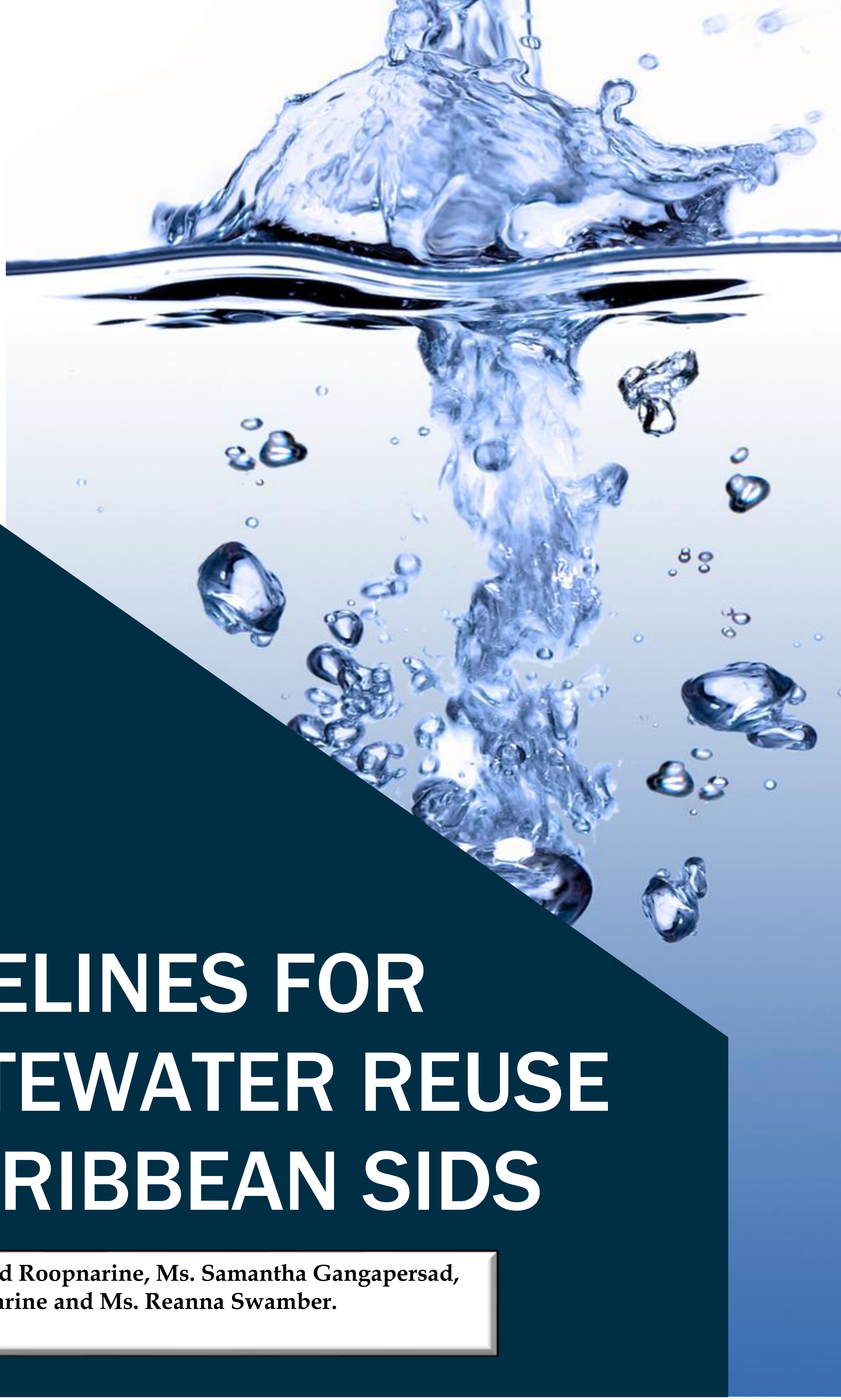
CARIBBEAN WATER AND WASTEWATER ASSOCIATION



GUIDELINES FOR WASTEWATER REUSE IN CARIBBEAN SIDS

Authors: Dr Ronald Roopnarine, Ms. Samantha Gangapersad, Ms. Cassie Roopnarine and Ms. Reanna Swamber.

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Foreword

Caribbean Small Island Developing States (SIDS) are among the countries most vulnerable to the impacts of climate change, including increasing water scarcity, saltwater intrusion, and heightened climate variability. To support the development of climate-resilient water management systems, the Guidelines for Water Reuse in Caribbean SIDS were developed to facilitate the safe, sustainable, and context-appropriate uptake of water reuse across the region.

These Guidelines were informed by comprehensive baseline assessments conducted in seven Caribbean countries, Barbados, Belize, Guyana, Jamaica, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines, and were further refined through structured stakeholder consultations at the national and regional levels.

The principal contribution of the Guidelines is the introduction of a structured and adaptable Process for Developing Water Reuse Standards in Caribbean SIDS, designed to support countries in establishing fit-for-purpose regulatory frameworks that reflect local institutional capacities, environmental conditions, and public health considerations.

