	-	-
Morbidity in Children Disease Linked to Poor Water Quality (20-59 years)				
Diarrhea and Gastroenteritis of Presumed Infectious Origin	-	486	1,571	-
Intestinal Parasitosis, Without Other Origin	2,505	-	-	-
Morbidity in children linked to poor water quality (over 60 years) diseases				
Diarrhea and Gastroenteritis of Presumed Infectious Origin	-	197	-	-
Intestinal Parasitosis, Without Other Origin	456	-	349	-

Despite government efforts through implementation of health programs, the Ngäbe-Buglé[3] have high rates of infant mortality. Diseases and most common causes of death are tuberculosis, intestinal infections, diarrhea, whooping cough, infectious and parasitic diseases and malnutrition. There are very few jobs or health sub-centers in the region. Those that exist have sparse coverage, infrastructure equipment and supplies and do not have equipment, medicines and sufficiently trained health personnel. Some of the morbidity and mortality in these regions is related to poor hygiene and diseases that can be treated with prior medical care (vaccination).

According to WHO, the environmental burden of disease Panama is 200 deaths related to water and sanitation; the Years of Life Lost due to Disability (DALYs for its acronym in English) is 9600. The burden of environmental disease is 25/1000, which equates to 80,000 DALYs. (World Health Organization 2015).

The report also states that the conditions of basic sanitation contribute to both the transmission of both dengue and malaria. Bocas del Toro has one of the highest rates for both illnesses. In the past, the habitat of the Aedes Aegypti Mosquito, which transmits dengue, was considered to be clean and stagnant waters. However, studies in Puerto Rico and Peru by the CDC have reported the discovery that mosquitoes carrying dengue may also have farms in septic tanks and sewage systems. As for malaria, the high levels of nitrogen and phosphorus cause eutrophication problems in those bodies of water flowing slowly. Increased levels of nitrogen and phosphorus associated with untreated wastewater might lead to increased risk of malaria in Isla Colon, which could impact the local community as well as the tourism industry.

2. Have any studies been conducted within the study site or your country or region that link wastewater pollution to human health?

Yes – Silva (2015) for Panama. No studies have specifically been conducted for Isla Colon.

3. Do any of these studies estimate a dose-response relationship between a given wastewater pollutant and a human health illness (e.g., gastroenteritis)? (See the BCA methods section for more detail.)

No.

4. Beyond wastewater, are there any other sources of water pollution contributing to these problems? (If so, please note how large of a contribution.)

- **Runoff from agriculture?**
- **Runoff from livestock?**
- **Runoff from aquaculture?**

[3] The Ngäbe-Buglé are a local indigenous population in Panama.

- **Industrial discharge?**
- **Cruise ships/yachts?**
- **Others?**

Not sure.

5. **Do you have a sense of the relative contribution from wastewater to overall health impacts compared to these other sources? If so, please describe.**

No – no health data were available or provided by the county medical office and no site-specific dose-response relationships are available for wastewater pollutants.

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IX. FUTURE WASTEWATER MANAGEMENT SCENARIO(S)

Objective: To identify and define at least one future wastewater management scenario to compare against the current infrastructure situation in terms of population served, untreated wastewater, pollution removal efficiency for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Wastewater consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits.

1. **What option or options are under consideration for improving wastewater management in the pilot area? Please provide a description and fill in Table 6 for each major wastewater treatment plant or infrastructure element. Please add columns as necessary if more than two alternatives are being considered.[4]**

As of August, 2015, IDAAN and CONADES are currently considering a few options for improving wastewater management in the Isla Colon area, under the Inter-Institutional Committee. IDAAN and CONADES appear to be considering two options for medium to long-term wastewater treatment (IDAAN 2015):

- Extension of the sewer system in Isla Colon to connect Isla Carenero to the Isla Colon WWTP. Would include conversion of the current dormant lagoon into a dry lagoon for sludge disposal.

[4] Note – since August 12, 2015, the understanding of the future wastewater management options for Isla Colon has changed. The Ministry of Environment states that the new understanding of future plans for wastewater treatment in Isla Colon is that the current WWTP in Bocas Town will be decommissioned and a new plant will be constructed. Additionally, the sewerage network will be extended to cover the entire population of the island. Not included in the scenario, but relevant for understanding ecosystem and health impacts for the island, is that a new WWTP will also be constructed for the neighboring island of Isla Carenero. Additionally, the sewerage network will be extend on that island. The total estimated costs for both islands is 15.5 million dollars.

- Extension of the sewer system to connect Isla Carenero to the Isla Colon WWTP AND expand the current WWTP by converting the dormant lagoon into a second oxidation lagoon with aeration system.

Table 6: Future wastewater management scenarios description

Data need	Alternative 1	Alternative 2
Design		
Location		
Design capacity - annual average and peak (if actual capacity is lower, that will be covered below under performance)		
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Oxidation pond with aeration system (1 pond)	Oxidation pond with aeration system (2 ponds)
Will effluent and water quality standards be met?	Yes	Yes
Sludge treatment and disposal	At dormant lagoon adjacent to current oxidation pond	
Discharge location (receiving water body). If coastal, is there an outfall(s)?		
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)		
Performance		
Flows (annual average, peak)		
Annual energy usage (kW hours, total cost)		
Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date,		

cause and estimated bypassed volume for each event).		
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)		
Annual average discharged concentrations and loads of:		
• BOD_5 (mg/l, kilograms per year)		
• Dissolved oxygen (mg/l)		
• Total Nitrogen (mg/l, kilograms per year)		
• Ammonia Nitrogen (mg/l, kilograms per year)		
• Total Phosphorus (mg/l, kilograms per year)		
• Total Suspended Solids (mg/l, kilograms per year)		
• Faecal coliforms (units as reported)		
• Enterococci (units as reported)		

2. What are the evaluation criteria for choosing an infrastructure option and who decides what these criteria are? For example, criteria may include cost-effectiveness, pollutant removal efficiency, and/or environmental impacts.

The option will be selected by the inter-institutional committee, but it is not clear how the committee will select the option.

3. What sort of improvements are expected from each future wastewater management scenario?

- **Increased coverage in terms of population treated?**
- **Improvement in water quality of receiving water bodies and downstream water bodies?**
- **Reduced levels of:**
    - **BOD5**
    - **Dissolved oxygen**

- **Total nitrogen**
- **Ammonia nitrogen**
- **Total phosphorus**
- **Total suspended solids**
- **Faecal coliforms**
- **Enterococci**

Data not available.

4. Will the new wastewater treatment technology allow any reuse of water?

- **Where does the treated water go – back in a river, out an outfall, or into a specific use (e.g. irrigation, industrial use, or drinking water)?**
- **Has anyone estimated the potential cost savings associated with reuse of this wastewater?**

No.

5. Have any engineering or financial analyses been conducted for future wastewater management alternatives? Do they provide cost data?

We were not able to find specific engineering or financial analysis conducted on future wastewater management alternative scenarios, however, IDAAN and CONADES have developed a budget estimate for future upgrades for the inter-institutional committee. CONADES (2015) has estimated a cost of $12,000,000 for the following activities:

- Conduct necessary studies and designs for the construction of the WWTP in Isla Colon.
- Study, design and construct the outfall for wastewater to the WWTP Carenero island Isla Colon.
- Extend the sewer system of Isla Colon.
- Optimize the existing sewerage system Isla Colon.
- Construct sanitary units for areas that are not served by sewers.
- Conduct an environmental impact study.

It is not clear if this cost applies to future option 1 vs future option 2, but can be used as a proxy for the costs for items listed above.

6. Please fill in Table 7 to the best extent possible based on either engineering/financial reports from the wastewater authority and relevant consultants, OR by referring to Annex 2 which provides information on relative cost by infrastructure type.

Table 7: Cost estimates for future wastewater management scenarios

Parameter	Alternative 1	Alternative 2

Year of installation		
Life expectancy (years)		
Total area of the plant (please list the area that will need to be purchased for the treatment facility)		
Capital/Investment expenses (This includes one-time construction, planning, and design costs, costs for new development, and cost for replacement and renovation of existing assets – including external or consulting services)		
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced sooner than the life expectancy of the treatment facility and the recurring capital cost, including likely year of replacement and the frequency of replacement)		
Annual recurring expenses: -Salary/wages for all personnel -Land rental value for land purchased (i.e., the value of land purchased to install the wastewater infrastructure) -Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)		
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)		
Other costs		
Net present value over infrastructure's lifetime		

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X. CHANGES TO ECOSYSTEM AND HUMAN HEALTH UNDER IMPROVED WASTEWATER MANAGEMENT SCENARIOS

Objectives: To quantify and/or describe how ecosystems and the goods and services they provide will change under each future wastewater management scenario, and the potential impacts on the local economy in terms of costs;

To quantify and/or describe how human health will be impacted under each future wastewater management scenario in terms of numbers of reported illnesses and costs.

Possible data sources: Peer-reviewed and grey literature; Government documents including environmental impact statements.

1. **Have any evaluations, studies, or environmental impact statements been conducted that estimate the impact on key ecosystems and human health under each new wastewater management scenario *compared to the current wastewater management situation*? Do you know of any experts that are currently studying potential impacts? If so, please describe these findings, including how likely management under each scenario is to:**
    - Reduce the annual loading of pollutants on receiving water bodies?
    - Reduce odor?
    - Reduce the incidence of harmful algal blooms and/or nutrient over-enrichment?
    - Reduce human health risk and/or the number of cases for illnesses previously identified?
    - Improve ecosystem health conditions for the key ecosystems identified previously?
    - Improve the provision of key ecosystem goods and services identified previously (e.g., increased likelihood of tourist visits, increased productivity of fisheries due to improved coral reef and mangrove health)

No – no environmental impact studies have yet been conducted.

2. **Can you establish a quantitative relationship between an improvement in water quality due to the future wastewater management alternative and a change in provision of ecosystem services for each key ecosystem? If so, please list your assumptions and quantitatively describe these changes (e.g., by reducing the amount of untreated wastewater entering the coral reef ecosystem, total nitrogen levels will decrease by 30% surrounding the reef which will improve coral reef health such that fisheries production increased by 20%).**

No.

3. **Can you monetize or value the change in ecosystem service provision (e.g., what is the economic value of reduced coral reef degradation in terms of fisheries improvement – this is often quantified by estimating the market value of fish sold in a marketplace)?**

No.

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XI. OTHER INFORMATION

1. **Please list any additional data or information you think would be useful to the study that might not have been discussed previously in this characterization form.**

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ANNEX 3B. CHARACTERIZATION FORM FOR DEFINING THE COSTS AND BENEFITS OF DOMESTIC WASTEWATER MANAGEMENT

STUDY SITE: Southwest Tobago

UN environment
United Nations
Environment Programme

CARIBBEAN ENVIRONMENT PROGRAMME

Annex 3B. Characterization Form for Defining the Costs and Benefits of Domestic Wastewater Management – Southwest Tobago

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STUDY SITE: Southwest Tobago

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RESPONDENT INFORMATION

This report was completed by:

Name: Erin Gray, Lauretta Burke, World Resources Institute; Roger Karim and Carl Santana, Trinidad and Tobago Water and Wastewater Authority (WASA)

Organization: World Resources Institute and WASA

Date: August 12, 2015

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Contents:

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I. DEFINE THE STUDY AREA

Objective: Define and map the study area including key geographic and land use data to identify wastewater pollution and other water pollution pathways and populations of interest.

Possible data sources: National environmental, water, and/or marine agencies; non-profit organizations (NGOs); academic institutes with marine/environmental centers that conduct research within the study site.

1. Please define the study area by providing a detailed description.

The study area should include the sewage catchment name(s) and geographic area, the populated area to be served by improved wastewater treatment, the area downstream which is expected to be influenced by the change in wastewater management (including receiving water bodies (e.g., rivers, lakes, oceans) and water catchments), and the upstream catchment (which might be contributing pollutants to the water body of focus).

The study area focuses on southwestern Tobago, including mostly St. Patrick Parish but also parts of St. Andrew. The study area includes the Buccoo Reef / Bon Accord ecological complex and includes the Courland, Buccoo and Bon Accord water catchments. The following developments are included: Bon Accord, Milford Court, Samaan Grove and surrounding area, and the Coral Gardens and Buccoo neighborhoods. The study area does not include Scarborough and the Scarborough wastewater treatment facility (WASA 2015)

2. Can you put it on a map? (with GIS; Google Earth; or participatory mapping)

If possible, indicate on a map the information provided in Question 1. This can be done in GIS, using Google Earth, and/or working with stakeholders using a participatory mapping approach to highlight on a hard copy map the response to Question 1.

Based on data received from the Institute of Marine Affairs (IMA 2015) sand WASA's Water Resources Agency (WRA 2015) we have the following maps:

Figure 1 - Tobago study area map (represented in a GIS)

