



# FINAL REPORT

## **SX-NRPB-367264-CS-CQS**

Assessment of Seawater Quality Testing of  
Six (6) Areas to Establish a Baseline

September 25, 2025

Prepared for:

**National Recovery Programme Bureau (NRPB)**  
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# TECHNICAL REPORT

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**Project Code:** EM03894642/25

**Client:** NATIONAL RECOVERY PROGRAMME BUREAU (NRPB)


**Client Address:** 57 Walter A. Nisbeth Rd, Philipsburg, Sint Maarten

**Report Title:** SX-NRPB-367264-CS-CQS: Assessment of Seawater Quality Testing of Six (6) Areas to Establish a Baseline

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**Appendices:**

**Report Version:** ORIGINAL  RE-ISSUE  AMENDED

## EXECUTIVE SUMMARY

The Caribbean Industrial Research Institute (CARIRI) was contracted by the National Recovery Program Bureau (NRPB) to execute project **SX-NRPB-367264-CS-CQS "Assessment of Seawater Quality Testing of Six (6) Areas to Establish a Baseline"**. The scope of this project involved:

- Field sample collection (**Deliverable 1**) in accordance with APHA and EU Directives:
  - Water and sediment samples from Great Salt Pond, Fresh Pond, Little Bay Pond, Great Bay Beach, Divi Little Bay and Rolandus Canal, and
  - Sludge from the WWTP drying beds.
- Laboratory analysis of selected parameters, using internationally recognized test methods, to determine the presence of pollutants, including microbial, chemical, and physical indicators.

This technical report represents the final deliverable (**Deliverable 2**) of the project; presentation of results and comparison of the results to local, regional, and international environmental quality standards.

Sampling was conducted over four events: Event 1 (2025.04.28 to 2025.04.29 and 2025.05.02 to 2025.05.03), Event 2 (2025.05.12 to 2025.05.13), Event 3 (2025.05.26 to 2025.05.27) and Event 4 (2025.06.09 to 2025.06.10). Samples were couriered on ice to Trinidad and relinquished to the laboratories at CARIRI, within holding time. The PCB analysis was outsourced to a US-based laboratory (EMSL Analytical Inc.).

### Water Quality Assessment:

The water quality results confirmed elevated concentrations of nutrients, suspended solids, and organic matter—particularly in the inland water bodies (Great Salt Pond, Little Bay Pond, Fresh Pond and Rolandus Canal). Beach sites (Great Bay Beach and Divi Little Bay) exhibited generally better water quality, with a few elevated cases of microbial indicators.

Most areas assessed had significant levels of microbial contamination, in particular Great Salt Pond, Little Bay Pond, Fresh Pond and Rolandus Canal. The highest concentration of the Coliform group was detected in Little Bay Pond ( $>6.0 \times 10^4$  CFU/100ml) and Fresh Pond (570 – 54,000 CFU/100ml). Generally, Enterococcus sp. was most predominant in the marine and saline type environments such as Great Salt Pond, Little Bay Pond, Great Bay Beach and Divi Little Bay. The highest concentration of the Enterococcus sp. was detected in Great Salt Pond ( $>6.0 \times 10^4$  CFU/100ml) and Little Bay Pond (200 – 51,000 CFU/100ml).

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All field readings were well within acceptable limits for pH, Dissolved Oxygen and Temperature, except for one pH reading (Event 3: Divi Little Bay Grab 2-BW pH 8.63) which was just above the limit of pH 6.5 to 8.5.

Data indicates very high pollutant loading levels in the majority of water bodies assessed. Oil and Grease was the only parameter in which average results were consistently within acceptable limit for all sites tested. All other parameters, most importantly, Biological Oxygen Demand, Chemical Oxygen Demand, Total Nitrogen and Total Phosphorous significantly exceeded acceptable levels.