List of Abbreviations

AKUT	AKUT Consultants
BOD	Biological Oxygen Demand
BOD_5	5-Day Biological Oxygen Demand
CAPEX	Capital Expenditure
CARICOM	Caribbean Community
CDB	Caribbean Development Bank
CFU	Colony Forming Units
COD	Chemical Oxygen Demand
CReW+	Climate Resilient Water Sector in the Caribbean Plus Project
CROSQ	CARICOM Regional Organisation for Standards and Quality
CWWA	Caribbean Water and Wastewater Association
dS/m	deciSiemens per metre
E. coli	Escherichia coli
Ecw	Electrical Conductivity of water
EED	Environmental Engineering Division
EIA	Environmental Impact Assessment
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility

GDP	Gross Domestic Product
GWP-C	Global Water Partnership–Caribbean
IDB	Inter-American Development Bank
IEC	International Electrotechnical Commission
IMF	International Monetary Fund
ISO	International Organization for Standardization
IWRM	Integrated Water Resources Management
me/L	milliequivalents per litre
mg/L	milligrams per litre
MPN	Most Probable Number
NH_3	Ammonia
NTU	Nephelometric Turbidity Units
OECS	Organisation of Eastern Caribbean States
OPEX	Operating Expenditure
PPE	Personal Protective Equipment
QMRA	Quantitative Microbial Risk Assessment
SAR	Sodium Adsorption Ratio
SDG	Sustainable Development Goal
SES/SMA/SSRH	São Paulo State Health, Environment and Water Resources Authorities (Brazil)
SIDS	Small Island Developing States
SP	Salmonella species

TDS	Total Dissolved Solids
TSS	Total Suspended Solids
TTBS	Trinidad and Tobago Bureau of Standards
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US EPA	United States Environmental Protection Agency
UV	Ultraviolet
WHO	World Health Organization

Introduction

Many Caribbean SIDS face water shortages due to limited resources and high-water demand. Impacts of climate change, including rising sea levels, saltwater intrusion, droughts, coastal erosion, intense storms, and extreme rainfall variability, also directly impact water availability, quality, and infrastructure resilience (Caribbean Regional Climate Centre 2021; UNEP 2023; IMF 2024). Increasing temperature data over the years show that a severe climate threat is approaching.

Caribbean SIDS share a critical need to strengthen water resilience through Integrated Water Resources Management (IWRM). IWRM provides a comprehensive framework to coordinate cross-sectoral water governance, improve infrastructure planning, protect ecosystems, and manage demand sustainably. Non-potable water reuse has emerged as an urgent and underutilized adaptation strategy for the region.

This document provides guidelines for non-potable water reuse in Caribbean SIDS. Water reuse extends the use of available water by reusing treated wastewater for agricultural, industrial, urban uses or water source recharge. Water reuse also protects natural water bodies by reducing direct wastewater effluent discharge into these bodies. The objectives of this guideline include:

1. To provide information on water reuse including the types of reuse, key parameters monitored and case studies.
2. To address the key issues for Caribbean SIDS implementing water reuse.
3. To provide a detailed, step by step process and supporting information for Caribbean SIDS to develop water reuse standards.

Types of Water Reuse

In water reuse standards, classes for reuse are typically categorized based on public exposure, the application of water reuse or a combination of the two. Each class of reuse water must meet the maximum water quality limits set in the standard. Some standards and/or guidelines limit the source of water reuse to treated domestic wastewater only, removing the necessity for monitoring an extensive list of elements (e.g., heavy metals). Water reuse standards also typically prescribe minimum levels of treatment for the wastewater depending on the class of reuse. Water reuse classes with public exposure should be treated to more advanced wastewater treatment levels including sufficient disinfection (UNEP, 2004).

Treated wastewater may be used for the irrigation of agriculture, landscaping and other forms of urban reuse, industrial reuse, and environmental restoration including groundwater recharge.

1. Agricultural reuse

Agriculture is an important contributor to the GDP of Caribbean SIDS. Agriculture is responsible for 70% of freshwater withdrawals globally (UNESCO, 2024). Using treated wastewater to irrigate crops and pastures, reduces the stress on the potable water supply. Additionally, high levels of nutrients, like phosphorus and nitrogen, which are considered pollutants to natural water bodies and cause eutrophication are advantageous to land-based crops.

The FAO in 1992 categorized agricultural water reuse into three classes: (i) irrigation of crops consumed uncooked, public parks and sports fields, (ii) irrigation of crops processed before consumption, pastures and trees, and (iii) areas where there is no exposure to public or workers. FAO, 1992 stated limitations for microbial contaminants including Helminth eggs and faecal coliforms, as well as toxic ions to crops including sodium, boron, chloride, and trace elements. The salinity of the treated wastewater should also be monitored as high salinity in irrigation water is harmful to the agricultural land (Postel, 1999). While higher levels of nutrients in the treated wastewater are useful for agriculture, too much nitrogen can be harmful to crops and must also be monitored (US EPA, 2012). Additionally, minimum distances may be set between the point of irrigation using treated wastewater and neighbouring waterbodies for pollution prevention.

2. Urban reuse

Water reuse can be used for many non-potable urban uses including, irrigation of recreational spaces (e.g., golf courses, public parks, sports fields), irrigation of landscaping around schools, hospitals and other public infrastructure, vehicle washing, firefighting, toilet and urinal flushing. Using treated wastewater for irrigation of landscaping around hotels as well as toilet flushing will support eco-tourism growth in Caribbean SIDs.

Treated wastewater intended for urban water reuse will involve public exposure, therefore water quality parameters indicating level of treatment like turbidity, Total Suspended Solids, and Biological/Chemical Oxygen Demand as well as indicators of microbial contamination should be strictly monitored to ensure limits are met. Safeguards should also be set to ensure that the reused water never cross contaminates the potable water supply. Colour coded pipelines and storage facilities may be used to distinguish the reused water supply from the potable water supply. Plumbers should also be trained to work with the reused water.

3. Industrial reuse

Treated wastewater may be used for various industrial applications including industrial cooling and cleaning and as industrial process water. Water quality parameters must be set to avoid technical issues including corrosion, scaling, and biological growth (US EPA, 2012). In the case of industrial process water, the water quality requirements depend on the specific process that uses the water. Monitoring of pH, turbidity, alkalinity, hardness and specific chemical concentrations may be required.