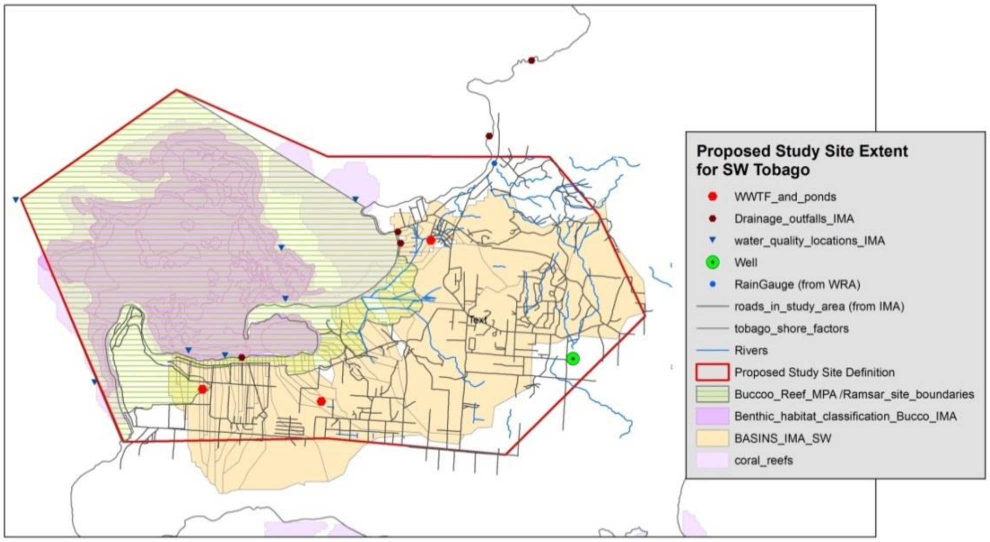


Figure 2 - Tobago study area, represented in Google Earth

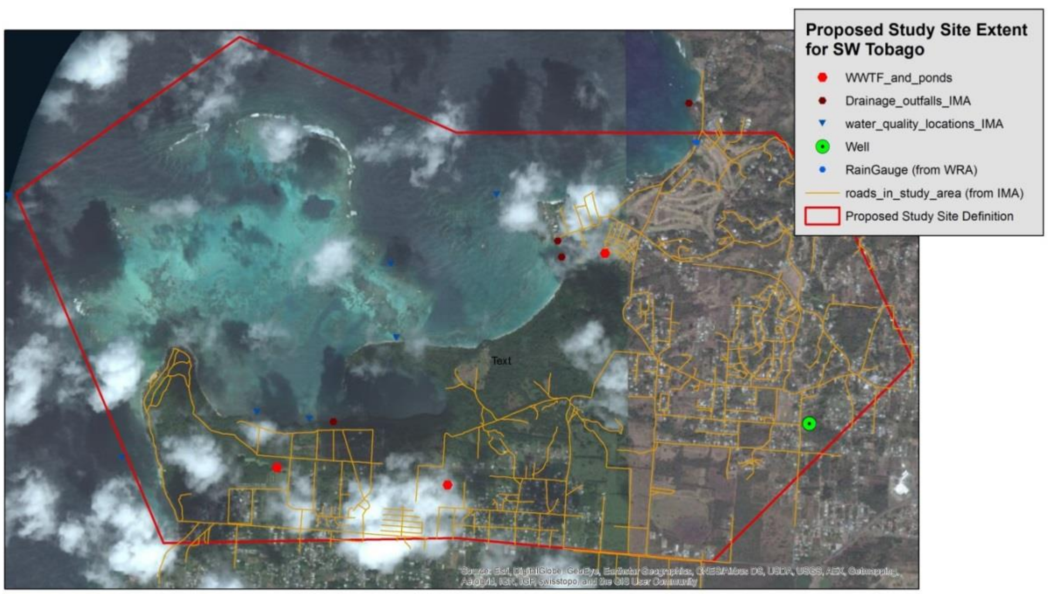
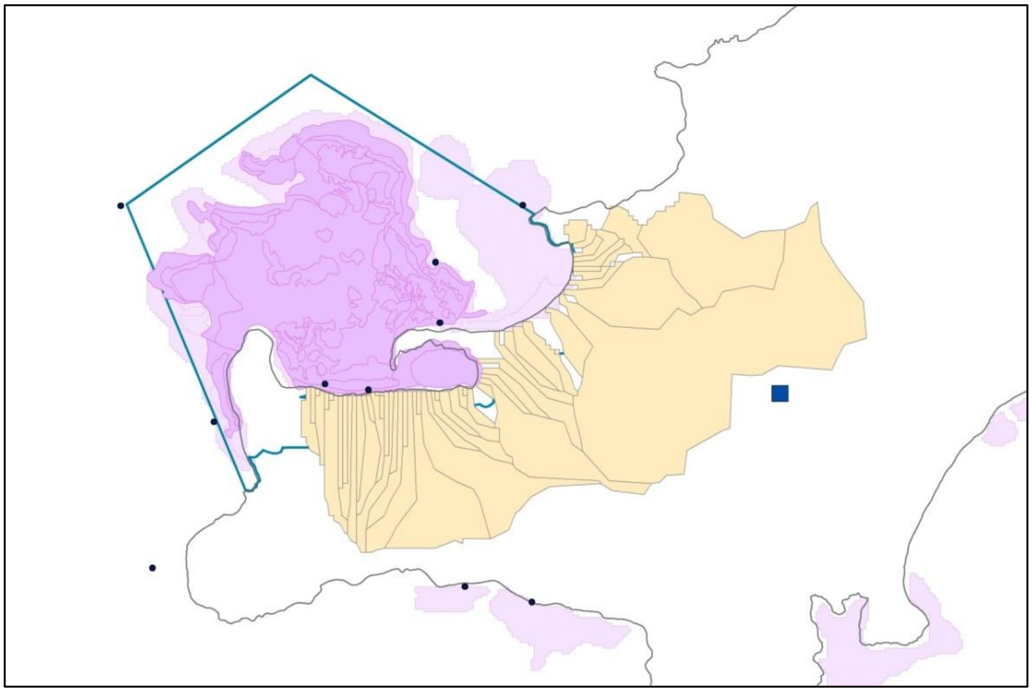


Figure 3 - Watersheds and Coral reefs of the SW Tobago study area



3. **What are the major <u>land uses</u> (such as residential, commercial, agricultural, open space / natural) in the study area?**
   - **Could you do rough estimates of percentages of each major land use?**

Existing land use data for southwest Tobago from Town and Country Planning Division (TCPD) from 1996 showed that the predominant land use in southwest Tobago is built development accounting for some 2416 ha or 38%. IMA reports that between 1992 and 2002, southwest Tobago experienced rapid growth and development in the tourism and related service sector (Juman and Bacon 2002). Alpha Engineering (2011) states that there is a high density of development in southwest Tobago with narrow roadways.

Development consists mainly of residential and commercial areas, and supporting infrastructure (roadways, sidewalks, drainage canals, parks, etc…). The southwestern tourist area around Crown Point, Store Bay, Buccoo Reef, and Pigeon Point has large expanses of sand and is dominated by resort-type developments.

There is also a cattle farm in the study site (Juman 2015).

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II. POPULATION

Objective: Population data is critical for understanding current and future wastewater demand as well as the number of people who may swim in or eat from waters contaminated with untreated wastewater.

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. How many people live in the study area? (Approximate if necessary)

The population of Tobago grew from 54,084 in 2000 to 60,874 in 2011 (CSO, 2012). About 54 percent of Tobago's population lives within the southwestern area (15,560 in St. Patrick and 17,536 in St. Andrew parishes), though these parishes exceed the study area. We estimate about 15,000 people live in the study area. The area also has many hotels and hence visitors creating additional need for wastewater treatment.

2. Can you disaggregate this by neighborhood / area / housing development / smaller administrative unit?

No.

3. How many households are in the study area? (Approximate if necessary.)

The 2011 CSO Census estimates that the average household size for Tobago in 2011 was 3 people. Hence, we estimate that there were about 5,000 households in the study area in 2011.

4. What is the population projection for the study area over the next 20, 30, and/or 50 years (for each period if data are available)?

The average annual growth rate in population for Tobago between 2000 and 2011 was 1.2%.
We currently do not have projection data for Tobago. Based on the 1.2% growth rate, we project the population for St. Patrick and St. Andrew Parishes to be:

- Current (2015): 15,730
- In 20 years (2035): 19,970
- In 50 years (2065): 28,560

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III. ECONOMIC ACTIVITIES

Objective: Economic data are important for understanding the economic activities that are important for the local economy that rely on ecosystems (especially those potentially impacted by water pollution).

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. **Are the following sectors important for the local economy (ideally for the study area)? Can you estimate the relative contribution from each sector to the local economy? If quantitative data are not available, please rate the sector's importance based on the following scale:**

   Importance Scale:
   - **Not important:** The sector is not relevant as it does not contribute much to local GDP (e.g., through jobs or financial contribution)
   - **Moderate importance:** The sector is important, but is not the main contributor to local GDP.
   - **Very important:** The sector contributes substantially to local GDP.
   - **Critical:** The sector contributes the largest amount of any sector to local GDP

- **Tourism? (Note types of tourism)**
- **Agriculture? (Note types of agriculture)**
- **Fisheries? (Note major fish species)**
- **Industry? (Note what industry/ies)**
- **Other?**

The most important sectors for Tobago's economy are tourism and fishing (mostly artisanal) (Wikipedia 2015). The island hosts a significant number of yachts and cruise ships each year (THA 2015; Ministry of Tourism 2015), which add to the demand for water and sanitation services, particularly in the ecologically-sensitive coastal zone.

Within the study area there is also a goat racing facility and a fish processing plant.

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IV. KEY ECOSYSTEMS

Objective: To understand potential benefits to ecosystem health from wastewater management improvements, it is necessary to a) identify key ecosystems in the study sites, b) their economic contribution in terms of key goods and services they provide, c) their contribution to key economic sectors. This will help to characterize the dependence of these sectors on healthy ecosystems, and as a result, the value of these ecosystems to the study population and the nation.

Possible data sources: Government environmental/water/natural resource agencies or ministries; Academic institutes and environmental NGOs conducting research or working towards the protection or conservation of ecosystems; Peer-reviewed and grey literature on key ecosystem both within and outside of the study area; Government reports including environmental impact statements, water quality permits, or benefit-cost analyses;

1. **What are the key ecosystems in the study area (e.g., coral reefs, mangroves, seagrass beds, beaches, forests, wetlands), especially downstream from population, sewage discharge, or treated**

wastewater discharge? Key ecosystems are those which are important to the local economy or those which provide important cultural services.

The study area includes the **Buccoo Reef Complex,** which is a mangrove-seagress-coral reef continuum that covers an area of 7 km^2 and includes the Bon Accord Lagoon and the Buccoo Reef. Included in the BRC is:

a. **Bon Accord Lagoon** (Juman 2005a and 2005b)**:** The Bon Accord Lagoon (BAL) forms the southern boundary of the Buccoo Reef Marine Park and has a surface area of 1.2 km^2. The BAL includes a **mangrove forest** (~0.8km^2) dominated by red mangrove, but also includes black, white, and buttonwood mangrove. This is the largest remaining mangrove system in southwest Tobago. The BAL also includes a **seagrass community** dominated by *Thalassia testudinum* which measures 0.5km^2. The BAL forms part of the BRC so impacts and is impacted by the health of the Buccoo Reef.

   The tide is mixed, mainly semidiurnal with a significant diurnal inequality. The lagoon is well-flushed, is an average of 2 meters deep, and has a reasonably high rate of tidal exchange between the lagoon and the adjacent coral reef.

b. **Buccoo Reef**

   The Buccoo Reef is a Holocene formation comprised of coralline limestone. The reef system consists of five emergent reef platforms, arcing seaward of the reef lagoon from Pigeon Point in the west to Sherrbird's Point on the east. The reef platforms are: Pigeon Point Reef, Western Reef, Northern Reef, Outer Reef, and Eastern Reef (Juman and Bacon 2002). The Buccoo Reef Complex was officially designated a marine protected area in 1973, the Buccoo Reef Marine Park.

c. **Recreational beaches**

   The southwest area of Tobago is popular for swimming/recreational beaches, including: Pigeon Point, Buccoo Point, Store Bay, and Crown Point.

d. **Nylon Pool**

   Nylon Pool is a popular tourist destination – it is an in-sea shallow white ground coral pool located off of Pigeon Point and is accessible by boat.

2. **Please rank how important these ecosystems are to the economic sectors previously listed in Section III (within the study area) (e.g., is tourism in the area dependent on healthy ecosystems?). Please indicate in Table 1 below the relative importance based on this scale:**

   Importance Scale:
   - **Not important**: The ecosystem has no relevance to the economic sector.

- **Moderate importance**: The economic sector is dependent on resources/services provided by the ecosystem but substitutes for natural resources are available (e.g., forest ecosystems provide water filtration services that can improve the health of fisheries, but water filtration systems are also available to filter water).
- **Very important:** The economic sector is dependent on the resources/services provided by the ecosystem and substitutes are <u>not</u> available or are exorbitantly expensive (e.g., mangroves provide important coastal protection services, guarding some shoreline industries from flooding and hurricanes. While options exist to improve coastal protection like dikes jetties, this type of infrastructure can be costly to build and maintain).
- **Critical:** The ecosystem is vital to the economic sector in that the sector would not profit or exist without the ecosystem (e.g., tourism in a coastal community may be completely dependent on coral reefs for scuba diving, snorkeling, and sand creation as these activities provide the most income to the local economy).

Table 1: Ranking of ecosystem important to key economic sectors

ECOSYSTEM	AGRICULTURE	FISHERIES	COMMERICAL
Example: Coral reefs	*Not important*	*Critical*	*Very important*
Coral Reef	Critical	Critical	Very important
Mangroves	Critical	Very important	Very important
Seagrass Beds	Critical	Moderate	Not clear
Beaches	Not important	Critical	Very important

3. **What goods and services do these key ecosystems provide (i.e., what are each of the ecosystems <u>used by people for</u>?). Please fill out Table 2 below and add or delete ecosystems as needed. You may refer to Table 3 which provides a general list of ecosystem services for major Caribbean ecosystem types, for guidance.**

Mangroves:

- Habitat for larvae, juveniles, and adult estuarine and marine organisms.
- Water filtration services (mangroves take up nutrients) that reduce over nutrient enrichment of the reef.
- Shoreline protection services during storms that help reduce flooding and erosion.

Seagrass beds:

- Habitat for larvae, juveniles, and adult estuarine and marine organisms.

- Water filtration services (mangroves take up nutrients) that reduce over nutrient enrichment of the reef.
- Shoreline protection services during storms that help maintain beach areas and integrity of the coastline.

Buccoo reef:

- Tourism and recreation (snorkeling and diving site; glass bottom tours site)
- Beach formation
- Habitat for marine organisms that support fisheries (the main catches are groupers and snappers (Juman and Bacon 2002))
- Shoreline protection services.

Table 2: Ecosystem goods and services

Ecosystem Goods and Services	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES
Food	X	X		X
Raw materials	X	X	X	X
Medicinal resources				
Genetic resources				
Other…	X	X	X	X
Flood/storm/erosion regulation	X	X	X	X
Climate regulation	X	X		X
Other…		X		X
Tourism and recreation	X	X	X	
History, culture, traditions		X		
Science, knowledge, education	X	X	X	X
Other…				
Primary production	X	X		X
Nutrient cycling	X	X		X
Species/ecosystem protection	X	X	X	X
Other…				

Table 3: Examples of coastal ecosystem goods and services

ECOSYSTEM GOODS AND SERVICES	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES
Provisioning services				
Food (e.g., fisheries)	X	X	X	X
Raw materials	X	X	X	X
Medicinal resources	X	X		X
Genetic resources	X	X		X
Regulating services				
Flood/storm/erosion regulation	X	X	X	X
Climate regulation	X	X	X	X
Cultural services				
Tourism and recreation	X	X	X	
History, culture, traditions	X	X	X	X
Science, knowledge, education	X	X	X	X
Supporting services				
Primary production	X	X	X	X
Nutrient cycling	X	X		X
Species/ecosystem protection	X	X	X	X

Source: WRI Coastal Capital Guidebook (Waite et al. 2013)

4. **Are there any existing estimates of the economic values of these uses of ecosystems for this study area or nearby (e.g., through peer-reviewed or grey literature)? If so, please list these values, describe the methodology used to develop them, and provide a citation.**

Yes – we identified 3 economic valuation studies. However these studies did not look at impacts from wastewater.

Brown et al. 2001:

Estimated the recreational value of Buccoo Reef Marine Park in Tobago, West Indies. Benefits derived from total annual visitor expenditure in estimates of Net Present Value (NPV) ranged from US $9.1 to $18.7 million over a 10-year period for different scenarios. Recreational user benefits were estimated as the total Willingness To Pay of visitors to southwest Tobago, both users and non-users of the park. The mean Willingness To Pay by all respondents, including those not willing to pay, ranged from $3.70 to $9.30. The resulting estimates showed an equivalent surplus of $600,000 to $2.5 million in NPV depending on the resulting environmental quality implied by the scenarios.

Burke et al. 2008:

- Coral reef-associated tourism and recreation in the Buccoo Reef area contributed an estimated US$7.2 to $8.8 million a year in 2006, of which approximately US$1.4 million were from glass bottom boat and snorkel tours, alone.
- Coral reefs provide shoreline protection services from waves and storm damage worth $18 – 33 million USD annually in 2006 for all of Tobago (Burke et al. 2008). In addition, the same study estimates the "Damages avoided" due to the presence of the Buccoo Reef to be between US$140 and 250 million over a 25-year time period.
- Burke et al. estimate the annual value of coral-reef related fisheries for all of Tobago was $0.8 – 1.5 million USD in 2006.[1]

Beharry-Borg and Scarpa,

- Uses two choice experiments designed to estimate willingness to pay (WTP) for an improvement in coastal water quality for two groups of beach recreationists: snorkellers and nonsnorkellers.
- Results indicate that individual specific-means of WTP estimates vary significantly between snorkellers and nonsnorkellers

5. Do you have statistics on visitation / tourism (both foreign and national) to key ecosystems and/or statistics on visitation/tourism for the country for eco-tourism? For example, do you have data on the number of tourists (including cruise ship passengers, national and international tourists, and others) that visit the key ecosystems identified above?

We have the following data from the Tobago House of Assembly for tourist visitation to Tobago (Tobago House of Assembly 2015; Ministry of Tourism 2015):

Table 4: Tourism visitation data from 2003 - 2014 for Tobago (THA 2015; Ministry of Tourism 2015)

Number of persons	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Yacht arrivals[1]	1,695	1,610	1,587	2,355	1,391	1,175	1,345	1,027	1,037	1,005	1,082	886
Cruise ship passenger arrivals[2]	25,661	29,120	32,919	29,708	18,426	22,257	70,134	61,615	44,623	31,364	20,274	29,735
Direct inter-national passengers (air)[3]	68,548	82,159	87,796	68,791	67,354							26,185

1. Data from 2003 – 2009 from THA (2015); Data from 2010 – 2014 from Ministry of Tourism (2015).
2. Data from THA (2015).
3. Data from 2003 – 2007 provided by THA (2015); Data for 2014 provided by the Ministry of Tourism

[1] Includes all of Tobago's coral reefs.

A Tobago Exit Survey Report from 2013 (Division of Tourism and Transportation 2013) and found that the average length of stay was 11 days, and that the average expenditure per person was calculated at USD $2,273. Expenditure per person per day with an average length of stay of 11.1 nights was USD $189. A typical visitor to Tobago is in the 45-54 age demographic, university educated professional whose main purpose of visit is for a vacation (> 80%). Business visitors were negligible averaging under 1% of total visitor arrivals to the island. The typical visitor travels with his/her spouse and prefers to stay at a hotel (>60%). Most international visitors are coming from Europe and North America.