4. Environmental Reuse

Reused water can be used to restore wetlands or to construct artificial wetlands to address the reducing wetland area caused by expanding urbanization. Wetlands offer numerous ecosystem services including providing a habitat for biodiversity, flood control and water purification. Therefore, reusing water in wetlands result in further purification of the treated wastewater. Treated wastewater may be used to augment streams and aquifers with declining water levels. This includes groundwater recharge to prevent declining groundwater, saltwater intrusion or land subsidence. These projects should be carefully planned to minimize contamination of groundwater by pathogens. Nutrient levels should be monitored to avoid eutrophication of waterbodies. Lastly, UV disinfection is preferred to chlorination for environmental water reuse to prevent harm to flora and fauna (UNEP, 2024).

Summary of Key Parameters and Maximum Limits

Fourteen water reuse standards and guidelines, including key international documents and national standards and guidelines from Latin American and Caribbean countries, Australia and the United States were surveyed. A repository of the surveyed standards and guidelines could be found here: Repository of WWRU Guidelines_updated.xlsx.

Table 1 includes a consolidated list of parameters from the various standards and guidelines surveyed. The table is meant to provide a summary of the key parameters monitored as well as the maximum limits for these parameters as stated in the surveyed standards and guidelines.

Table 1: Consolidated list of monitoring parameters from the surveyed national water reuse standards and regulations in the Caribbean and Latin American region and key international regulations and guidelines.

<table>
<tr><th>Parameter</th><th>Description</th><th>Referenced Document</th></tr>
<tr><td colspan="3">Health Parameters</td></tr>
<tr><td>E. Coli</td><td>Limited to <105 CFU per 100 ml for restricted irrigation and to <103 CFU per 100 ml for unrestricted irrigation.
E. Coli is broadly accepted as a better indicator of faecal contamination than feacal coliforms.</td><td>WHO 2006</td></tr>
<tr><td>Faecal coliforms (thermotolerant coliforms)</td><td>Limited to <103 geometric mean number per 100 ml for unrestricted irrigation.</td><td>WHO 1989</td></tr>
<tr><td>Helminth Eggs</td><td>Limited to <1 mean number of eggs per litre regardless of restriction level of water reuse.</td><td>WHO 2006</td></tr>
<tr><td>Giardia</td><td rowspan="2">Monitored in Florida</td><td rowspan="3">US EPA Guidelines 2012 Resolution 1207-Colombia 2014 & US EPA 2012</td></tr>
<tr><td>Cryptosporidium</td></tr>
<tr><td>Enterococci</td><td>Monitored in Texas and Virginia in the US, and Colombia. US limits are between 4 and 11 monthly-geometric mean per 100 ml.</td></tr>
<tr><td>Salmonella sp.</td><td>Monitored in Colombia (< 1 MPN/ 100 ml).</td><td>Resolution 1207-Colombia 2014</td></tr>
<tr><td>Legionella spp.</td><td>Monitored in the EU where there is a risk of aerosolization (<103 CFU per litre)</td><td>EU Regulation 2020</td></tr>
</table>

Parameter	Description	Referenced Document
Parameters for treatment level/ aesthetics		
5-Day Biological Oxygen Demand (BOD5)	In the EU, the BOD5 is limited to 10 mg/l for Class A water reuse-irrigation of crops consumed raw and there is direct contact with irrigation water. Other classes of water reuse are limited to BOD5 < 25 mg/l.	EU Regulation 2020
Turbidity	Turbidity is limited to 5 NTU for Class A water reuse. There are no turbidity limits for the other classes in this regulation.	
Total suspended solids (TSS)	The TSS is limited to 10 mg/l for Class A water reuse. Other classes of water reuse are limited to TSS < 35 mg/l.	
Fats and oils	Costa Rica Regulation 2010 includes a range for Fats and oils (< 50 mg/l)	Costa Rica Regulation 2010
Chemical Oxygen Demand (COD)	COD is strongly correlated to BOD. Costa Rica has limits for both COD (< 150 mg/l) and BOD (< 50 mg/l) ranging higher than the EU Regulations.	Costa Rica Regulation 2010
Parameters for optimal crop growth		
Residual chlorine	Residual chlorine is monitored in 7 US states, Brazil and Colombia. São Paulo, Brazil regulation for water reuse 2017 sets maximum limits of residual chlorine < 1 mg/l.	US EPA 2012, Resolution 1207-Colombia 2014 & Joint Resolution SES/SMA/SSRH No. 01-São Paulo, Brazil 2017
Electrical Conductivity (Ecw) and Total dissolved solids (TDS)	Salinity may be measures as Ecw (dS/m) or TDS (mg/l). Maximum limits of 0.7 dS/m or 450 mg/l was recommended for water reuse with no requirement for crop restriction.	FAO 1992

Parameter	Description	Referenced Document
Sodium adsorption ratio (SAR)	The SAR is the Na concentration relative to Ca and Mg ions. Soil permeability is affected by the SAR and the TDS or Ecw of the reclaimed water. Ranges for SAR and Ecw to maintain good soil permeability is included in the FAO guidelines. A maximum SAR limit of 3 is provided for using the reclaimed water with no crop restrictions, on the basis of sodium ion toxicity.	
Boron	The recommended maximum limit for boron concentration is 0.7 mg/l when using the reclaimed water with no crop restrictions.	
Chloride	The maximum limit for chloride concentration is 4 me/l for surface irrigation of reclaimed water with no crop restrictions, and 3 me/l for sprinkler irrigation of reclaimed water with no crop restrictions.	
Nitrogen	The maximum limit for nitrogen concentration as nitrate is 5 mg/l when using reclaimed water with no crop restrictions.	
Bicarbonate	The maximum limit for bicarbonate concentration is 1.5 me/l when using reclaimed water with no crop restrictions.	
pH	pH range of 6.5 to 8 is recommended.	

Parameter	Description	Referenced Document
Trace elements	Maximum concentrations for trace elements (including Al, As, Be, Cd, Co, Cr, Cu, F, Fe, Li, Mn, Mo, Ni, Pb, Se, C, and Zn) are included in the FAO guidelines for agricultural reuse based on their toxicity to crops and ability damage to soil.	
Parameters for environment		
Phosphorus	Excess phosphorus in natural waters can result in eutrophication and harm biodiversity. Florida, North Carolina and Washington set maximum limits of 1-2 mg/l phosphorus for environmental reuse.	US EPA 2012
Nitrogen	Florida and North Carolina set maximum limits of 4-6 mg/l nitrogen for environmental reuse. There are maximum nitrogen limits (ammonia + nitrate) of < 10 mg/l for urban reuse in New Jersey and maximum ammonia limits for urban reuse in North Carolina (NH_3 < 6 mg/l). Special requirements may be mandated in Arizona if nitrogen > 10 mg/l.	
Other harmful chemical compounds		
Heavy metals, cyanide, total phenols, total hydrocarbons, fluoride, sulphate	Resolution 1207 of Colombia 2014 and the official Mexican standard for water reuse 1997 include restrictions for heavy metals and cyanide. Resolution 1207 of Colombia 2014 also include limits for total phenols, total hydrocarbons, fluoride and sulphate. These more extensive lists are likely because there are no restrictions for the source of wastewater that could be reused.	Resolution 1207 of Colombia 2014 & Official Mexican standard for water reuse in public services 1997
Emerging contaminants		

Parameter	Description	Referenced Document
Pharmaceuticals, disinfection byproducts, pesticides, fire retardants	The Australian Guidelines for Water Recycling provides maximum limits for an extensive list of chemicals are including more than 86 pharmaceuticals.	Australian Guidelines for Water Recycling, 2008

Monitoring Systems for Water Reuse

Monitoring of the parameters in Table 1 is important to ensure public health safety, crop productivity and environmental protection. According to the Guidelines for the safe use of wastewater, excreta and greywater (WHO 2006), monitoring systems for water reuse should be site specific depending on function and size of the operations, however, should answer the following questions:

WHO 2006
1. What information should be collected? 2. How often and by whom should this information be collected? 3. To whom will this monitoring information be given? 4. What decisions will be taken on the basis of the monitoring information? 5. How can those decisions be implemented?

Standards and regulations for water reuse should include minimum frequencies of monitoring for each parameter for which maximum limits are set. The methods of analysis for sampling and measuring each of these parameters should be validated and documented according to ISO/IEC-17025 or other official standards. Enforcement of the standard or regulation for water reuse is essential for public safety; therefore, it is critical that there is an institution with clear responsibility for monitoring. Legal penalties for not meeting water reuse regulations should also be defined. Monitoring costs should be included in capital and operating costs for national reuse projects.

Case-studies for Water Reuse in Caribbean SIDS

Wastewater Reuse Standard Development in Trinidad and Tobago: TTS 664:2022, Wastewater Reuse – Agricultural and other Applications – Requirements

To support the uptake of water reuse, a voluntary standard for wastewater reuse and agriculture and irrigation for green spaces was developed in 2022, Trinidad and Tobago. This standard was developed through the GEF CReW+ Project, a partnership project funded by the Global Environment Facility (GEF) and co-implemented by the Inter-American Development Bank (IDB) and the United Nations Environment Programme.

A baseline assessment of water reuse showed that there are several policies and/or regulations in Trinidad and Tobago which support water reuse, including the Draft National Integrated Water Resources Management Policy (2022), the National Environment Policy (2018) and the Water Pollution Rules (2019). Additionally, a comprehensive review of fifty-seven (57) international standards and regulations was conducted as input to the standard development process, by AKUT consultants engaged through the GEF CReW+ Project.

The Trinidad and Tobago Bureau of Standards (TTBS) lead the standard development process for TTS 664:2022, following their established voluntary standard development process. TTBS created a Specifications Committee, including the key water reuse stakeholders in Trinidad and Tobago. The Committee developed a working draft of the standards using information from the baseline assessment and the review of standards and regulations. The working draft was refined to a Specification Committee draft standard and advertised on the TTBS website for public comment. Additional stakeholder feedback was also solicited during a virtual stakeholder consultation meeting. The Specifications Committee reviewed and disposed of the stakeholder and public comments. The final standard was published in December 2022.

The standard included three classes of water reuse with varying levels of public exposure and limited the wastewater reuse to treated domestic wastewater only. The parameters identified for monitoring included Escherichia Coli or Feacal coliforms, Helminth ova, Biological Oxygen Demand or Chemical Oxygen Demand, Turbidity and Residual Chlorine. These monitoring parameters were selected to protect public health and to reduce damage to crops, particularly where chlorination was used to disinfect the treated wastewater. Monitoring of trace elements was not included since the standard limits water reuse to treated domestic wastewater only. It was assumed that treated domestic wastewater would have negligible concentrations of trace elements.

Water Reuse Progress in Barbados

Modern water reuse in Barbados dated back to the 1990's, when the total wastewater production in Barbados was estimated at 11 million m3 annually in 1996 (FAO 2014). One notable example is the Sam Lord's Castle Hotel, which was in one of the driest areas in Barbados and faced difficulty meeting their high-water demand for irrigation of large green spaces and gardens. The hotel applied with the Ministry of Health and Environment to use their treated wastewater from an extended aeration system with chlorine disinfection for sprinkler and drip irrigation of green spaces. This application was granted and the Environmental Engineering Division (EED) of the Ministry of Health and Environment was responsible for approving and monitoring this operation. There were no water reuse standards enacted in Barbados, however BOD and TSS were monitored monthly by the EED (UNEP 1997).

The project illustrates the potential for reclaimed water use in reducing freshwater demand and environmental stress. However, it highlights concerns regarding insufficient monitoring, operational training, and microbiological quality control leading to high public health and environmental risks (UNEP 1997). Irrigation around hotels have since stopped due to mandated connections to wastewater treatment plants in Barbados. However, successful applications of water reuse such as the Coverly Residential Development and the One Farm Project are still ongoing in Barbados (Stakeholder Consultations 2025).