Generally, the visitor is usually a first time visitor (68%) to the island. Of the repeat visitors (32%), the majority had travelled to the island 1-3 times (54.9%).

The most popular activity was visiting the various beaches on the island (28.4%). This was followed by sightseeing (22.6%), shopping (14.4%) and water sports/scuba diving (13.4%).

The most popular sites/attractions that tourists visited were Pigeon Point Heritage Park (PPHP), the Rain Forest, Buccoo Reef and Argyle Waterfall. Visitors were asked to rate the various sites/attractions on a scale of 1 to 5 with 1=Poor and 5=Excellent. The Buccoo Reef scored 3.7 points, up 0.1 point over 2011.

A possible indication of ecosystem decline might be related to quality of tours. The survey states, "Although visitors were generally pleased with the quality of the tours and tour guides on the island, the percentage of visitors that rated these services as very satisfactory declined consistently throughout the three-year period. 46.9% of visitors in 2011 compared to 34.3% in 2013 said that they were very satisfied with the tour guides. Tours also dropped from 45.5% rating them as highly satisfactory in 2011 to 37.8% in 2013."

The Trinidad and Tobago Ministry of Tourism (2015) found that the total contribution of travel and tourism to domestic GDP has increased from $10.5 million TT in 2010 to $12.6 million TT in 2014.

Note: This is to understand the potential health costs from exposure to wastewater pollutants so it is important to understand whether the key ecosystems identified a) receive untreated wastewater effluent and b) are important for fishing and recreational swimming/bathing.

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V. CURRENT WASTEWATER MANAGEMENT SITUATION

Objective: To understand how wastewater is currently treated within the study site to allow comparison against future wastewater management alternatives in terms of population served, untreated wastewater, pollution removal effectiveness for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits; Wastewater experts; Historical costs; National price books.

1. On-site wastewater treatment coverage:

- **Please estimate the percentage of the total domestic wastewater sector within the study that uses each type of on-site system below. For example: 30% of the total population uses on-site treatment. Of this 30%, 10% uses septic system, 10% uses pit latrines, and 10% uses soakaway systems).**
    - **Septic systems**
    - **Pit latrines**
    - **Soakaway systems**
    - **Other?**

WASA estimates that 88% of the study area population is serviced by pit latrines or on-lot systems (WASA 2015).

- **What percentage of on-site systems (septic systems, pit latrines, soakaway systems, etc.) are properly maintained (i.e., regularly pumped out, drain fields not clogged, etc.)?**

Alpha Engineering (2011) states:

- In periods of heavy rain, the soakaway and filter trench systems in the Bon Accord catchment do not function as they should and can release harmful fecal coliform into the surface drainage network and the coralline sub-structure, and ultimately into the sea. This can impact nearby bays used for bathing, recreation, and habitat.
- The commercial buildings along Milford Road utilize mostly septic tanks. During periods of high water table levels, the soakaway and filter trench systems release effluent directly into the surface drainage network and ultimately into the sea. In the dry season the effluent finds its way into the coralline sub-surface and also discharges itself into the sea.

2. Wastewater collection system (i.e., sewerage):

- **Please describe the coverage of the current sewage collection system in terms of length of pipelines and the ultimate treatment point.**

WASA estimates that 12% of Tobago's population is connected to a central system or private wastewater treatment plant (WASA 2015).

- **Please estimate the percentage of the total population and commercial and industrial establishments within the study that are connected to a centralized sewerage system.**

No commercial or industrial establishments are connected to a centralized sewerage system within the study area (WASA 2015).

3. Wastewater treatment plants:

- **Please describe the number and type of wastewater treatment plants (WWTP) currently in place in the study area.**

WASA owns and operates two wastewater systems in the study area: the Milford Court WWTP (adopted from the National Housing Agency (NHA), and the Coral Gardens WWTP (adopted from the NHA). In addition, the Golden Grove and Bon Accord Waste stabilization ponds provides wastewater treatment for the established housing developments within these communities. The remainder of the population within the study area is served by small package/ septic facilities (for the hotels and guest houses) and on lot septic tanks and soakaway system (for the individual households).

The **Bon Accord catchment** area includes all hotels and guesthouses along the western end of Old Store Bay Road and the Bon Accord housing development. The hotels and guesthouses mostly use septic tanks with soakaway or filter trench systems with the Bon Accord housing development using the Bon Accord waste stabilization ponds. In periods of heavy rain, the soakaway and filter trench systems do not function as they should and can release harmful fecal coliform into the surface drainage network and the coralline sub-structure, and ultimately into the sea. This can impact nearby bays used for bathing, recreation, and habitat (Alpha Engineering 2011).

The **Milford Court area** includes a WWTP referred to as the **Milford Court or Bon Accord WWTP**. The Bon Accord WWTP has a capacity of 259 m^3/day and was originally designed as a package plant with activated sludge treatment. It was converted to a membrane bioreactor plant in 2003 and is currently operating at capacity with acceptable treatment levels most of the time (Santana 2014). However, the draft CEC application (Alpha Engineering 2011) states that the WWTP servicing Milford Court is dysfunctional and is contributing untreated effluent into the surface system and ultimately into the ocean.

There is also a **fish processing plant** and commercial buildings in the area. According to the Draft CEC application (Alpha Engineering 2011), the wastewater being produced at the fish processing plant does not undergo any treatment prior to entering the drainage system. The commercial buildings along Milford Road utilize mostly septic tanks. During periods of high water table levels, the soakaway and filter trench systems release effluent directly into the surface drainage network and ultimately into the sea. In the dry season the effluent finds its way into the coralline sub-surface and also discharges itself into the sea. There is a new Metal Industries Company building which is currently under construction has in place a proposal for its own packaged WWTP to treat the wastewater generated in the facility. This will potentially add yet another source of effluent into the surface water drainage system. However WASA plans to integrate the discharges from the MIC building into its proposed system for the area

The **Coral Gardens/Buccoo area** includes a school, a community center, goat race facilities, a fish depot and a pan yard. There is also an existing WWTP, the **Coral Gardens WWTP**, that services the Coral Gardens residential development. According to the Alpha Engineering report (2011), the plant is currently not functioning the way it was designed to and the effluent from this plant does not meet the requirements of the EMA or WASA and currently flows into the surface water drainage system and ultimately into the sea. This Plant has been in operation for approximately 40 years, it is well past the expected lifetime. The design flow rate is 136 m^3/day and it serves roughly 959 people in Tobago.

WASA (2014) states that the Coral Gardens WWTP has a capacity of 240 m^3/day. WASA also states that the plant originally designed as a package plant with activated sludge treatment. It was converted to a membrane bioreactor plant in 2004 and is currently operating at capacity with acceptable treatment.

There are three drainage outfalls located within the study area (see Map #1). In Bon Accord Lagoon there is one sewage outfall and one outfall draining the Latour's cattle farm. In Buccoo Bay, there is one sewage outfall.

- **For each WWTP, please fill in Table 5 to the best extent possible. Please see Annex 2 for a glossary of wastewater terminology. Please copy and paste this table as needed if more than one treatment plant exists within the study site:**

Table 5: Wastewater Treatment Plant information for current situation (WASA 2015)

Data need	**Data**
Design	
Location	Milford Court (a.k.a. Bon Accord)
Design capacity - Nominal design capacity for dry and wet weather flows.	259 m^3/day (average daily flow)
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Membrane bioreactor
Effluent limits	T&T Water Pollution Rules
Sludge treatment and disposal	Via tanker to Studley Park Landfill (Louise et al. 2005)
Discharge location (receiving water body). If coastal, identify the outfall locations.	The Bon Accord Sewage outfall carries land-based runoff from a cattle farm, housing development, and sewage treatment plant into the Bon Accord lagoon via the mangrove forest.
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Current flows (annual average flow, monthly average peak flow)	currently at design capacity of 259 m^3/day (average daily flow)
Annual energy usage (kW hours, total cost)	

Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and estimated bypassed volume for each event).	
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	Reported over flow occurrences during period of very heavy rainfall
Annual average discharged concentrations and loads of:	Not available
BOD_5 (mg/l, kilograms per year)	
Dissolved oxygen (mg/l)	
Total Nitrogen (mg/l, kilograms per year)	
Ammonia Nitrogen (mg/l, kilograms per year)	
Total Phosphorus (mg/l, kilograms per year)	
Total Suspended Solids (mg/l, kilograms per year)	
Faecal coliforms (units as reported)	
Enterococci (units as reported)	

Table 6: Wastewater Treatment Plant information for current situation (WASA 2015)

Data need	Data
Design	
Location	Coral Gardens (a.k.a. Buccoo WWTP)
Design capacity - Nominal design capacity for dry and wet weather flows.	The design flow rate is 136 m^3/day and it serves roughly 959 people in Tobago
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Membrane bioreactor
Effluent limits	T&T Water Pollution Rules

Sludge treatment and disposal	Via tanker to Studley Park Landfill (Louise et al. 2005)
Discharge location (receiving water body). If coastal, identify the outfall locations.	Canals – drain into the Buccoo Bay (Louise et al. 2005)
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Current flows (annual average flow, monthly average peak flow)	at capacity of 136 m^3/day (average daily flow)
Annual energy usage (kW hours, total cost)	
Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and and estimated bypassed volume for each event).	
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	Reported over flow occurrences during period of very heavy rainfall
Annual average discharged concentrations and loads of:	Not available
BOD_5 (mg/l, kilograms per year)	
Dissolved oxygen (mg/l)	
Total Nitrogen (mg/l, kilograms per year)	
Ammonia Nitrogen (mg/l, kilograms per year)	
Total Phosphorus (mg/l, kilograms per year)	
Total Suspended Solids (mg/l, kilograms per year)	
Faecal coliforms (units as reported)	
Enterococci (units as reported)	

4. **What is the estimated annual percentage of total wastewater generated that is untreated and released into water bodies? What is the estimated annual volume?**

Not sure, but there is definitely some untreated wastewater that is being released directly into water bodies.

5. **If there is untreated sewage, where does this go? If possible, please also note on a map the receiving water bodies and ecosystems that receive the untreated sewage – either directly, or via an outfall.**

Untreated sewage seems to enter primarily through canals directly into coastal areas including the Buccoo Bay / Bon Accord Lagoon.

Juman et al. (2002) state that the drainage area for the Buccoo/ Bon Accord Lagoon falls in the Southwestern Coast Hydrometric area No.15. The immediate drainage area are bounded to the east by Grafton and Shirvan Roads, to the south by Milford Road and to the northwest and west by the coastline running diagonal from Mt. Irvin Bay to Bon Accord Lagoon, and to the west from Pigeon Point to Milford Bay at the western end of Milford Road. There are no rivers within this drainage area; however there are several streams and surface drains transporting runoff from a cattle farms and sewage treatment plants (STP's) (Coral Garden and Mt Pleasant STP) into Buccoo Bay and Bon Accord Lagoon.

6. **Is there an interest in improving, upgrading, or expanding the current wastewater management system in the area? If so, please describe who is interested and why.**

Yes – the area has been looking to improve wastewater management for almost two decades, beginning with a wastewater study for Tobago by Thames Water. In 2011, WASA submitted CEC applications to the EMA to undertake upgrade works and CECs were granted, drafted a CEC application. The new system design aimed to reduce risk to human and environmental health and enhance tourism (WASA 2015).

7. **Current wastewater treatment costs - What capital and annual operating and maintenance costs are associated with the current wastewater management situation? Please fill in Table 7 to the best extent possible. If you do not have specific cost data, please provide a description of the *likely* costs associated with the current scenario by referring to Annex 2, section D.**

Table 7: Current wastewater scenario costs (WASA 2015)

Data need	Current wastewater management situation
Year of installation	2003 (refurbished)- Coral Gardens and Milford Court WWTPs
Life expectancy (years)	10-15 years
Total land area occupied by the plant (hectares)	500 m2
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced	- $TT 1 Million(estimated) per year per plant,

within the next 20 years and the total capital cost, including likely year of replacement and the frequency of replacement)	- plus a regular swap out of some components , costing about TT$2-3 million every five years.
Annual recurring expenses: -Salary/wages for all personnel plus personnel of any contracts associated with operation of the WWTP. -Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)	$TT 0.5 Million (estimated) per year per plant
External services costs (if applicable, net value of total costs of external services including outsourcing, costs for construction)	$ TT 0.1 Million (estimate) per year per plant
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)	
Other costs?	
Net present value over infrastructure's lifetime	

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VI. WATER QUALITY

Objective: To identify and list water quality standards and requirements that are applicable to the wastewater sector and identify and provide historic data (over the past five years) on water quality within wastewater receiving bodies and key ecosystems in the study area.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants or engineers that work with the wastewater authority

1. What water quality standards/requirements apply for the study area?

- **National/Regional and Local water quality standards?**
  - **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
  - **Numeric criteria?**

- **Bathing/swimming standards**

- **International standards (e.g., LBS Protocol)**
    - **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
    - **Numeric criteria?**

The national water standards are the Water Pollution Rules by the Environmental Management Authority. T&T is also a signatory the Land-Based Sources and Activities (LBS) protocol. Standards are summarized below:

Table 8: Water quality standards for Trinidad and Tobago

Parameter	Unit	LBS Protocol		Trinidad and Tobago (Water Pollution Rules Schedule II)			
		Class I waters	Class II waters	Inland surface water	Coastal nearshore	Marine offshore	Environmentally Sensitive
Total Suspended Solids	mg/l	30	150	50	150	100	15
Biochemical Oxygen Demand (BOD5)	mg/l	30	150	30	50	100	10
pH	pH units	5 to 10	5 to 10	6 to 9	6 to 9	6 to 9	6 to 9
Fats, Oil and Grease	mg/l	15	50	10	15	100	no release
Faecal Coliform ((Parties may meet effluent limitations either for faecal coliform or for E. coli (freshwater) and enterococci (saline water))	Unit? ???	Faecal Coliform: 200 mpn/100 ml; or a. E. coli: 126 organisms/100ml; b. enterococci: 35 organisms/100 ml		400	400	400	100
Floatables	mg/l	not visible	not visible	not visible	not visible	not visible	not visible
Toxicity	mg/l			no acute toxic effects	no acute toxic effects	no acute toxic effects	no acute toxic effects
Dissolved oxgyen	mg/l			<4	<4	<4	<4
Total Phosphorus	mg/l			5	5	5	0.1
Sulphide	mg/l			1	1	1	0.2
Chloride	mg/l			250	no increase above ambient	no increase above ambient	no increase above ambient
Total residual chlorine	mg/l			1	1	2	0.2
Dissolved hexavalent chromium	mg/l			0.1	0.1	0.1	0.01
Total chromium	mg/l			0.5	0.5	0.5	0.1
Dissolved iron	mg/l			3.5	3.5	3.5	1
Total petroleum hydrocarbons	mg/l			25	40	80	no release
Total nickel	mg/l			0.5	0.5	0.5	
Total copper	mg/l			0.5	0.5	0.5	0.01
Total zinc	mg/l			2	2	2	0.1
Total arsenic	mg/l			0.1	0.1	0.1	0.01
Total cadmium	mg/l			0.1	0.1	0.1	0.01

Total mercury	mg/l			0.01	0.01	0.01	0.005
Total lead	mg/l			0.1	0.1	0.1	0.05
Total cyanide	mg/l			0.1	0.1	0.1	0.05
Phenolic compounds	mg/l			0.5	0.5	0.5	0.1
Radioactivity	mg/l			NIAA	NIAA	NIAA	NIAA

2. What data or information do you have about water quality in the study area? Can you provide:

- **Ambient water quality monitoring data in freshwater bodies?**
- **Ambient water quality monitoring data in coastal waters?**

The Institute of Marine Affairs (2015) has provided the following water quality data: nitrates, ammonia, total suspended solids, reactive phosphates, Chl A, Dissolved solids, and DDPH. Only total suspended solids, however, are covered by the Water Pollution Rules and the LBS Protocol.

3. Please compare these data to water quality standards/requirements:

- **Are any water quality standards being violated in lakes, non-tidal streams and rivers, and coastal areas? Please provide frequency and severity.**
- **What are the pollutants causing the violation and what are their sources (e.g., untreated wastewater, WWTP effluent, onsite septic systems, soakaways, pit latrines, sources from other sectors such as mining or agriculture)**

Data not available.