More recently, the Government of Barbados introduced the National Water Reuse Policy 2018 to institutionalize wastewater reuse and promote public acceptance. Under this policy, the "All is Water" communication campaign was launched in 2024 to enhance public awareness of the value of water and the safety of reclaimed wastewater. The communication strategy aims to dismantle longstanding misconceptions about reused water and support the implementation of the Water Reuse Act 2023, a central component of Barbados's long-term water management reforms (GEF CReW+ 2024).

The Water Reuse Act 2023 states that treated wastewater may be sold for non-potable domestic use, commercial use, agricultural use, industrial use or other related uses and covers permits, penalties and administration for wastewater treatment and water reclamation. Barbados is currently the only Caribbean country with regulation for wastewater reuse. However, there is still no national standard that sets limits for public health and environmental parameters associated with the different water reuse applications taking place in Barbados. A national monitoring system for water reuse is also lacking.

Key issues for water reuse in Caribbean SIDS

Table 2: Issues response matrix for water reuse in Caribbean SIDS.

Key Issue	Description / Evidence	Implications if Unaddressed	Strategic Responses
Public Perception and Acceptance	Public outreach and acceptance are critical to the success of water reuse projects. A 2014 study on attitudes towards water reuse in Trinidad and Tobago revealed that the idea of using treated wastewater for non-potable uses such as firefighting and landscaping was generally acceptable however there was apprehension towards potable water reuse (Peters and Goberdhan, 2015).	• Low public trust and resistance to reuse schemes. • Political reluctance to invest in water reuse. • Underutilization of treated wastewater, even where technically feasible.	• Adopt the term "water reuse" rather than "wastewater reuse" consistently in policy and public communication. • Implement sustained public education and outreach campaigns for water reuse. • Integrate water reuse concepts into primary and secondary school curricula • Use phased implementation, starting with non-

Key Issue	Description / Evidence	Implications if Unaddressed	Strategic Responses
	Public perception likely varies with knowledge of wastewater treatment as well as the severity of water shortage issues faced.		potable reuse (irrigation, landscaping, industry) to build confidence.
Limited Wastewater Treatment Capacity	Many Caribbean SIDS are lacking national wastewater management policies resulting in limited coverage and slow expansion of treatment infrastructure. Both centralized and decentralized solutions are underdeveloped.	• Insufficient wastewater treatment leading to continued marine and groundwater pollution. • Missed opportunities for climate-resilient water supply diversification. • Inability to meet water demand or use of more expensive water production (e.g. desalination).	• Develop and implement national wastewater management policies. • Expand centralized treatment where population density allows. • Promote decentralized systems such as constructed wetlands for small communities and tourism facilities.

Key Issue	Description / Evidence	Implications if Unaddressed	Strategic Responses
			Constructed wetlands cost $200 USD per population equivalent (Perez et al., 2023). • Integrate water reuse at the design stage of new wastewater treatment projects.
Institutional Fragmentation	Fragmented water sector responsibilities are spread across various institutions. This increases the difficulty of launching new initiatives like creating IWRM, wastewater management policies	• Delays in policy development and project approval • Overlapping mandates and accountability gaps • Inefficient use of technical and financial resources	• Clearly define roles and responsibilities for water reuse within national policies. • Establish inter-agency working groups with clear leadership for water reuse initiatives.

Key Issue	Description / Evidence	Implications if Unaddressed	Strategic Responses
	and water reuse standards.		• Embed water reuse within broader IWRM and climate adaptation frameworks. • Strengthen coordination mechanisms between utilities, regulators, and health authorities
Lack of Standards and Regulations	Barbados is currently the only Caribbean country with formal water reuse regulations. Trinidad and Tobago has a voluntary wastewater reuse standard. Most Caribbean SIDS lack binding standards governing treatment	• Increased public health, environmental and business risks with water reuse. • Regulatory uncertainty discourages investment and scaling of projects.	• Develop national water reuse policies, regulations, and standards aligned with international best practice • Define reuse categories (e.g., agricultural, industrial, environmental)

Key Issue	Description / Evidence	Implications if Unaddressed	Strategic Responses
	levels, monitoring, and permitted uses.		with corresponding treatment and monitoring requirements • Harmonize standards regionally to support knowledge sharing and capacity building.
Financing Constraints	Water reuse projects involve upfront capital costs and ongoing monitoring and operating costs. Low political will to invest in wastewater treatment, due to low public awareness of the benefits, result in limited opportunities for water reuse.	• Incomplete construction and delayed projects. • Unsustainable projects due to lack of funding for spare parts, repairs, and other requirements for continued operation.	• Private-public partnerships should be explored for infrastructure development and operation. • Include full life-cycle costs, including monitoring and compliance, in

Key Issue	Description / Evidence	Implications if Unaddressed	Strategic Responses
		• Lack of funding to maintain monitoring systems resulting in increased health, environmental and business risks associated with water reuse. • Overreliance on international funders.	capital and operating budgets. • Leverage climate finance and resilience funding by positioning reuse as an adaptation measure.

Principles for Water Reuse

- Public health protection first
- Fit-for-purpose treatment
- Climate resilience
- Incremental implementation
- Regional harmonization
- Participatory approach-stakeholder involvement

Process for Developing Water Reuse Standards in Caribbean SIDS

1. Baseline Assessment

- Inventory existing policies & regulations: Review national water laws, environmental and health regulations, building codes, and regional/international guidelines (WHO, FAO, ISO, US EPA, EU, etc.).
- Assess current practices: Map existing wastewater management systems, treatment plants, informal reuse practices, and discharge points.
- Identify drivers and barriers: Water scarcity, agriculture demand, public health risks, cultural perceptions, and institutional gaps.