4. If any water quality standards are being violated, have the violations been linked to wastewater discharges? If so, please provide specific information on the linkage.

Data not available.

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VII. ECOSYSTEM IMPACTS

Objective: To understand if there is a demonstrated link between wastewater pollution and ecosystem health.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants/engineers working with the wastewater authority; Environmental impact statements; Environmental/marine NGOs and government agencies; Academic and grey literature.

1. Within the study area, are any of the following causing ecological impacts, such as algal blooms or damage to coral reefs:

- **Discharge of untreated or partially treated sewage?**
- **Discharge of treated wastewater effluent?**
- **Irregular release of wastewater from a WWT system due to overflow, rainwater events, or power failure, etc.?**

Yes – discharge of untreated/partially treated sewage and irregular release of wastewater. Treated wastewater effluent is not a problem.

2. **Have any studies been conducted within the study site or your country or region that link wastewater pollution to ecosystem health? If so, what are the findings?**

The primary study was conducted by La Pointe (201), which found evidence of elevated wastewater pollution, especially in the wet season when wastewater ammonium loads from soakaways and other sources are maximal.

A 2001 study of water quality and benthic biota at fringing coral reefs in Tobago found that recent increases in local nutrient pollution, particularly from sewage, had served to push Tobago's coral reefs over the threshold indicative of eutrophication on Caribbean coral reefs (La Pointe, 2007).

Secondary treatment of sewage does not remove dissolved nutrients sufficiently to protect coral reef ecosystems – enters the area from the sewage treatment plants servicing subdivisions like Coral Gardens Estates and Bon Accord.

3. **Is there evidence of the following in any of the key ecosystems present in the study area: (e.g., freshwater, wetlands, mangroves, beaches, coral reefs, forests, wetlands):**
    - **Is it unsightly due to pollution? Are there algal blooms or obvious evidence of pollution?**

There are occasional algal blooms in the study area, including at the coral reef. It is not clear if these are seasonal or related to wastewater.

- **Is there odor due to pollution?**

There are reports of odor in coastal mangroves.

- **Are there impacts to fish or other aquatic life (e.g., fish kills, overgrowth of algae on coral reefs)?**

Not sure.

- **Are you seeing a change in ecosystem health and/or growth?**

The Buccoo Reef encloses the Bon Accord lagoon. Sewage discharge and nutrient and sediment runoff into the lagoon are major problems, resulting in the poor condition of the inner reef, while the outer reef is relatively healthy.

There is a general decline in coral reef health over the past few decades – and this is thought to be due to coral bleaching events (which could be tied to eutrophication). Additionally, tourists were previously allowed to walk on the reef, although this practice has now been banned.

Juman (2005a) and LaPointe et al. (2010) found evidence of eutrophication citing higher biomass of macro-algae. LaPointe et al.'s study found evidence of domestic sewage wastewater being the most important source of marine pollution in the BRC. The study found evidence of dissolved inorganic nitrogen (DIN) enrichment in the BRC due to elevated macroalgal δ15N in the BRC compared to other areas in Tobago, primarily from submarine groundwater discharge of leachate from soakway sytems and from direct sewage outfall discharges. Additionally, LaPointe et al. found elevated Chl a concentrations during the wet season which provides additional evidence of watershed-driven eutrophication in the BRC.

Juman (2005b) states that the enhanced nutrient delivery from pollution sources has enhanced the mangrove's productivity.

Juman (2005a) states that the seagrass community is diminishing. In the wet season there is increased run-off from the mangrove and the land, resulting in increased sedimentation and nutrient loading. High nitrate and phosphate concentrations and total suspended solids were recorded close to the Bon Accord sewage outfall. This could be related to nutrient loading within the BAL that may be increasing the proliferation of phytoplankton, epiphytic and macro-algae that compete with seagrass for light and space.

LaPointe et al. (2010) found that Thalassia tesudinum had invaded the Nylon Pool, stating that this is a symptom of sewage-driven eutrophication in oligotrophic coral reef regions.

4. **Beyond wastewater, are there any other sources of water pollution contributing to these problems? If so, please indicate the relative contribution to total water pollution using the following scale:**

    No contribution – Minor contribution – Moderate contribution – Significant contribution

    - **Runoff from croplands?**
    - **Runoff from livestock?**
    - **Runoff from aquaculture?**
    - **Industrial discharge?**
    - **Cruise ships/yachts?**
    - **Others?**
    - **Do you have a sense of the relative contribution from wastewater to overall pollution of key ecosystems compared to these other sources? If so, please describe.**

Yes – some water pollution from cruise ships/yachts; and runoff from the cattle farm and fish processing plant.

No because water quality data is not tracked or is not available for wastewater discharge locations.

5. **Are there any economic or cultural uses of the key ecosystems that are in decline due to wastewater discharge issues (from untreated or improperly treated wastewater)? Please refer to Annex 2, section B for examples of Caribbean coastal ecosystems and impacts that have been documented from exposure to untreated or improperly treated wastewater.**

6. **Do tourists have any awareness of water quality issues and do they modify activities / visitation? Are you able to quantify or describe the change in visitation (e.g., reduced annual snorkeling rates or reduced number of visitors to recreational beaches)?**

There does not appear to be a decline in tourism at this time.

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VIII. HUMAN HEALTH IMPACTS

Objective: To understand if there is a link between wastewater pollution and key human health illnesses including gastroenteritis, ear and eye infections, and other illnesses (as listed in Annex 2, section C); and to estimate the impacts on the local economy due to human health impacts (e.g., from hospitalization, medication, time taken off work, and death).

Possible data sources: Health agencies or ministries; Hospitals or doctor's offices; national statistics/census data; international statistics from multilateral, intergovernmental or NGOs (e.g., World Bank or World Health Organization); peer-reviewed or grey-literature.

1. **Please describe any known human health impacts, such as gastrointestinal illness, respiratory illness, ear infections, eye infections, or skin rashes/lesions that are occurring in the study site that relate to wastewater. Please see Annex 2, section C for a list of human illnesses related to swimming in, drinking from, or eating seafood from water contaminated with wastewater.**

   - **Are health data recorded on any of these key illnesses? If so, who collects this data? What can you say about the average frequency and duration of occurrence for each type of illness (e.g., 50 cases per year; 1 case per resident person per year)?**
   - **Do reported incidences of these illnesses result in doctors' visits, hospitalization, or death? Do you have statistical data on illnesses and hospital data?**
   - **What activities seem to be contributing (e.g., swimming; eating contaminated seafood)?**
   - **How specific can you be about location?**
   - **Is wastewater pollution the main cause of these health issues? If not, what are the main causes of these diseases?**

LaPointe et al. (2010) state that sewage pollution presents a significant health risk (e.g., from elevated coliform bacteria and fecal streptococci counts found in the area). However, stakeholders present at the WRI/EMA introductory workshop say health data is likely not available.

In 2013, a study by Lahkan et al. was conducted on acute gastroenteritis and food-borne pathogens in T&T. The study states, "During 2000-2005, there were seven large outbreaks of [Acute GastroEnteritis] AGE with over 20,000 cases reported per year but less than 70 cases were of known aetiology (11). The national surveillance system for AGE in T&T is based on both syndromic cases of AGE and its laboratory confirmed pathogens collected using standard data collection forms—weekly syndromic and monthly laboratory data-collection forms (11)—based on the Caribbean Public Health Agency (CARPHA), formerly known as the Caribbean Epidemiology Centre (CAREC).[….] The reason why these illnesses are not well understood lies in the fact that most affected people are not captured by the National Surveillance Unit (NSU).

For acute gastroenteritis - the annual incidence rate was 0.6748 episodes per person-year, with 0.7083 episodes per person-year in males and 0.6321 episodes per person-year in females. The major reasons cited for cases of acute gastroenteritis were food consumption (35.1%), drinking water (17.1%), contact with another sick person (9.9%), contact with an animal (9.9%), and bacterial infection (<1%). Thus – it is unclear the percentage of average cases that might be due to wastewater pollution.

Foodborne pathogens found in the study were *salmonella, Shigella*, rotavirus, and norovirus – all of which have a link to wastewater.

Lahkan et al. found that the common duration for diarrhea was 3 days (with a range of 1-10 days). Time spent away due to diarrhea can involve the following costs: medication and medical costs, costs for a caretaker, loss of leisure activity, loss of income, and loss of days from school.

For acute gastroenteritis, the mean duration of illness was 2.3 days.

2. Have any studies been conducted within the study site or your country or region that link wastewater pollution to human health?

LaPointe (2010 states that wastewater seems to be the major source of water pollution in the Buccoo Reef area (LaPointe et al. 2010)

3. Do any of these studies estimate a dose-response relationship between a given wastewater pollutant and a human health illness (e.g., gastroenteritis)? (See the BCA methods section for more detail.)

4. Beyond wastewater, are there any other sources of water pollution contributing to these problems? (If so, please note how large of a contribution.)

- **Runoff from agriculture?**
- **Runoff from livestock?**
- **Runoff from aquaculture?**
- **Industrial discharge?**
- **Cruise ships/yachts?**
- **Others?**

Yes – some water pollution from cruise ships/yachts; and runoff from the cattle farm and fish processing plant.

5. **Do you have a sense of the relative contribution from wastewater to overall health impacts compared to these other sources? If so, please describe.**

No – no health data were available or provided by the county medical office and no site-specific dose-response relationships are available for wastewater pollutants.

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IX. FUTURE WASTEWATER MANAGEMENT SCENARIO(S)

Objective: To identify and define at least one future wastewater management scenario to compare against the current infrastructure situation in terms of population served, untreated wastewater, pollution removal efficiency for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Wastewater consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits.

1. **What option or options are under consideration for improving wastewater management in the pilot area? Please provide a description and fill in Table 9 for each major wastewater treatment plant or infrastructure element. Please add columns as necessary if more than two alternatives are being considered.**

The future infrastructure scenario is based on the Alpha Engineering Draft CEC application from 2011. The scenario involves:

Bon Accord. The proposed solution for the Bon Accord catchment includes the expansion of system by the installation of an expanded collection system (e.g., small bore sewer lines and lift stations) that will transport effluent from area that are not currently connected, to the existing waste stabilization ponds at Bon Accord. This will be made possible by utilizing the existing anaerobic tanks (septic systems) on individual properties. The solution allows the elimination of some dysfunctional package plants and treatment of liquid wastes from on site (septic) systems. Gray water will not be treated.

Milford Court. The proposed solution for the Milford Court area includes the expansion of the system by the installation of a collection system (small bore sewer lines and lift stations) to transport effluent from the area that are not currently connected, to the existing WSP at Golden Grove. This will be made possible by utilizing the existing anaerobic tanks on individual properties. The solution also involves converting the Milford Court WWTP into anaerobic treatment tanks only. The effluent from these tanks will be piped to the Golden Grove WSP. Gray water will not be treated.

Coral Gardens / Buccoo. The proposed solution for the Coral Gardens/Buccoo area is to allow for full removal and treatment of all domestic wastewater (black and grey water) from the community. This would involve the conversion of the Coral Gardens WWTP into anaerobic tanks and the construction of a new lift station to allow for the discharge of the effluent via pipelines to the Golden Grove WSP. Additionally, new sewer lift stations will be built at the site of the Buccoo Integrated Facility (goat race facility). A full bore 200 mm gravity collection mains to collect sewage from the school, goat race facility, community center, fish depot, and pan yard and houses not currently connected to the system would be constructed.

Table 9: Future wastewater management scenarios description

Data need	Alternative 1
Design	
Location	Southwest Tobago
Design capacity - annual average and peak (if actual capacity is lower, that will be covered below under performance)	Bon Accord catchment= 1834 m3/ d ADF Golden Grove catchment= 1666 m3/d ADF
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Current system upgraded (see description above), waste stabilization ponds, wetland, and increased distribution pipelines, gravity lift stations
Will effluent and water quality standards be met?	Yes
Sludge treatment and disposal	Via tanker to Studley Park landfill
Discharge location (receiving water body). If coastal, is there an outfall(s)?	Alpha Engineering (2011) states there will be fewer discharge locations than the current situation. Principal discharge point at the Bon Accord and Golden Grove constructed wetlands
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Flows (annual average, peak)	Estimated 2035 ADF of 3500 m3/d
Annual energy usage (kW hours, total cost)	

Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and estimated bypassed volume for each event).	
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	The occurrence of overflows is expected to be reduced (but unclear on the improvement level)
Annual average discharged concentrations and loads of:	WP standard to be met Bon Accord : BOD: 5 mg/l SS : 4mg/l FC : 83#/100 ml Golden Grove: BOD : 0 mg/l SS : 0 mg/l FC : 93#/100ml
• BOD_5 (mg/l, kilograms per year)	
• Dissolved oxygen (mg/l)	
• Total Nitrogen (mg/l, kilograms per year)	
• Ammonia Nitrogen (mg/l, kilograms per year)	
• Total Phosphorus (mg/l, kilograms per year)	
• Total Suspended Solids (mg/l, kilograms per year)	
• Faecal coliforms (units as reported)	
• Enterococci (units as reported)	

2. What are the evaluation criteria for choosing an infrastructure option and who decides what these criteria are? For example, criteria may include cost-effectiveness, pollutant removal efficiency, and/or environmental impacts.

For WASA, the following are important evaluation criteria:

- Cost (this option is 10% of the cost of a full conventional collection and treatment system for the South west Tobago) – including both capital and O&M costs
- Shorter time to implement- (10 months versus 36 months)

For EMA, the following are important to consider:

- Water Pollution Rules
- Requirements of Certificates of Environmental Clearance and Environmental Impact Statements

Other stakeholders from the WRI/EMA workshops indicated:

- Human health impacts
- Ecosystem impacts
- Ecosystem service impacts
- Economic growth/disruption related to construction of new facilities
- Energy consumption of plant
- Ease of operation of infrastructure

3. What sort of improvements are expected from each future wastewater management scenario?

- **Increased coverage in terms of population treated?**
- **Improvement in water quality of receiving water bodies and downstream water bodies?**
- **Reduced levels of:**
    - **BOD5**
    - **Dissolved oxygen**
    - **Total nitrogen**
    - **Ammonia nitrogen**
    - **Total phosphorus**
    - **Total suspended solids**
    - **Faecal coliforms**
    - **Enterococci**

WASA expects that the future scenario will meet WPR and LBS protocol standards.

The improvement also caters for expected wastewater flows to the year 2025.

4. Will the new wastewater treatment technology allow any reuse of water?

- **Where does the treated water go – back in a river, out an outfall, or into a specific use (e.g. irrigation, industrial use, or drinking water)?**
- **Has anyone estimated the potential cost savings associated with reuse of this wastewater?**

Potentially.

- The treated water enters the constructed wetlands adjacent to the Bon Accord Lagoon
- Some discussions were held but the cost for implementation of the treatment required was found to be prohibitive and the reuse customers were very limited (watering of the golf courses)

5. Have any engineering or financial analyses been conducted for future wastewater management alternatives? Do they provide cost data?

The Alpha Engineering (2011) CEC application has cost data.

- Scenario 1, Alpha Engineering proposed solution utilizes the existing waste stabilization ponds (Bon Accord and Samaan Grove) to treat waste from the major polluters in the South West Tobago and is estimated at $ TT 120 million –capital cost.
- The development of a conventional gravity sewerage collection system and Wastewater Treatment Plant for the entire South West Tobago was estimated at $ TT 800 Million in 2009 including a 1.4 km outfall pipeline in the sea- capital cost.