Key Considerations:

- Data quality & availability: Verify completeness, accuracy, and temporal coverage of wastewater data.
- Institutional mapping: Identify agencies with mandates over water, sanitation, and reuse to understand overlaps or gaps.
- Climate vulnerability context: Include climate-related stressors (droughts, floods, sea-level rise) affecting wastewater infrastructure.
- Socioeconomic factors: Assess affordability, willingness to pay, and end-user perceptions.

2. Stakeholder Engagement

- Identify key actors: Ministries of Health, Water, Agriculture, Environment, Standards Bureaus, utilities, private sector, academia, and community representatives.

- Conduct stakeholder consultations: National workshops, targeted surveys, technical working groups, cross-sectoral committees, and community meetings.
- Regional harmonization: Engage CARICOM, CWWA, GWP-C, and OECS for knowledge exchange and to encourage alignment.

Key Considerations:

- Inclusivity: Ensure participation from women, youth, indigenous groups, and marginalized communities.
- Communication strategy: Develop a stakeholder engagement plan outlining objective, feedback mechanisms, and frequency of interaction.
- Conflict resolution: Define mechanisms for addressing competing interests (e.g., agriculture vs. environment).
- Regional collaboration: Foster inter-country technical exchange and learning through CARICOM/CWWA networks.
- Include Behavioural Change and Public Awareness Campaigns to build trust and address stigma around reuse.

3. Define Policy and Objectives

- Policy alignment: Integrate wastewater reuse into broader IWRM, climate adaptation, and food security policies.
- Establish objectives: Safe reuse for irrigation, industrial cooling, aquifer recharge, environmental flow support, etc.
- Establish principles: Health protection, environmental sustainability, economic feasibility, and social acceptance.

Key Considerations:

- Coherence: Ensure alignment with SDG 6, national development plans, and regional blue/green economy frameworks.
- Equity: Address rural vs. urban disparities in wastewater service access.

- Adaptive management: Build flexibility for future updates in light of technological or environmental change.
- Policy Coherence Matrix to cross-reference with existing water, sanitation, health, and agriculture policies.

4. Risk Assessment and Technical Basis

- Identify reuse applications: Agriculture, landscape irrigation, industry, aquaculture, groundwater recharge.
- Risk assessment: Apply WHO's multiple-barrier approach and quantitative microbial risk assessment (QMRA).
- Set health/environmental targets: Microbial (E. coli, helminth eggs, viruses), chemical (nutrients, heavy metals, pharmaceuticals).
- Technology review: Evaluate treatment technologies suitable for SIDS (low-cost, decentralized, energy-efficient).

Key Considerations:

- Risk differentiation: Separate microbial, chemical, and physical risks for different reuse purposes.
- Environmental thresholds: Include soil salinity, groundwater contamination risk, and nutrient loading limits.
- Cost-benefit analysis: Evaluate trade-offs between treatment levels and end-use risks.
- Local capacity: Select technologies adaptable to SIDS' limited land and energy resources.
- Climate Resilience Screening to assess how reuse systems perform under extreme events.

5. Draft Standards Development and Review

- Classify reuse categories: E.g., unrestricted irrigation, restricted irrigation, industrial, environmental.
- Draft water quality standards for each reuse category: Establish thresholds for selected indicators (e.g., pathogens, nutrients, heavy metals, salinity, and emerging pollutants).
- Draft operational standards: Monitoring frequency, sampling methods, validation of testing methods, reporting protocols.
- Guidelines for reuse infrastructure requirements: Pretreatment, storage, distribution safety, worker protection
- Circulation of draft standard for stakeholder review

Key Considerations:

- Scientific justification: Ensure each parameter is evidence-based and context-appropriate.
- Comparability: Benchmark against WHO 2022, ISO 16075, and US EPA reuse guidelines.
- Operational feasibility: Reflect realities of small utilities with limited laboratory resources.
- Stakeholder validation: Facilitate national technical working group review sessions.
- Create a Regional Technical Advisory Panel to harmonize approaches and promote CARICOM consistency.

6. Institutional Framework

- Define the lead agency: The competent authority for standard-setting and enforcement.

- Define roles and responsibilities: e.g., utilities (treatment), agriculture (application), health ministries (public safety), environment (monitoring).

Key Considerations:

- Clear mandates: Avoid duplication of responsibilities among ministries.
- Coordination mechanisms: Establish inter-agency committees or MOUs for implementation.
- Legal authority: Ensure the lead agency has enforcement powers and sufficient resources.
- Accountability: Define monitoring and reporting obligations across institutions.
- Introduce a Regional Governance Framework Template to guide national-level adaptation.

7. Capacity Building and Resources

- Training: Regulators, utilities, farmers, local authorities, etc.
- Laboratory strengthening: Regional reference labs for wastewater quality monitoring.
- Financial models: Explore public-private partnerships, reuse tariffs, and regional funding (Green Climate Fund, GEF, IDB, CDB).

Key Considerations

- Targeted training: Prioritize operators, regulators, and laboratory technicians.
- Accreditation and certification: Build regional accreditation mechanisms for labs testing reuse parameters.
- Knowledge management: Develop online platforms for sharing regional best practices.
- Sustainability: Secure recurrent funding for long-term maintenance.
- Integrate Gender-responsive and Youth-focused Training Modules to promote inclusive capacity development.

8. Pilot Testing and Validation

- Financial and technical feasibility studies
- Demonstration projects: Implement small-scale pilots (e.g., irrigation in agriculture, hotel landscaping).
- Monitoring and evaluation: Track compliance, yield, public perception, and cost-effectiveness.
- Feedback loop: Use results to refine draft standards.

Key Considerations:

- Representative sites: Choose diverse hydroclimatic and socioeconomic contexts.
- Performance metrics: Define indicators for yield, quality, acceptance, and cost.
- Risk communication: Engage the public during pilot implementation to build confidence.
- Replication potential: Document lessons for scale-up and replication across SIDS.
- Develop a Standardized Evaluation Framework for assessing pilot performance regionally.