6. **Please fill in Table 10 to the best extent possible based on either engineering/financial reports from the wastewater authority and relevant consultants, OR by referring to Annex 2 which provides information on relative cost by infrastructure type.**

Table 10: Cost estimates for future wastewater management scenarios

Parameter	**Alternative 1**
Year of installation	2015 (estimated at end of 2014)
Life expectancy (years)	50 years
Total area of the plant (please list the area that will need to be purchased for the treatment facility)	Bon Accord- 4.6367 hectares Samaan Grove- 6.0997 hectares
Capital/Investment expenses (This includes one-time construction, planning, and design costs, costs for new development, and cost for replacement and renovation of existing assets – including external or consulting services)	Engineering & construction supervision costs: $4.91 million TT Collection system and WW treatment : $120 Million TT Land management issues: $ 22 million TT **Total = $ 146.91 million TT (Costs include connections to individual properties)**
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced sooner than the life expectancy of the treatment facility and the recurring capital cost, including likely year of replacement and the frequency of replacement)	Not available
Annual recurring expenses: -Salary/wages for all personnel -Land rental value for land purchased (i.e., the value of land purchased to install the wastewater infrastructure)	Not available $TT 3 Million /yr

-Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)	
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)	Not available
Other costs	
Net present value over infrastructure's lifetime	**Total = $ 146.91 million TT**

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X. CHANGES TO ECOSYSTEM AND HUMAN HEALTH UNDER IMPROVED WASTEWATER MANAGEMENT SCENARIOS

Objectives: To quantify and/or describe how ecosystems and the goods and services they provide will change under each future wastewater management scenario, and the potential impacts on the local economy in terms of costs;

To quantify and/or describe how human health will be impacted under each future wastewater management scenario in terms of numbers of reported illnesses and costs.

Possible data sources: Peer-reviewed and grey literature; Government documents including environmental impact statements.

1. **Have any evaluations, studies, or environmental impact statements been conducted that estimate the impact on key ecosystems and human health under each new wastewater management scenario *compared to the current wastewater management situation*? Do you know of any experts that are currently studying potential impacts? If so, please describe these findings, including how likely management under each scenario is to:**

    - Reduce the annual loading of pollutants on receiving water bodies?
    - Reduce odor?
    - Reduce the incidence of harmful algal blooms and/or nutrient over-enrichment?
    - Reduce human health risk and/or the number of cases for illnesses previously identified?
    - Improve ecosystem health conditions for the key ecosystems identified previously?
    - Improve the provision of key ecosystem goods and services identified previously (e.g., increased likelihood of tourist visits, increased productivity of fisheries due to improved coral reef and mangrove health)

No – we are not aware of any studies that estimate the potential change in ecosystem and ecosystem service condition due to the proposed wastewater management scenario. As a result, a cost-benefit analysis cannot be conducted.

WASA (2015) provided the following data: Within the targeted areas of the project, the system is designed to capture the major polluters (commercial). The impact of this initiative will be to capture approximately 90% of the building structures along the Crown point/Pigeon point coastline. All buildings within reach of the coastline in the Buccoo area would be sewered under this project. The net result of the works in both Crown Point/ Pigeon point and Buccoo areas would be 80% central sewer coverage. Individual homes within the project area that are not targeted for connection to the sewer system would be inspected to insure that their on-lot system is functioning properly.

The upgraded waste stabilization ponds are considered secondary treatment. WASA has indicated that treated effluent from the ponds will meet water quality levels established by the Water Pollution Rules.

Alpha Engineering listed potential benefits from the upgrades listed in the CEC application (2011). These benefits include:

- Fewer outfall locations which means fewer pollution sources and more control over the quality of wastewater discharged
- Better quality effluent that meets EMA water quality standards
- Possibility of reusing effluent in agriculture or aquaculture
- Lower capital and O&M costs (as waste stabilization ponds require less operators, electricity and mechanical equipment)

2. **Can you establish a quantitative relationship between an improvement in water quality due to the future wastewater management alternative and a change in provision of ecosystem services for each key ecosystem? If so, please list your assumptions and quantitatively describe these changes (e.g., by reducing the amount of untreated wastewater entering the coral reef ecosystem, total nitrogen levels will decrease by 30% surrounding the reef which will improve coral reef health such that fisheries production increased by 20%).**

No.

3. **Can you monetize or value the change in ecosystem service provision (e.g., what is the economic value of reduced coral reef degradation in terms of fisheries improvement – this is often quantified by estimating the market value of fish sold in a marketplace)?**

No.

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XI. OTHER INFORMATION

1. **Please list any additional data or information you think would be useful to the study that might not have been discussed previously in this characterization form.**

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XII. REFERENCES

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ANNEX 3C. CHARACTERIZATION FORM FOR DEFINING THE COSTS AND BENEFITS OF DOMESTIC WASTEWATER MANAGEMENT

STUDY SITE: Chaguanas, Trinidad

UN environment
United Nations
Environment Programme

Caribbean Environment Programme

Annex 3C. Characterization Form for Defining the Costs and Benefits of Domestic Wastewater Management – Chaguanas, Trinidad

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STUDY SITE: Chaguanas, Trinidad

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RESPONDENT INFORMATION

This report was completed by:

Name: Erin Gray and Lauretta Burke, World Resources Institute (WRI); Roger Karim, WASA

Organization: WRI and WASA

Date: August 12, 2015

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Contents

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I. DEFINE THE STUDY AREA

Objective: Define and map the study area including key geographic and land use data to identify wastewater pollution and other water pollution pathways and populations of interest.

Possible data sources: National environmental, water, and/or marine agencies; non-profit organizations (NGOs); academic institutes with marine/environmental centers that conduct research within the study site.

1. Please define the study area by providing a detailed description.

The study area should include the sewage catchment name(s) and geographic area, the populated area to be served by improved wastewater treatment, the area downstream which is expected to be influenced by the change in wastewater management (including receiving water bodies (e.g., rivers, lakes, oceans) and water catchments[1]), and the upstream catchment (which might be contributing pollutants to the water body of focus).

The study area for Chaguanas encapsulates the Borough of Chaguanas (including the Chaguanas sewerage catchment) and the potential growth boundary as Chaguanas develops from a borough to a city. The study area includes the Cunupia, Guayamare watersheds and a section of the Caparo watershed - these watersheds are upstream of the southern portion of the Caroni Swamp. As a result, the southern portion of the Caroni Swamp is also included in the study area. The Chaguanas sewerage catchment is roughly 3,000 – 5,000 hectares and includes approximately 9-12 sewerage catchments (WASA 2015).

There are three reports from WASA that discuss wastewater in Chaguanas. These reports are valuable for providing some additional context, but may not reflect current knowledge. Thus, the first paragraph of this section best represents the overview of the study area. The three reports include:

1) **WASA 2008**: A report by WASA's Wastewater Unit from 2008 entitled, "Wastewater services in Chaguanas and Environs," prepared by WASA's Wastewater Unit
2) **GENIVAR 2009:** A report drafted by GENIVAR for WASA entitled, "WASA Water and wastewater master plan and policy development: Wastewater alternatives Report for Trinidad – Draft" that appears to be from 2009. We have received section 4.12 and 6.6.9 of this report from WASA.
3) **WASA (Chapter 3.3.9)**: Chapter 3.3.9 of a report by WASA from an unknown year, "Detailed designs and tender documents for construction contracts for the rehabilitation, expansion, and integration of wastewater treatment facilities."

The WASA 2008 report defines current and future wastewater infrastructure scenarios for an area called "the Chaguanas Catchment." This area is defined as covering 2,955 hectares, with 86% of that area being developed (2,529 ha). The boundaries of the study area include:

- Warrenville to the north
- Felicity to the west

[1] See glossary for definition of water bodies and water catchments

- Cunupia to the east
- Edinburgh to the south

This report states there are 12 separate wastewater systems (or catchments) existing in the area that serve the following developments:

1. Boodram Development
2. Centre City Mall
3. Homeland Gardens
4. Mid Center Mall
5. Orchard Gardens
6. Point Pleasant
7. Charlieville
8. Edinburgh 500
9. Penco Lands
10. Chaguanas Senior Comprehensive School
11. Lange Park

The WASA chapter 3.3.9 states that the Chaguanas sewerage catchment occupies an area of 4,773 hectares which corresponds to the area of the Borough of Chaguanas. The report states there are 9 sewerage catchments existing within the area including:

1. Boodram Development
2. Centre City Mall
3. Homeland Gardens
4. Mid Centre Mall
5. Orchard Gardens
6. Point Pleasant
7. Ramsaran Park
8. Saint Anthony's Park
9. Simon Development

2. Can you put it on a map? (with GIS; Google Earth; or participatory mapping)

If possible, indicate on a map the information provided in Question 1. This can be done in GIS, using Google Earth, and/or working with stakeholders using a participatory mapping approach to highlight on a hard copy map the response to Question 1.

A map provide to WRI by WASA ("Chag-Edin Catchment" – figure 1) provides an overview of the Chaguanas region sewage collection system. This map (including both the North and South sections) represents the wastewater treatment catchments, but based on input from WASA (2015), we believe the Cunupia, Guayamare, and Caparo watersheds should also be included in the study area, as their respective river/streams run through Chaguanas and into the Caroni Swamp. WASA (2015) notes that we may need to examine this closer to determine how these two watersheds fall into the Chaguanas catchment since other factors need to be considered including proximity to water courses, geotechnical considerations, population density, population growth, and economic criteria. Figure 2 reflects this broader definition of the study area, including these catchments.

Figure 1 - Map showing contour line that divides Northern and Southern sections of the Chaguanas region sewage collection. (WASA, 2008)

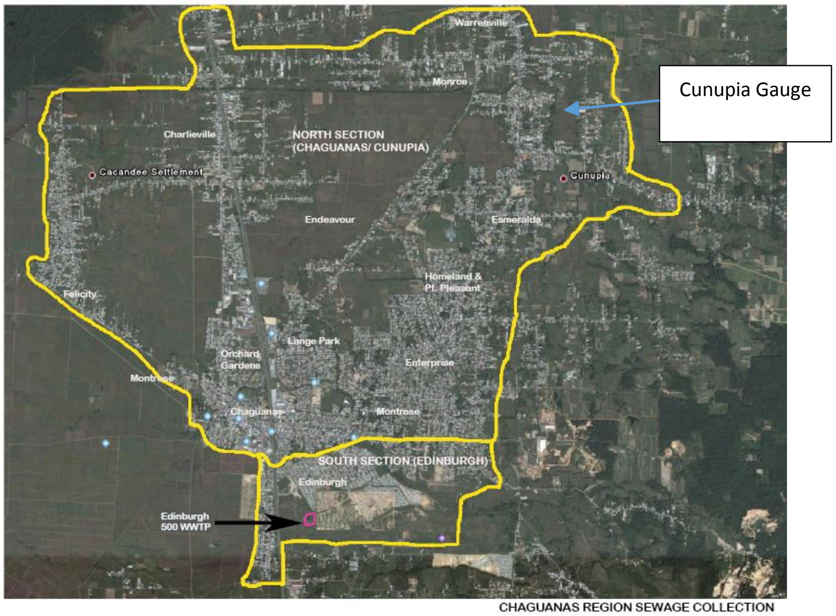
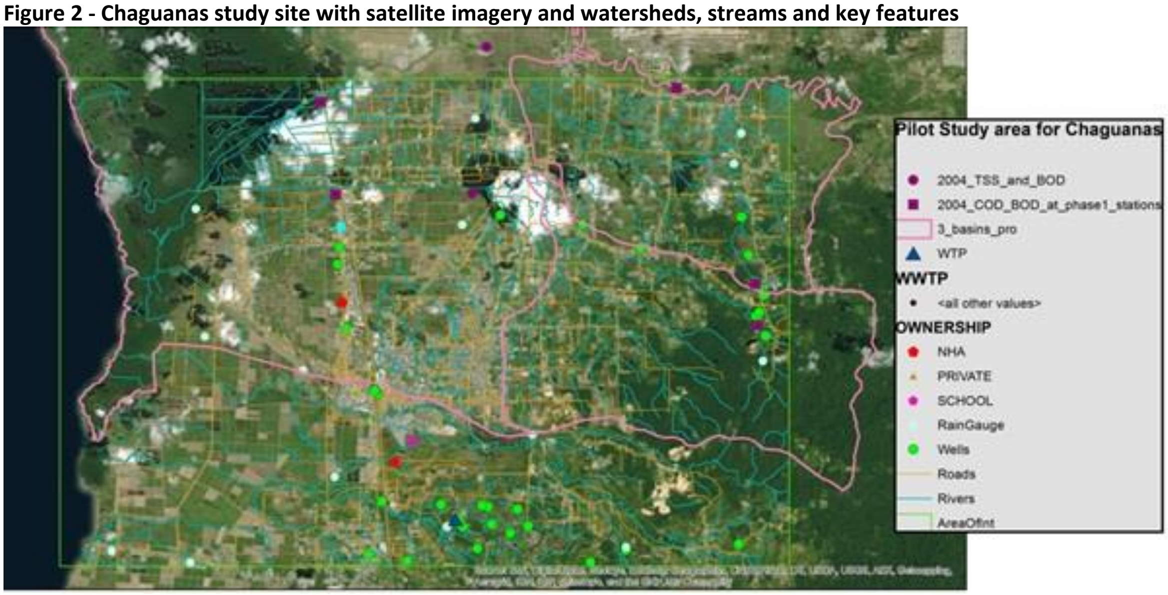


Figure 2 - Chaguanas study site with satellite imagery and watersheds, streams and key features

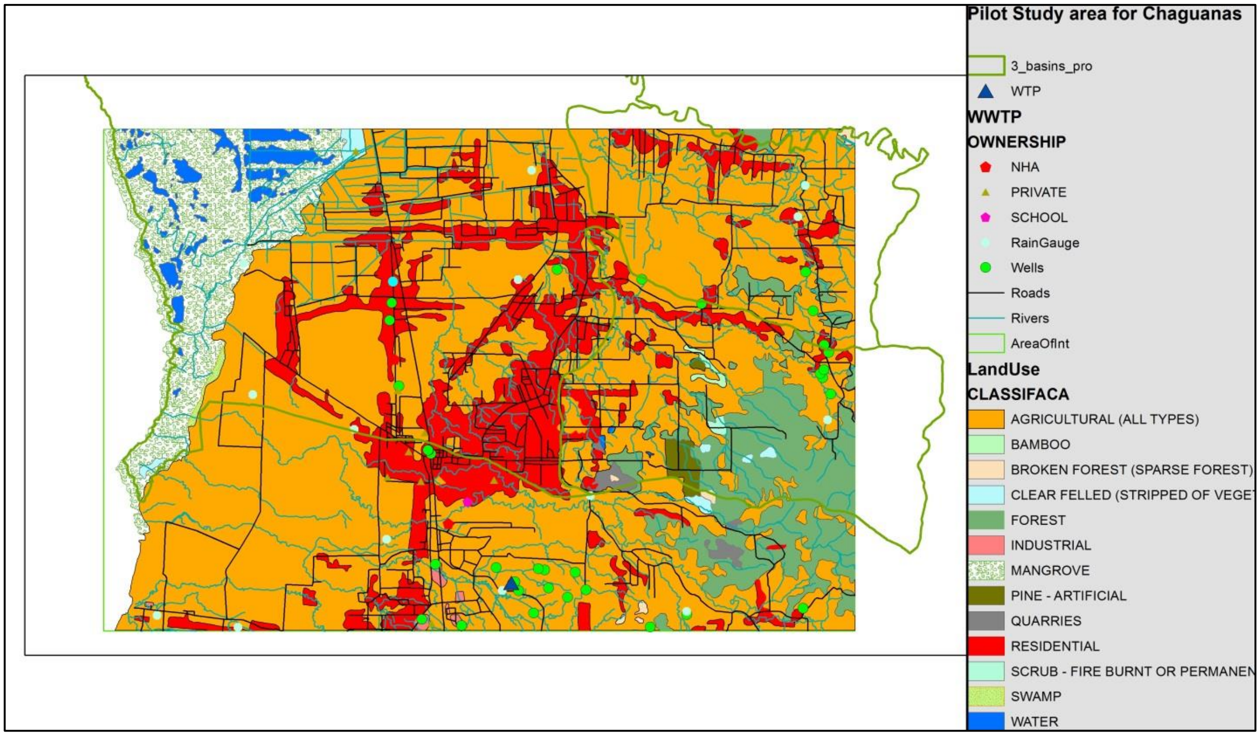


3. What are the major land uses (such as residential, commercial, agricultural, open space / natural) in the study area?

- **Could you do rough estimates of percentages of each major land use?**

Figure 3 provides an overview of major land cover types in the study area. The major land uses are agriculture, followed by residential, and mangrove.

Figure 3 - Land Use in the Chaguanas study area



The WASA 2008 report states that there has been a major thrust towards development in the Chaguanas catchment towards land development, catering to residential, light industrial, commercial, and agricultural purposes. WASA (2015) states that Chaguanas may soon grow from being a Borough to a city.

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II. POPULATION

Objective: Population data is critical for understanding current and future wastewater demand as well as the number of people who may swim in or eat from waters contaminated with untreated wastewater.

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. How many people live in the study area? (Approximate if necessary)

See #3.

2. Can you disaggregate this by neighborhood / area / housing development / smaller administrative unit?

No.

3. How many households are in the study area? (Approximate if necessary.)

According to the 2011 Census (CSO 2012), there were 24,644 households in the Borough of Chaguanas in 2011, with an average household size of 3.4. The population living downstream of the Borough and/or in the southern portion of the Caroni swamp is uncertain.

4. What is the population projection for the study area over the next 20, 30, and/or 50 years (for each period if data are available)?

Table 1: Summary population and household data by WASA report for the Borough of Chaguanas

REPORT	CURRENT POPULATION	PROJECTED POPULATION
WASA 2008	98,396 (as of 2007)	132,930 (for 2037)
GENIVAR 2009	85,502 (as of 2010)	89,025 (for 2035)
WASA 3.3.9	84,000 (as of 2012)	123,600 (for 2040)
CSO 2011 Census[2]	83,516 (as of 2011)	151,277 (for 2041)

The Central Statistical Office found that the annual population growth rate for the Borough of Chaguanas between 2000 and 2011 was 2%. The population then that could be predicted for 2041 based on a population of 83,516 from the Central Statistical Office (CSO) for 2011 would be 151,277.

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III. ECONOMIC ACTIVITIES

Objective: Economic data are important for understanding the economic activities that are important for the local economy that rely on ecosystems (especially those potentially impacted by water pollution).

[2] Corresponds to the Borough of Chaguanas from CSO 2011.

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. **Are the following sectors important for the local economy (ideally for the study area)? Can you estimate the relative contribution from each sector to the local economy? If quantitative data are not available, please rate the sector's importance based on the following scale:**

   Importance Scale:
   - **Not important:** The sector is not relevant as it does not contribute much to local GDP (e.g., through jobs or financial contribution)
   - **Moderate importance:** The sector is important, but is not the main contributor to local GDP.
   - **Very important:** The sector contributes substantially to local GDP.
   - **Critical:** The sector contributes the largest amount of any sector to local GDP

According to Wikipedia (2015), "[Chaguanas] originally grew in size due to its proximity to the Woodford Lodge sugar refinery and the Central Trinidad town of Couva. It remained a minor town until the 1980s when it began to grow rapidly as it drew people for its bargain shopping and moderately-priced housing. However, its rapid growth has seen property values increase dramatically. Chaguanas became a borough in 1990; prior to that it was part of the County of Caroni.

- **Tourism? (Note types of tourism):** Moderately important. Caroni swamp is a designated Ramsar site and is a popular ecotourism destination for birdwatching and boat tours. The site is a roosting ground for the national bird, the Scarlet Ibis. Thus – the site is important both economically and culturally. It is unclear, however, the importance for the local economy of the Borough of Chaguanas.

- **Agriculture? (Note types of agriculture):** Somewhat important – while agriculture appears to be a predominant land use in the area, we are not sure of the importance to the local economy. The Chaguanas Spatial Development Plan (Ministry of Local Government 2013) states, "the loss of relatively good agricultural lands has led to the economy being based on mainly commercial activity and to a lesser extent light industrial activity. There is a dependence on these sectors to generate jobs. The economy needs to be more diversified and good agricultural lands need to be protected through zoning regulations."
- **Fisheries? (Note major fish species):** Moderately to very important – Caroni Swamp is a popular fishing site, especially for oysters. It is unclear, however, the importance for the local economy in the Borough of Chaguanas.
- **Industry? (Note what industry/ies):** Moderately important – According to Wikipedia, ABEL or Alstons Building Enterprises Limited is a member of the ANSA McAl Group of Companies and is situated in Longdenville. It is the largest manufacturer of clay building blocks and Metpro steel and aluminum windows and doors and Astralite and Spectra uPVC windows and doors in the

English-speaking Caribbean. Also, the dissolution of the state-owned sugar company, Caroni (1975) Limited, had a profound effect on Chaguanas, since this company was a major employer.

- **Commercial:** Very Important. According to Wikipedia (2015), "Chaguanas developed as a market town and still attracts bargain shoppers. Much of Chaguanas' development has centered around the Chaguanas Main Road where numerous shopping plazas have been constructed. The Chaguanas Main Road (east of the Chaguanas flyover) continued to develop, primarily through small and medium size businesses, to fulfill the expanding population centers. Retail development expanded with the construction of three malls in the downtown in the 1980s (Centre City, Mid Centre and Ramsaran Plaza, later to become Centre Pointe Mall). Centre City Mall has been significantly renovated and there are future plans to expand further to become the largest mall in the Caribbean. It will feature two major buildings, one near to the Uriah Butler Highway and another close to the center of Chaguanas, joined by an enclosed walkover above the Mulchan Seuchan Link Road. More recently, construction of Price Plaza in Endeavour expanded upscale retail opportunities. Price Plaza includes a warehouse-style store PriceSmart, TGI Friday's and Ruby Tuesday restaurants, a food court, SuperPharm, as well as many other retail outlets. MovieTowne is situated nearby the Price Plaza and continuing further expansion. Adjoining to the Movietowne complex are other restaurants and bars, e.g. Woodforde Cafe, Wild Olive Restaurant, and Hollywood Grill. A new shopping complex is planned to be built in 2013-15 in the Brentwood planned housing and commercial development."
- **Financial:** Moderately important. According to Wikipedia (2015), "Chaguanas has also developed into a financial center. The Unit Trust Corporation (UTC), First Citizens Bank (FCB), Sagicor, Republic Bank of Trinidad and Tobago, Scotiabank, RBTT, and the Bank of Baroda all have major corporate offices in Chaguanas."

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IV. KEY ECOSYSTEMS

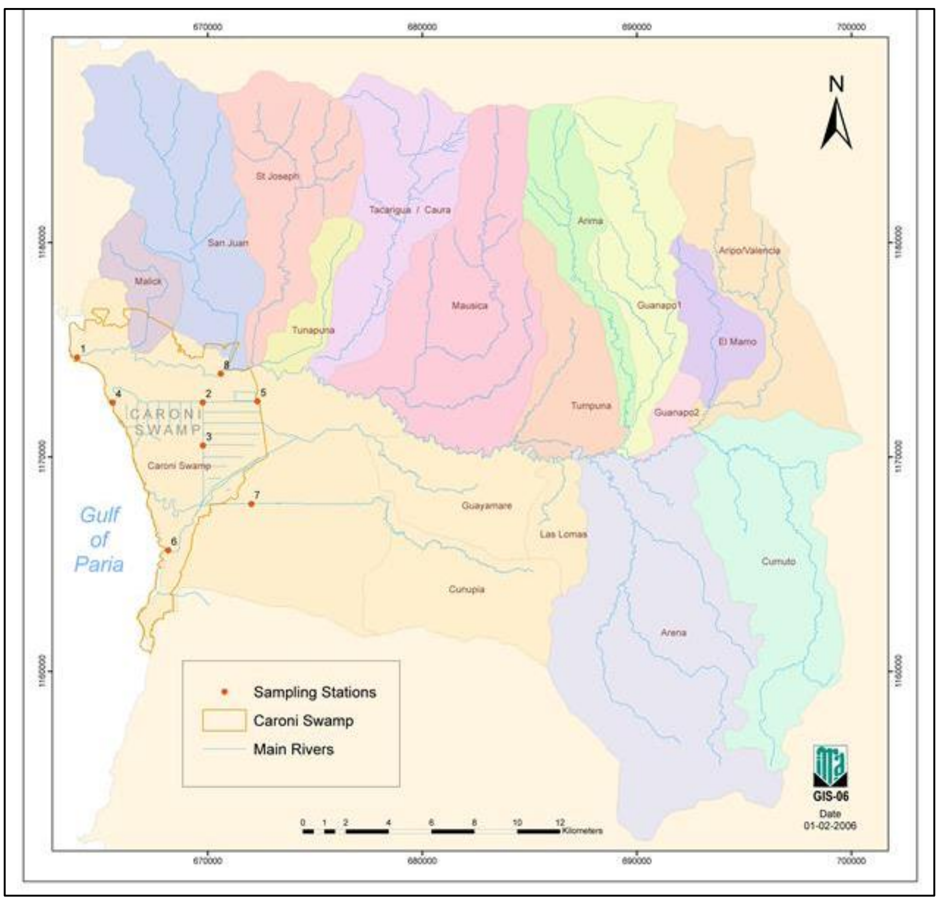
Objective: To understand potential benefits to ecosystem health from wastewater management improvements, it is necessary to a) identify key ecosystems in the study sites, b) their economic contribution in terms of key goods and services they provide, c) their contribution to key economic sectors. This will help to characterize the dependence of these sectors on healthy ecosystems, and as a result, the value of these ecosystems to the study population and the nation.

Possible data sources: Government environmental/water/natural resource agencies or ministries; Academic institutes and environmental NGOs conducting research or working towards the protection or conservation of ecosystems; Peer-reviewed and grey literature on key ecosystem both within and outside of the study area; Government reports including environmental impact statements, water quality permits, or benefit-cost analyses;

1. What are the <u>key ecosystems</u> in the study area (e.g., coral reefs, mangroves, seagrass beds, beaches, forests, wetlands), especially downstream from population, sewage discharge, or treated wastewater discharge? Key ecosystems are those which are important to the local economy or those which provide important cultural services.

An important ecosystem in the study area is the Caroni Swamp. Juman, Bacon, and Gerald (2002) provide an overview of the Caroni River Basin (CRB). The CRB covers a total of about 883.4 km2, equivalent to 22% of the land surface area of the island (Juman et al). The CRB includes the Caroni Swamp, which is a Ramsar site as of 2005 and is the largest mangrove area in Trinidad. The swamp consists of 5,611 ha of mangrove and herbaceous marsh, interrupted by numerous channels and lagoons. The swamp comprises eight mangrove species. It is situated on the eastern coast of the Gulf of Paria, a semi-enclosed sea bordered on the north by the Caribbean Sea and the southeast by the Atlantic Ocean and lying between Trinidad and Venezuela. It is shallow, with an average depth of about 25 m and a maximum depth of 300 m in a trench to the north. Figure 5 provides an overview of the CRB and IMA water quality sampling locations.

Figure 4 - IMA water quality sampling stations in Caroni Swamp and Caroni River Basin Catchments (IMA)



Beyond the Caroni Swamp, there are also important riverine ecosystems within the study area. However, little information is available on characteristics of these water bodies.

2. **Please rank how important these ecosystems are to the economic sectors previously listed in Section III (within the study area) (e.g., is tourism in the area dependent on healthy ecosystems?). Please indicate in Table 2 below the relative importance based on this scale:**

Importance Scale:

- **Not important**: The ecosystem has no relevance to the economic sector.
- **Moderate importance**: The economic sector is dependent on resources/services provided by the ecosystem but substitutes for natural resources are available (e.g., forest ecosystems provide water filtration services that can improve the health of fisheries, but water filtration systems are also available to filter water).
- **Very important:** The economic sector is dependent on the resources/services provided by the ecosystem and substitutes are not available or are exorbitantly expensive (e.g., mangroves provide important coastal protection services, guarding some shoreline industries from flooding and hurricanes. While options exist to improve coastal protection like dikes jetties, this type of infrastructure can be costly to build and maintain).
- **Critical:** The ecosystem is vital to the economic sector in that the sector would not profit or exist without the ecosystem (e.g., tourism in a coastal community may be completely dependent on coral reefs for scuba diving, snorkeling, and sand creation as these activities provide the most income to the local economy).

The table below indicates our best guess based on information reviewed in studies listed in the bibliography and consultations with stakeholders.

Table 2: Ranking of ecosystem important to key economic sectors

ECOSYSTEM	AGRICULTURE	FISHERIES	INDUSTRY	TOURISM	COMMERICAL	FINANCE
Caroni swamp	Not important	Very important	Not important	Very important	Moderate importance	Not important
Riverine ecosystems	n/a*	n/a	n/a	n/a	n/a	n/a

*n/a = not available

3. **What goods and services do these key ecosystems provide (i.e., what are each of the ecosystems used by people for?). Please fill out the table below and add or delete ecosystems as needed. You may refer to Table 4 which provides a general list of ecosystem services for major Caribbean ecosystem types, for guidance.**

Table 3: Ecosystem goods and services

Ecosystem Goods and Services	CARONI SWAMP
Food	X
Raw materials	X
Medicinal resources	
Genetic resources	
Other…	
Flood/storm/erosion regulation	X
Climate regulation	X
Other…	
Tourism and recreation	X
History, culture, traditions	X
Science, knowledge, education	X
Other…	
Primary production	X
Nutrient cycling	X
Species/ecosystem protection	X
Other…	

Table 4: Examples of coastal ecosystem goods and services

ECOSYSTEM GOODS AND SERVICES	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES
Provisioning services				
Food (e.g., fisheries)	X	X	X	X
Raw materials	X	X	X	X
Medicinal resources	X	X		X
Genetic resources	X	X		X
Regulating services				
Flood/storm/erosion regulation	X	X	X	X
Climate regulation	X	X	X	X
Cultural services				
Tourism and recreation	X	X	X	
History, culture, traditions	X	X	X	X
Science, knowledge, education	X	X	X	X
Supporting services				
Primary production	X	X	X	X
Nutrient cycling	X	X		X
Species/ecosystem protection	X	X	X	X

Source: WRI Coastal Capital Guidebook (Waite et al. 2013)

4. **Are there any <u>existing estimates of the economic values</u> of these uses of ecosystems for this study area or nearby (e.g., through peer-reviewed or grey literature)? If so, please list these values, describe the methodology used to develop them, and provide a citation.**

There is a study by Rambial (1980) that estimates the recreational and fishing value for the Caroni Swamp from Rambial (1980). The study found that the economic benefits of the Caroni Swamp were estimated to be TT$2020 per hectare across the 5000 hectare reserve based on estimated recreational and fishing resources in 1974 by Rambial (1980).

Additionally, it appears that an additional study was recently conducted by Mackoon, entitled, "An Economic Valuation of the Recreational Resources at the Caroni Swamp Bird Sanctuary." This study will estimate the domestic access value of the recreational resources at the Caroni Swamp Bird Sanctuary. The major economic activity is recreation which occurs in the form of guided boat tours. An Individual Travel Cost Model (ITCM) was used to estimate the domestic access value of this direct use of the Swamp. Results are not yet available, however.

5. **Do you have statistics on visitation / tourism (both foreign and national) to key ecosystems and/or statistics on visitation/tourism for the country for eco-tourism? For example, do you have**

data on the number of tourists (including cruise ship passengers, national and international tourists, and others) that visit the key ecosystems identified above?

No data is available on visitation to the Caroni Swamp. However, daily boat tours are conducted within the swamp.

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V. CURRENT WASTEWATER MANAGEMENT SITUATION

Objective: To understand how wastewater is currently treated within the study site to allow comparison against future wastewater management alternatives in terms of population served, untreated wastewater, pollution removal effectiveness for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits; Wastewater experts; Historical costs; National price books.

1. **On-site wastewater treatment coverage:**
   - **Please estimate the percentage of the total domestic wastewater sector within the study that uses each type of on-site system below. For example: 30% of the total population uses on-site treatment. Of this 30%, 10% uses septic system, 10% uses pit latrines, and 10% uses soakaway systems).**
     - **Septic systems**
     - **Pit latrines**
     - **Soakaway systems**
     - **Other?**

A report by the CSO (2000) states that within the Chaguanas *municipality*, ~15% of people are connected to a sewerage system, ~65% use septic tanks or soak-away systems, almost ~20% use pit latrines, and 0.23% have no treatment whatsoever. WASA recently confirmed this estimate in July, 2015 (2015).

- **What percentage of on-site systems (septic systems, pit latrines, soakaway systems, etc.) are properly maintained (i.e., regularly pumped out, drain fields not clogged, etc.)?**

Not clear – although stakeholders at both the introductory Environmental Management Authority (EMA) and World Resources Institute (WRI) wastewater workshop in October 2014 (EMA and WRI 2014) and the follow-up workshop in July 2015 (EMA and WRI 2015) indicated that there is some untreated wastewater from on-site systems leaking into local water bodies. Additionally, the Chaguanas Spatial Development Plan (Ministry of Local Government 2013) identified untreated wastewater as a hazard for the local area.