9. Formalization into Legal Frameworks and Adoption

- National standards: Adopt through Bureau of Standards or legislative framework.
- Develop and/or amend legal instruments: Water/environmental acts, and creation of new wastewater reuse regulations.
- Incorporate compliance mechanisms in regulations: e.g., licensing, permits, penalties, incentives.
- Regional guidance: Encourage CARICOM regional harmonization for consistency.
- Publication & dissemination: Manuals, technical bulletins, outreach campaigns.

Key Considerations:

- Legal hierarchy: Clarify how reuse standards interface with existing water, sanitation, and environmental laws.
- Incentive mechanisms: Introduce tax breaks or subsidies for reuse investments.
- Compliance mechanisms: Define penalties, enforcement protocols, and grievance redress systems.
- Regional consistency: Align with the CARICOM Regional Organization for Standards and Quality (CROSQ).
- Implementation Guidelines and Compliance Toolkits for regulators and end-users.

10. Monitoring, Review, and Continuous Improvement

- Implementation monitoring: Routine audits, compliance reports, and environmental health checks.
- Periodic standards review: Every 5 years, update based on scientific advances, climate impacts, and lessons learned.
- Public reporting: Transparency to build trust and acceptance.

Key Considerations:

- Data integration: Create digital dashboards for real-time monitoring of reuse quality and performance.
- Independent audits: Include third-party reviews for transparency and credibility.
- Feedback incorporation: Ensure adaptive updates informed by new research and stakeholder input.
- Knowledge dissemination: Publish results through regional databases and technical bulletins.
- Establish a Regional Reuse Monitoring Network linked to CARICOM or CWWA for data sharing and continuous learning

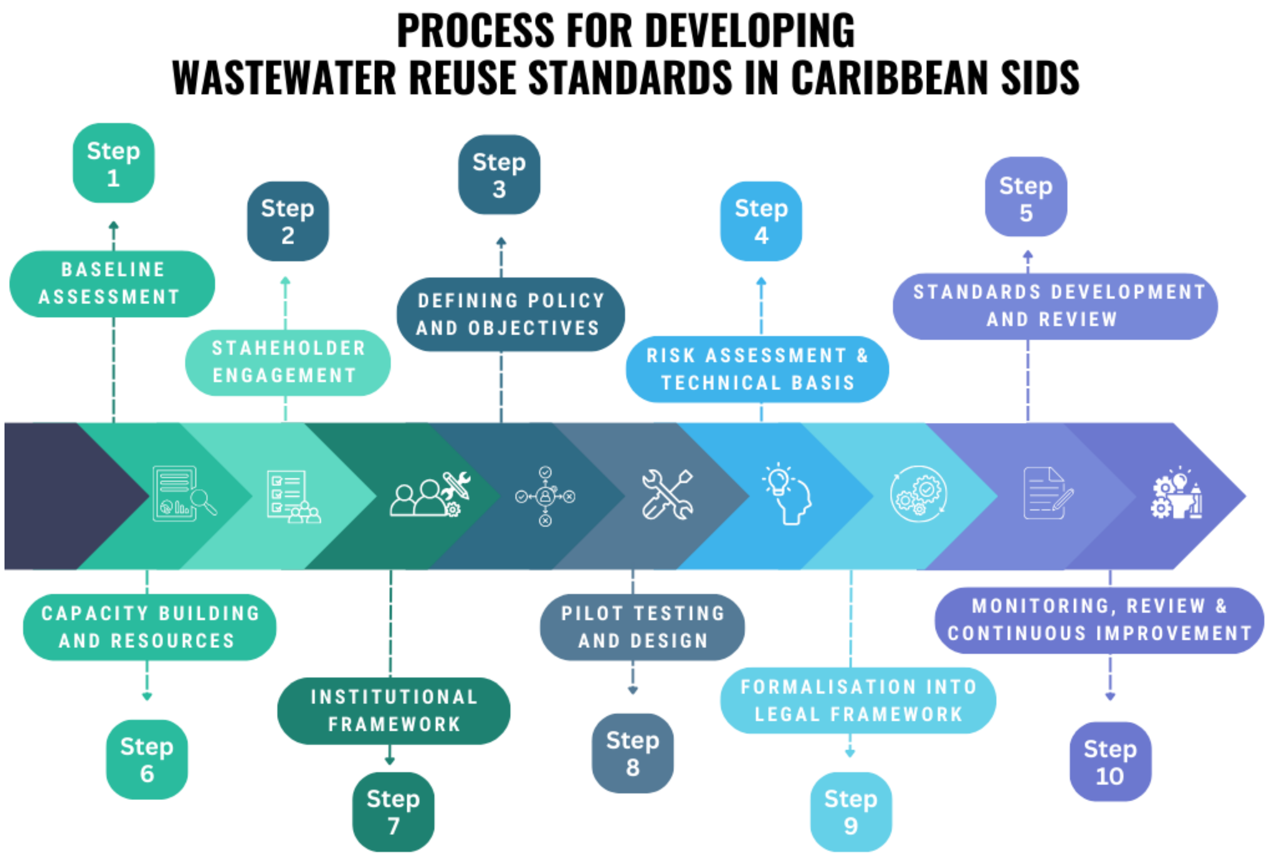

Figure 1: Summary Process Flow Chart

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Annexes

Annex A: Baseline Assessment Checklist (Template)

(Use to structure the baseline assessment deliverable.)