2. **Wastewater collection system (i.e., sewerage):**
   - **Please describe the coverage of the current sewage collection system in terms of length of pipelines and the ultimate treatment point.**

Information not available.

- **Please estimate the percentage of the total population and commercial and industrial establishments within the study that are connected to a centralized sewerage system.**

According to the WASA 2008 report, only 14% of the total population in the study area has access to centralized sewerage facilities. Additionally, stakeholders at the follow-up WRI/EMA workshop in July 2015 indicated that industrial wastewater discharge into WASA's network is a concern – if industrial sources discharge into WASA's sewerage network they are not required to meet Water Pollution Rule standards, and can overburden the sewerage system.

3. Wastewater treatment plants:

- **Please describe the number and type of wastewater treatment plants (WWTP) currently in place in the study area.**

Currently, there are 14-15 package wastewater treatment plants and up to three may be constructed in the near term (WASA 2015). These systems serve the following developments:

- Charlieville
- Orchard Gardens
- Centre City Mall
- Centre Pointe Mall
- Mid Centre Mall
- Edinburgh 500
- Penco Lands
- Chaguanas Senior Comprehensive School
- Lange Park
- Boodram Development
- Homeland Gardens
- Point Pleasant

The Orchard Gardens plant is currently dysfunctional and is discharging untreated wastewater directly into its receiving water bodies (WASA 2015). WASA plans to address this plant immediately. A large number of the remaining package plants are operated by private operators and are in a dire state of disrepair, with raw sewage discharging directly into the receiving streams.

There are four major wastewater treatment plants in the study area: Edinburgh 500, Penco, Lange Park, and Charlieville plants. WASA states these are operating satisfactorily (2015). The Environmental Management Authority (EMA) has provided WRI with recent Certificate of Environmental Clearance (CEC) for WASA from 2009 for the Chaguanas area and environs for the activity, "the establishment, modification, expansion and decommissioning or abandonment (inclusive of associated works) of pipeline distribution systems for the delivery of potable, process water and sewage." In 2013, a CEC was issued to WASA for the decommissioning and demolition of the existing Homeland Gardens and Pointe Pleasant WWTPs and the establishment of a new WWTP at the corner of Mahogany Drive and Teak

Drive in Chaguanas. Certificates of Environmental Clearance are issued by EMA (under the Environmental Management Act, Section 35) and certify the environmental acceptability of a proposed activity, provided that all conditions in the CEC are met. The status of these activities, however, are unknown.

Environmental Impact Statements are not available for any of these plants.

- **For each WWTP, please fill in Table 5 to the best extent possible. Please see Annex 2 for a glossary of wastewater terminology. Please copy and paste this table as needed if more than one treatment plant exists within the study site:**

Information is not available for any of the four main WWTPs nor the package plants. WASA (2015) states that as most plants were constructed before the establishment of the Water Pollution Rules in 2001, water quality monitoring is not required for these plants.

Table 5: Wastewater Treatment Plant information for current situation

Data need	Data
Design	
Location	
Design capacity - Nominal design capacity for dry and wet weather flows.	
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	
Effluent limits	
Sludge treatment and disposal	
Discharge location (receiving water body). If coastal, identify the outfall locations.	
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Current flows (annual average flow, monthly average peak flow)	

Annual energy usage (kW hours, total cost)	
Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and estimated bypassed volume for each event).	
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	
Annual average discharged concentrations and loads of:	
BOD_5 (mg/l, kilograms per year)	
Dissolved oxygen (mg/l)	
Total Nitrogen (mg/l, kilograms per year)	
Ammonia Nitrogen (mg/l, kilograms per year)	
Total Phosphorus (mg/l, kilograms per year)	
Total Suspended Solids (mg/l, kilograms per year)	
Faecal coliforms (units as reported)	
Enterococci (units as reported)	

4. What is the estimated annual percentage of total wastewater generated that is <u>untreated</u> and released into water bodies? What is the estimated annual volume?

Data is not available on untreated wastewater volume delivered to receiving water bodies. However, WASA (2015) noted several sources of untreated wastewater, including:

a. Unauthorized/unplanned developments
b. Grey water: Grey water is not treated from the 86% of the population using on-site treatment
c. Dysfunctional package WWTPs
d. Population pressure: the population is expected to exceed the capacity of the current plants

5. If there is <u>untreated sewage</u>, where does this go? If possible, please also note on a map the receiving water bodies and ecosystems that receive the untreated sewage – either directly, or via an outfall.

It is thought that untreated sewage travels to the southern portion of the Caroni swamp.

6. Is there an interest in improving, upgrading, or expanding the current wastewater management system in the area? If so, please describe who is interested and why.

Yes –evidenced by the studies conducted by WASA and GENIVAR, the Chaguanas Spatial Development Plan, and the CEC application submitted by WASA.

7. Current wastewater treatment costs - What capital and annual operating and maintenance costs are associated with the current wastewater management situation? Please fill in Table 6 to the best extent possible. If you do not have specific cost data, please provide a description of the *likely* costs associated with the current scenario by referring Annex 2, section D.

Limited cost information has been provided to date from WASA.

Table 6: Current wastewater scenario costs

Data need	Current wastewater management situation
Year of installation	
Life expectancy (years)	15 years
Total land area occupied by the plant (hectares)	
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced within the next 20 years and the total capital cost, including likely year of replacement and the frequency of replacement)	Recurring capital expenses are not known, but the average cost for a package WWTP is approximated at $10 million TT per plant (WASA 2015)
Annual recurring expenses: -Salary/wages for all personnel plus personnel of any contracts associated with operation of the WWTP. -Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)	$20,000 - $30,000 TT per month per plant (excludes electricity) (WASA 2015)
External services costs (if applicable, net value of total costs of external services including outsourcing, costs for construction)	
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)	

Other costs?	
Net present value over infrastructure's lifetime	

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VI. WATER QUALITY

Objective: To identify and list water quality standards and requirements that are applicable to the wastewater sector and identify and provide historic data (over the past five years) on water quality within wastewater receiving bodies and key ecosystems in the study area.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants or engineers that work with the wastewater authority

1. What water quality standards/requirements apply for the study area?

- **National/Regional and Local water quality standards?**
  - **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
  - **Numeric criteria?**

- **Bathing/swimming standards**

- **International standards (e.g., LBS Protocol)**
  - **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
  - **Numeric criteria?**

The national water standards are the Water Pollution Rules by the Environmental Management Authority. T&T is also a signatory the LBS protocol. Standards are summarized in Table 7 below:

Table 7: Water Quality Standards for Trinidad and Tobago

Parameter	Unit	LBS Protocol		Trinidad and Tobago (Water Pollution Rules Schedule II)			
		Class I waters	Class II waters	Inland surface water	Coastal nearshore	Marine offshore	Environmentally Sensitive
Total Suspended Solids	mg/l	30	150	50	150	100	15
Biochemical Oxygen Demand (BOD5)	mg/l	30	150	30	50	100	10
pH	pH units	5 to 10	5 to 10	6 to 9	6 to 9	6 to 9	6 to 9
Fats, Oil and Grease	mg/l	15	50	10	15	100	no release

Faecal Coliform ((Parties may meet effluent limitations either for faecal coliform or for E. coli (freshwater) and enterococci (saline water))		Faecal Coliform: 200 mpn/100 ml; or a. E. coli: 126 organisms/100ml; b. enterococci: 35 organisms/100 ml		400	400	400	100
Floatables	mg/l	not visible	not visible	not visible	not visible	not visible	not visible
Toxicity	mg/l			no acute toxic effects	no acute toxic effects	no acute toxic effects	no acute toxic effects
Dissolved oxgyen	mg/l			<4	<4	<4	<4
Total Phosphorus	mg/l			5	5	5	0.1
Sulphide	mg/l			1	1	1	0.2
Chloride	mg/l			250	no increase above ambient	no increase above ambient	no increase above ambient
Total residual chlorine	mg/l			1	1	2	0.2
Dissolved hexavalent chromium	mg/l			0.1	0.1	0.1	0.01
Total chromium	mg/l			0.5	0.5	0.5	0.1
Dissolved iron	mg/l			3.5	3.5	3.5	1
Total petroleum hydrocarbons	mg/l			25	40	80	no release
Total nickel	mg/l			0.5	0.5	0.5	
Total copper	mg/l			0.5	0.5	0.5	0.01
Total zinc	mg/l			2	2	2	0.1
Total arsenic	mg/l			0.1	0.1	0.1	0.01
Total cadmium	mg/l			0.1	0.1	0.1	0.01
Total mercury	mg/l			0.01	0.01	0.01	0.005
Total lead	mg/l			0.1	0.1	0.1	0.05
Total cyanide	mg/l			0.1	0.1	0.1	0.05
Phenolic compounds	mg/l			0.5	0.5	0.5	0.1
Radioactivity	mg/l			NIAA	NIAA	NIAA	NIAA

2. What data or information do you have about water quality in the study area? Can you provide:

- **Ambient water quality monitoring data in freshwater bodies?**
- **Ambient water quality monitoring data in coastal waters?**

Table 8: Caparo River water quality data from WASA (2015)

Date taken	Turbidity	pH	Organic Nitrogen (mg/l)	TSS (mg/l)	Dissolved oxygen (mg/l)
04-Sep-13		7.95		130	6.66
27-May-13	28.9	8.96			5.26
03-Jul-13	28.4	6.92			6.39
17-Jul-13	27.52	6.96		140	5.86
16-Aug-13		7.53		220	7.28
16-Oct-13		7.64		160	7.74

08-Nov-13		7.93		92	7.25
23-Jul-14		7.33			5.63

Table 9: Cunupia River water quality data from WASA (2015)

Date Taken	pH	TSS (mg/l)	Dissolved Oxygen (mg/l)
04-Sep-13	6.97	120	5.78
16-Oct-13	7.32	20	6.34
15-Nov-13	7.26	22	5.58
18-Jun-14	6.97	40	5.3
18-Jun-14	6.97	40	5.3
16-Jul-14	7.25		6.22

Additionally, IMA has provided some data for points within the study area, shown in Table 10.

Table 10: IMA (2015) water quality data for research stations within the Chaguanas study site

Date Taken	Caroni River	Guayamare	Madame Espagnole /Bejucal Canal	Cunupia	Cunupia	Tumpuna
2000	43	20	37	28	59	61
2004	2.5	5.4	3.6	1.9	5.9	1.9
2004	0	0	0	0	0	0
2004	58333	107837	3833	38283	29700	13190

3. **Please compare these data to water quality standards/requirements:**
    - **Are any water quality standards being violated in lakes, non-tidal streams and rivers, and coastal areas? Please provide frequency and severity.**
    - **What are the pollutants causing the violation and what are their sources (e.g., untreated wastewater, WWTP effluent, onsite septic systems, soakaways, pit latrines, sources from other sectors such as mining or agriculture)**

Overall, water quality data retrieved to date are very sparse and do not cover all pollutants listed in Table 7, and as a result, do not provide a good depiction of water quality nor potential wastewater impacts.

4. **If any water quality standards are being violated, have the violations been linked to wastewater discharges? If so, please provide specific information on the linkage.**

Data not available.

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VII. ECOSYSTEM IMPACTS

Objective: To understand if there is a demonstrated link between wastewater pollution and ecosystem health.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants/engineers working with the wastewater authority; Environmental impact statements; Environmental/marine NGOs and government agencies; Academic and grey literature.

1. **Within the study area, are any of the following causing ecological impacts, such as algal blooms or damage to coral reefs:**
   - **Discharge of untreated or partially treated sewage?** Not sure
   - **Discharge of treated wastewater effluent?** Not sure
   - **Irregular release of wastewater from a WWT system due to overflow, rainwater events, or power failure, etc.?** Not sure

Juman and Ramsewak (2013) state that the Caroni Swamp receives water polluted with sewage, wastewater from industry and agriculture run-off, but the study does not say where the wastewater and sewage is coming from exactly.

2. **Have any studies been conducted within the study site or your country or region that link wastewater pollution to ecosystem health? If so, what are the findings?**

No.

3. **Is there evidence of the following in any of the key ecosystems present in the study area: (e.g., freshwater, wetlands, mangroves, beaches, coral reefs, forests, wetlands):**
   - **Is it unsightly due to pollution? Are there algal blooms or obvious evidence of pollution?**
   - **Is there odor due to pollution?**
   - **Are there impacts to fish or other aquatic life (e.g., fish kills, overgrowth of algae on coral reefs)?**
   - **Are you seeing a change in ecosystem health and/or growth?**

Juman and Ramsewak (2013) conducted a study on land cover changes in the Caroni Swamp between 1942 and 2007 using remote sensing technology, geographic information systems, and extensive field surveys. The report found that freshwater marsh and agriculture increased from 1942 to 1957, but declined after this period as freshwater was diverted away from the wetland and salt water intruded further inland. The study also found that, “Although mangrove forest was cleared for built development, its coverage has consistently increased in the Swamp from 1957, with the exception of 2003 when there was a decrease by less than 100 ha. This is in contrast to most areas in the tropics where mangrove coverage continue to decline. In this case, the mangrove trees are outcompeting/shading marsh vegetation, causing shift in the wetland communities. In the Caroni Ramsar Site, the natural wetland communities generally increased from 1942 to 2003, but declined in 2007, as built development more than doubled."

The Ministry of Food Production reported two pollution incidents to Water Resources Agency in March and June 2014 within the Caparo River in the vicinity of Petersfield (WRA 2015). The area is currently under cultivation as former Caroni lands. Farmers reported fish kills in the two incidents at the same location. Water quality analysis showed high nutrient concentrations and a heavy foam presence was observed during the field investigation. The suspected pollution source is discharge from a commercial laundromat located upstream.

4. **Beyond wastewater, are there any other sources of water pollution contributing to these problems? If so, please indicate the relative contribution to total water pollution using the following scale:**

   No contribution – Minor contribution – Moderate contribution – Significant contribution

   - **Runoff from croplands?**
   - **Runoff from livestock?**
   - **Runoff from aquaculture?**
   - **Industrial discharge?**
   - **Cruise ships/yachts?**
   - **Others?**
   - **Do you have a sense of the relative contribution from wastewater to overall pollution of key ecosystems compared to these other sources? If so, please describe.**

Local stakeholders have indicated that agricultural and industrial pollution are two other major contributors to water pollution. Industrial polluters also frequently discharge into the WASA sewerage network and as a result, do not have to meet Water Pollution Rule standards for their effluent (EMA and WRI 2015).

5. **Are there any economic or cultural uses of the key ecosystems that are in decline due to wastewater discharge issues (from untreated or improperly treated wastewater)? Please refer to Annex 2, section B for examples of Caribbean coastal ecosystems and impacts that have been documented from exposure to untreated or improperly treated wastewater.**

Not sure – no data available.

6. **Do tourists have any awareness of water quality issues and do they modify activities / visitation? Are you able to quantify or describe the change in visitation (e.g., reduced annual snorkeling rates or reduced number of visitors to recreational beaches)?**

The Trinidad and Tobago Ministry of Tourism (2015) has provided tourism data for Trinidad as a whole (so not specifically for the study site). This information helps to shed light, however, on the contribution of the tourism sector to the national economy.

Table 11 provides arrival data by mode of transportation.

Table 11: Tourism arrival data for Trinidad (Ministry of Tourism 2015)

	2010	2011	2012	2013	2014
Air arrivals					386,262
Cruise arrivals	40,605	15,654	17,745	12,770	13,085
Yacht arrivals				1,060	1,030

For accommodations in Trinidad, there are 152 establishments including 21 apartments, 34 bed and breakfasts, 34 guest homes, 5 host homes, 53 hotels, and 5 villas. In total there are 3,788 rooms. The average expenditure per visitor has increased from $6,527 TT to $8,199 TT. Direct employment in Trinidad and Tobago from tourism is equal to 27,200 jobs and the total contribution to GDP from travel and tourism for both Trinidad and Tobago has increased from $10.5 million TT in 2010 to $12.6 million TT in 2014.

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VIII. HUMAN HEALTH IMPACTS

Objective: To understand if there is a link between wastewater pollution and key human health illnesses including gastroenteritis, ear and eye infections, and other illnesses (as listed in Annex 2, section C); and to estimate the impacts on the local economy due to human health impacts (e.g., from hospitalization, medication, time taken off work, and death).