Project / Country: ____________________ Date: ____________________

Lead agency / focal point: ____________________ Assessment team: _________________

A1. Inventory of policies and regulations

- National water laws and regulations reviewed
- Environmental regulations (discharge, permits, EIAs) reviewed
- Public health regulations / sanitation codes reviewed
- Building / plumbing / cross-connection controls reviewed
- Relevant regional/international guidance identified (e.g., WHO/FAO/ISO/US EPA/EU)

Notes (key gaps/constraints): ____

A2. Current practices and infrastructure mapping

- Existing wastewater systems and treatment plants mapped
- Informal reuse practices identified (if any)
- Discharge points and receiving environments identified

Notes (coverage, condition, capacity constraints): ____________________________

A3. Drivers and barriers

- Drivers documented (e.g., scarcity, agriculture demand)
- Barriers documented (e.g., institutional gaps, public health risks, perceptions)

Top 3 drivers:

1) ________________________

2) ________________________

3) ________________________

Top 3 barriers:

1) ________________________

2) ________________________

3) ________________________

A4. Key considerations (minimum)

- Data quality and availability checked (completeness, accuracy, time coverage)
- Institutional mapping completed (mandates, overlaps, gaps)
- Climate vulnerability context included (droughts, floods, sea-level rise impacts)
- Socioeconomic factors assessed (affordability, willingness-to-pay, perceptions)

Baseline outputs produced:

- Policy/regulatory summary
- Wastewater/reuse system map
- Baseline gaps and priority actions list

Annex B: Stakeholder Mapping Template

(Use to identify and plan engagement across institutions and groups.)

Instructions: List stakeholders, rate influence/interest, and define engagement actions. Ensure inclusivity and a clear communication approach.

Stakeholder category	Institution / group	Mandate / interest	Influence (H/M/L)	Interest (H/M/L)	Proposed role (lead / technical / review / end-user)	Engagement method & frequency	Focal point / contact
Ministry (Health)							
Ministry (Water)							
Ministry (Agriculture)							
Ministry (Environment)							
Standards Bureau							
Utility / Operator							
Private sector							
Academia / labs							
Communities / users							

Inclusivity check (minimum):

- Representation considered for women, youth, indigenous groups, and marginalized communities.

Conflict resolution mechanism (brief): ___________________________

Public awareness / trust-building actions (brief): ________________

Annex C: Sample Reuse Classification Framework (Illustrative)

(Use to define reuse categories based on application and public exposure, then link each class to minimum controls and parameters.)

C1. Classification logic (choose one approach)

- By public exposure, by reuse application, or a combination of both.

C2. Example reuse classes (non-numeric, adaptable)

Class	Typical applications	Public exposure	Example minimum controls (non-exhaustive)	Example key parameters to include
Class 1: Unrestricted / High exposure	Urban landscaping, parks/sports fields, toilet flushing	High	Strong disinfection; strict operational control; cross-connection safeguards	Microbial indicators + turbidity/TSS + BOD/COD
Class 2: Restricted / Controlled exposure	Restricted irrigation; selected industrial uses	Medium	Controlled access; PPE/worker protection; site buffers	For irrigation: helminth eggs/fecal indicators + salinity + nutrients (e.g., N)
Class 3: Industrial (process-dependent)	Cooling/cleaning/process water	Low–Medium	Fit-for-purpose quality; corrosion/scaling control	pH, turbidity, alkalinity, hardness; process-specific chemicals

Class 4: Environmental	Wetland restoration; aquifer/stream augmentation	Variable	Protection of ecosystems; careful pathogen control; avoid eutrophication	Nutrients; pathogen controls; consider UV preference where relevant

Note: The standard should specify water quality thresholds, plus monitoring frequency, sampling methods, and reporting protocols for each class.

Annex D: Pilot Project Evaluation Template

(Use to evaluate demonstration projects and generate evidence to refine the draft standard.)

Pilot title / site: ____________________ Reuse class: ________

Implementing entity: ____________________ Duration: ________

D1. Objectives and evaluation questions

- Primary objective: ____
- Key evaluation questions (3–5):
    1. ____________________
    2. ____________________
    3. ____________________

D2. Core indicators (minimum set)

(Track compliance, performance, acceptance, and costs.)

Dimension	Indicator	Baseline	Target	Data source / method	Frequency	Responsible party

Compliance	Meets class requirements			Sampling / lab results		
Performance	Yield / service level			Operator records		
Social acceptance	User/community perception			Survey/interviews		
Economics	OPEX/CAPEX; unit cost			Financial records		
Risk communication	Outreach activities delivered			Logs/materials		

D3. Replication and learning

- What worked well: ____
- What needs improvement: _____________________________________
- Recommendations to refine standards: _________________________

Annex E: Minimum Monitoring Framework (Template)

(A simple, scalable framework that regulators and operators can implement, aligned to class-based standards and continuous improvement.)

E1. Monitoring responsibilities

- Operator (utility/facility): routine sampling, operational logs, incident reporting
- Regulator/competent authority: audits, compliance review, environmental/public health checks

E2. Minimum monitoring elements (define per class)

(Complete for each reuse class; keep parameters "fit-for-purpose".)

Reuse class	Routine operational checks	Water quality verification	Site checks	Reporting
Class 1 (High exposure)	Treatment performance (incl. disinfection functioning)	Microbial + turbidity/TSS + BOD/COD	Cross-connection safeguards, signage	Monthly summary + incident reporting
Class 2 (Restricted irrigation)	Process control & access control	Microbial indicators + helminth eggs (where relevant) + salinity + N	Buffers/setbacks, PPE compliance	Routine compliance reporting
Class 3: Industrial	Process control for scaling/corrosion	pH, turbidity, alkalinity, hardness; process-specific	Storage/distribution integrity	Routine compliance reporting
Class 4: Environmental	Ecosystem protection controls	Nutrients; pathogen controls; eutrophication risk	Receiving environment observation	Routine compliance reporting

E3. Review and transparency (minimum)

- Routine audits and compliance reports (implementation monitoring).
- Public reporting to support trust and accountability.

- Periodic review cycle (e.g., every 5 years) to update standards based on evidence and changing conditions.

Cost note: Ensure monitoring costs are budgeted in capital and operating costs.