Possible data sources: Health agencies or ministries; Hospitals or doctor's offices; national statistics/census data; international statistics from multilateral, intergovernmental or NGOs (e.g., World Bank or World Health Organization); peer-reviewed or grey-literature.

1. **Please describe any known human health impacts, such as gastrointestinal illness, respiratory illness, ear infections, eye infections, or skin rashes/lesions that are occurring in the study site that relate to wastewater. Please see Annex 2, section C for a list of human illnesses related to swimming in, drinking from, or eating seafood from water contaminated with wastewater.**
   - **Are health data recorded on any of these key illnesses? If so, who collects this data? What can you say about the average frequency and duration of occurrence for each type of illness (e.g., 50 cases per year; 1 case per resident person per year)?**
   - **Do reported incidences of these illnesses result in doctors' visits, hospitalization, or death? Do you have statistical data on illnesses and hospital data?**

- **What activities seem to be contributing (e.g., swimming; eating contaminated seafood)?**
- **How specific can you be about location?**
- **Is wastewater pollution the main cause of these health issues? If not, what are the main causes of these diseases?**

In 2013, a study by Lahkan et al. was conducted on acute gastroenteritis and food-borne pathogens in T&T. The study states, "During 2000-2005, there were seven large outbreaks of [Acute GastroEnteritis] AGE with over 20,000 cases reported per year but less than 70 cases were of known aetiology (11). The national surveillance system for AGE in T&T is based on both syndromic cases of AGE and its laboratory confirmed pathogens collected using standard data collection forms—weekly syndromic and monthly laboratory data-collection forms (11)—based on the Caribbean Public Health Agency (CARPHA), formerly known as the Caribbean Epidemiology Centre (CAREC).[….] The reason why these illnesses are not well understood lies in the fact that most affected people are not captured by the National Surveillance Unit (NSU).

For acute gastroenteritis - the annual incidence rate was 0.6748 episodes per person-year, with 0.7083 episodes per person-year in males and 0.6321 episodes per person-year in females. The major reasons cited for cases of acute gastroenteritis were food consumption (35.1%), drinking water (17.1%), contact with another sick person (9.9%), contact with an animal (9.9%), and bacterial infection (<1%). Thus – it is unclear the percentage of average cases that might be due to wastewater pollution.

Foodborne pathogens found in the study were *salmonella, Shigella*, rotavirus, and norovirus – all of which have a link to wastewater.

There is currently no specific data for the study site, but do have data for T&T on gastroenteritis, diarrhea, and food-borne illnesses for T&T. Lahkan et al. found that the common duration for diarrhea was 3 days (with a range of 1-10 days). Time spent away due to diarrhea can involve the following costs: medication and medical costs, costs for a caretaker, loss of leisure activity, loss of income, and loss of days from school.

For acute gastroenteritis, the mean duration of illness was 2.3 days.

For acute gastroenteritis - the annual incidence rate was 0.6748 episodes per person-year, with 0.7083 episodes per person-year in males and 0.6321 episodes per person-year in females.

2. **Have any studies been conducted within the study site or your country or region that link wastewater pollution to human health?**

Lahkan et al. (2013) – see above.

3. **Do any of these studies estimate a dose-response relationship between a given wastewater pollutant and a human health illness (e.g., gastroenteritis)? (See the BCA methods section for more detail.)**

No.

4. **Beyond wastewater, are there any other sources of water pollution contributing to these problems? (If so, please note how large of a contribution.)**
   - **Runoff from agriculture?**
   - **Runoff from livestock?**
   - **Runoff from aquaculture?**
   - **Industrial discharge?**
   - **Cruise ships/yachts?**
   - **Others?**

Stakeholders indicate that agricultural runoff and industrial pollution are likely sources of water pollution in the study area (EMA and WRI 2014, 2015). No data are available, however, to support this.

5. **Do you have a sense of the relative contribution from wastewater to overall health impacts compared to these other sources? If so, please describe.**

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IX. FUTURE WASTEWATER MANAGEMENT SCENARIO(S)

Objective: To identify and define at least one future wastewater management scenario to compare against the current infrastructure situation in terms of population served, untreated wastewater, pollution removal efficiency for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Wastewater consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits.

1. **What option or options are under consideration for improving wastewater management in the pilot area? Please provide a description and fill in for each major wastewater treatment plant or infrastructure element. Please add columns as necessary if more than two alternatives are being considered.**

Based on recent guidance from WASA (2015) and the WASA 2008, GENIVAR 2009, and WASA Chapter 3.3.9 reports, there appear to be two future wastewater management scenarios that are being considered:

1) Regionalized treatment at two main wastewater treatment plants: the existing Edinburgh 500 WWTP and a proposed Chaguanas WWTP in the northern area.
2) Regionalized treatment at one main wastewater treatment plant that will replace all existing treatment plants.

1) *Regionalized treatment at two wastewater treatment plants: Edingburgh 500 and Chaguanas WWTP*

For the purpose of this report, we focus on the WASA 2008 report, as this was initially recommended to us by WASA. The report identified the following as being included in this future wastewater management scenario: developments located south of the contour will have their wastewater treated at the Edinburgh 500 WWTP while the wastewater for developments located north of the contour will be directed to a new WWTP, referred to as the Chaguanas Regional WWTP. The total construction period would be roughly two years.

The ultimate average wastewater flow anticipated for the catchment area is 66,000 m^3/d; this is broken down as follows: Edinburgh 500 WWTP: 12,000 m^3/d; Chaguanas Regional WWTP: 54,000 m^3/d.

- **Edinburgh 500 WWTP -** The plant currently uses an activated sludge-extended aeration process, using aerated lagoons. The plant was constructed in the late 1980's and has a design capacity of 3000 m^3/d. The Plant is bordered by housing developments and the Caparo River. In 2004, the Firm MacViro Consultants Ltd undertook a condition assessment of the Edinburgh 500 WWTP and prepared detailed designs and Tender Documents to refurbish and expand the WWTP to a design flow of 12,000 m^3/d. The total flow from the existing and planned developments is estimated to be 9,334 m^3/d. The ultimate flow from the Edinburgh area is anticipated to fall below the design flow of 12,000 m3/d planned for the expanded WWTP, thereby allowing some spare capacity for servicing other developments and un-sewered areas near-by. The ultimate population that will have access in the Edinburgh area is 28,730 persons.

- **Chaguanas Regional Wastewater Treatment Plant -** A 14.1 ha site on the northwestern corner of the catchment Caroni lands has been identified as potentially available to locate the Chaguanas Regional Wastewater Treatment Plant. The spacious location allows for modular expansion of the WWTP as growth takes place in the catchment area. It also ensures that the closest neighbors will have the minimum 20-metre setback to cater for odors and noise from the new facility. It is located at a low point in the catchment, which is ideal, since it will facilitate a gravity feed system from the majority of the area to the new treatment facility. The ultimate average design flow to be sent to the new Chaguanas Regional WWTP is anticipated to be 54,000 m^3/d; this translates into approximately 104,200 persons having access to a centralized wastewater system. Ten plants can be decommissioned with the construction of this new facility. The new plant borders developments that have been earmarked for agricultural and light industrial growth; which may present the potential to reuse the effluent and sludge generated from the process in these adjacent developments. The effluent could also be exported for reuse. The effluent generated from the Plant can also be used to supplement the base flow in a tributary of the Cunupia River particularly during the dry-season; this will have a positive impact for downstream users in the agriculture and farming industry.

Reuse of wastewater might be possible for this scenario.

1. *Regionalized treatment at two wastewater treatment plants: Edingburgh 500 and Chaguanas WWTP*

This scenario was first described to WRI by WASA at a meeting in 2015 (WASA 2015).WASA is considering a scenario whereby all package plants and the four major WWTPs would be decommissioned over time, and WASA would construct one large centralized wastewater treatment plant and sewerage connections with the goal of connecting everyone in Borough of Chaguanas to this centralized system. For the population that is difficult to connect, WASA plans to have them use primary treatment (i.e., septic systems) with added disinfection. The treatment technology for the WWTP would likely include anaerobic digesters and clarifiers (conventional treatment).

Additionally, treated wastewater could be reused based on this solution.

WASA is currently in the planning stage of hiring a consultant to conduct a cost-effectiveness analysis and identify a future wastewater management strategy.

Table 12: Future wastewater management scenarios description: Scenario 1: Two regional plants (WASA 2008, 2015)

Data need	Edinburgh WWTP	Chaguanas WWTP
Design		
Location	South of the contour (bordered by housing developments and the Caparo River)	North of the contour (northwestern corner of the catchment Caroni lands)
Design capacity - annual average and peak (if actual capacity is lower, that will be covered below under performance)	12,000 m^3/d	54,000 m^3/d
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Activated sludge-extended aeration process, using aerated lagoons	Not sure.
Will effluent and water quality standards be met?	Yes	Yes
Sludge treatment and disposal	Not sure	Not sure

Discharge location (receiving water body). If coastal, is there an outfall(s)?	Not sure	Not sure
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)		
Performance		
Flows (annual average, peak)		
Annual energy usage (kW hours, total cost)		
Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and estimated bypassed volume for each event).		
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)		
Annual average discharged concentrations and loads of:		
• BOD_5 (mg/l, kilograms per year)		
• Dissolved oxygen (mg/l)		
• Total Nitrogen (mg/l, kilograms per year)		
• Ammonia Nitrogen (mg/l, kilograms per year)		
• Total Phosphorus (mg/l, kilograms per year)		
• Total Suspended Solids (mg/l, kilograms per year)		
• Faecal coliforms (units as reported)		
• Enterococci (units as reported)		

Table 13: Future wastewater management scenarios description: Scenario 2: one regional plant (WASA 2015)

Data need	Regional WWTP
Design	
Location	
Design capacity - annual average and peak (if actual capacity is lower, that will be covered below under performance)	
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Anaerobic digesters and clarifiers
Will effluent and water quality standards be met?	Yes
Sludge treatment and disposal	
Discharge location (receiving water body). If coastal, is there an outfall(s)?	
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Flows (annual average, peak)	
Annual energy usage (kW hours, total cost)	
Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and and estimated bypassed volume for each event).	
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	
Annual average discharged concentrations and loads of:	
• BOD_5 (mg/l, kilograms per year)	
• Dissolved oxygen (mg/l)	

• Total Nitrogen (mg/l, kilograms per year)	
• Ammonia Nitrogen (mg/l, kilograms per year)	
• Total Phosphorus (mg/l, kilograms per year)	
• Total Suspended Solids (mg/l, kilograms per year)	
• Faecal coliforms (units as reported)	
• Enterococci (units as reported)	

2. What are the evaluation criteria for choosing an infrastructure option and who decides what these criteria are? For example, criteria may include cost-effectiveness, pollutant removal efficiency, and/or environmental impacts.

For WASA, the following are important evaluation criteria (WASA 2015):

- Cost (this option is 10% of the cost of a full conventional collection and treatment system for the South west Tobago) – including both capital and O&M costs
- Shorter time to implement- (10 months versus 36 months)

For EMA, the following are important to consider:

- Water Pollution Rules
- Requirements of Certificates of Environmental Clearance and Environmental Impact Statements

Other stakeholders from the WRI/EMA workshops indicated:

- Human health impacts
- Ecosystem impacts
- Ecosystem service impacts
- Economic growth/disruption related to construction of new facilities
- Energy consumption of plant
- Ease of operation of infrastructure

3. What sort of improvements are expected from each future wastewater management scenario?

- **Increased coverage in terms of population treated?** Yes –as planned for the next 15-20 years.
- **Improvement in water quality of receiving water bodies and downstream water bodies?**
- **Reduced levels of:**

- **BOD5**
- **Dissolved oxygen**
- **Total nitrogen**
- **Ammonia nitrogen**
- **Total phosphorus**
- **Total suspended solids**
- **Faecal coliforms**
- **Enterococci**

The improvements for both scenarios would allow for additional treatment required by expanded population growth and development, and WASA expects that water quality standards will be met as set by the Water Pollution Rules.

4. Will the new wastewater treatment technology allow any reuse of water?

- **Where does the treated water go – back in a river, out an outfall, or into a specific use (e.g. irrigation, industrial use, or drinking water)?**
- **Has anyone estimated the potential cost savings associated with reuse of this wastewater?**

Possibly yes for both scenarios. This decision has not yet been made.

5. Have any engineering or financial analyses been conducted for future wastewater management alternatives? Do they provide cost data?

Not that we are aware of.

6. Please fill in Table 14 to the best extent possible based on either engineering/financial reports from the wastewater authority and relevant consultants, OR by referring to Annex 2 which provides information on relative cost by infrastructure type.

Table 14: Cost estimates for future wastewater management scenarios (WASA 2008)

Parameter	Scenario 1: Two WWTPs	Scenario 2: One WWTP
Year of installation	Unknown	Unknown
Life expectancy (years)	Unknown	Unknown
Total area of the plant (please list the area that will need to be purchased for the treatment facility)	14.1 hectares	Unknown

Capital/Investment expenses (This includes one-time construction, planning, and design costs, costs for new development, and cost for replacement and renovation of existing assets – including external or consulting services)	PHASE 1 COSTS: (TT$164.2 million) • Land acquisition – TT$2 million • Expand Edinburgh 500 – TT$25.8 million • Chaguanas Regional Phase 1 - TT$106.7 million • Trunk sewers to existing Chaguanas collection areas - TT$15.7 million • Environmental impact assessment - TT$2 million • Lange Park and Orchard Gardens WWTPs - TT$12 million PHASE 2 COSTS: (TT$866.4 million) • Expand Chaguanas WWTP - TT$191.8 million • Trunk sewers Cunupia - TT$25.3 million • Collection piping, Chaguanas - TT$261.3 million • Collection piping, Cunupia - TT$388 million	Unknown
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced sooner than the life expectancy of the treatment facility and the recurring capital cost, including likely year of replacement and the frequency of replacement)	Unknown	Unknown
Annual recurring expenses: -Salary/wages for all personnel	Unknown	Unknown

-Land rental value for land purchased (i.e., the value of land purchased to install the wastewater infrastructure) -Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)		
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)	Phase 1 Engineering and Contingency costs - TT$57.47 million Phase 2 Engineering and contingency costs - TT$303.24 million	Unknown
Other costs	Unknown	Unknown
Net present value over infrastructure's lifetime	Unknown	Unknown
	TT$1,391.31 million	Unknown

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X. CHANGES TO ECOSYSTEM AND HUMAN HEALTH UNDER IMPROVED WASTEWATER MANAGEMENT SCENARIOS

Objectives: To quantify and/or describe how ecosystems and the goods and services they provide will change under each future wastewater management scenario, and the potential impacts on the local economy in terms of costs;

To quantify and/or describe how human health will be impacted under each future wastewater management scenario in terms of numbers of reported illnesses and costs.

Possible data sources: Peer-reviewed and grey literature; Government documents including environmental impact statements.

1. **Have any evaluations, studies, or environmental impact statements been conducted that estimate the impact on key ecosystems and human health under each new wastewater management scenario *compared to the current wastewater management situation*? Do you know of any**

experts that are currently studying potential impacts? If so, please describe these findings, including how likely management under each scenario is to:

- Reduce the annual loading of pollutants on receiving water bodies?
- Reduce odor?
- Reduce the incidence of harmful algal blooms and/or nutrient over-enrichment?
- Reduce human health risk and/or the number of cases for illnesses previously identified?
- Improve ecosystem health conditions for the key ecosystems identified previously?
- Improve the provision of key ecosystem goods and services identified previously (e.g., increased likelihood of tourist visits, increased productivity of fisheries due to improved coral reef and mangrove health)

No.

2. **Can you establish a quantitative relationship between an improvement in water quality due to the future wastewater management alternative and a change in provision of ecosystem services for each key ecosystem? If so, please list your assumptions and quantitatively describe these changes (e.g., by reducing the amount of untreated wastewater entering the coral reef ecosystem, total nitrogen levels will decrease by 30% surrounding the reef which will improve coral reef health such that fisheries production increased by 20%).**

No.

3. **Can you monetize or value the change in ecosystem service provision (e.g., what is the economic value of reduced coral reef degradation in terms of fisheries improvement – this is often quantified by estimating the market value of fish sold in a marketplace)?**

No.

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XI. OTHER INFORMATION

1. **Please list any additional data or information you think would be useful to the study that might not have been discussed previously in this characterization form.**

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