### **Sediment Assessment:**

For Great Salt Pond (GSP-C1-HM) and Great Bay Beach (GBB-C1-HM), all metals measurements were well below concern thresholds. In the Fresh Pond composite sample (FP- C1-HM), the cadmium level (1.83 mg/kg) and zinc level (129 mg/kg) suggest potential ecological impairment. In the Little Bay Pond sample LP-C1-HM, cadmium (1.55 mg/kg) slightly exceeded the lower threshold; other metals were within low-to-moderate risk levels.

### **Sludge Assessment:**

The sludge may be considered suitable for beneficial reuse, as all heavy metals were well below the international regulatory limits outlined in US EPA 503. pH, Organic Matter, and Nutrients were in normal ranges and do not indicate any concern.

Based on the findings of this baseline study, recommendations include:

- Expansion of the scope of assessment (areas and frequency),
- Development of an Integrated Watershed and Coastal Zone Management framework,
- Pursuit of Blue Flag Certification (Great Bay Beach and Divi Little Bay),
- Exploration of sludge reuse options (as an alternative to landfill disposal),
- Establishment of local standards and Institutional strengthening,
- Public Education and Awareness Campaigns,
- Assessment of WWTP performance and Landfill integrity, and
- Remediation using green alternatives.

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## 1. INTRODUCTION

This technical report presents the findings of an environmental monitoring assessment conducted across six surface water sites in Sint Maarten, including ponds, beaches, and a canal. The assessment forms part of the broader Wastewater Management Project, supported by the Government of Sint Maarten with financing provided by The Netherlands through the Sint Maarten Trust Fund, which is administered by the World Bank. The primary objective of this assignment was to establish a baseline of water, sediment, and sludge quality to better understand the current environmental conditions, identify potential impacts from treated and untreated wastewater, and support future monitoring and decision-making efforts.

### 1.1 Purpose and Scope of the Study

The purpose of this project was to conduct a comprehensive **baseline environmental assessment** of water, sediment, and sludge quality at six key locations in Sint Maarten.

The assessment focused on understanding the current state of **surface water and sediment quality** in three ponds (Fresh Pond, Little Bay Pond, Great Salt Pond), two recreational beaches (Great Bay Beach and Divi Little Bay), and one engineered canal (Rolandus Canal). In addition to the environmental sampling, the project included the **analysis of sludge** collected from the WWTP drying beds. This component provided insight into the characteristics of waste residuals generated from wastewater treatment operations.

The primary objectives of the assignment included:

- Field sample collection of water and sediment from each surface water body, and **sludge from the WWTP drying beds**.
- Laboratory analysis of selected parameters to determine the **presence of pollutants**, including microbial, chemical, and physical indicators.
- Comparison of the results to **local, regional, and international environmental quality standards**.
- Establishment of a **baseline dataset** to serve as a **reference point** for future monitoring.

This baseline study will support evidence-based decision-making and environmental management by providing robust, scientifically grounded information for both current and future assessments of Sint Maarten's wastewater and surface water systems.

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## 1.2 Client and Project Background

**Project P179067 "Sint Maarten Wastewater Management Project"** represents a strategic investment to improve wastewater infrastructure in Sint Maarten. It is a World Bank-supported initiative that seeks to:

- Expand and rehabilitate sewer networks in Cul-de-Sac,
- Upgrade the A.Th. Illidge Road WWTP, including treatment and sludge handling capacity,
- Strengthen systems within the Ministry of VROMI (environment and infrastructure),
- Enhance legal/regulatory frameworks, sanitation strategy, and sludge management, and
- Establish environmental monitoring systems, including coastal and inland water quality.

The **total budget** is estimated at USD 25 million

- USD 10 million from the **Sint Maarten Trust Fund** (managed by the World Bank) and
- USD 15 million co-financed by the **Government of Sint Maarten** and the **Netherlands**.

The Wastewater Management Project is executed by the Government of Sint Maarten through the **National Recovery Program Bureau (NRPB)**, as the **managing agency**. The NRPB, established in 2019, acts as the central Project Implementation Unit (PIU) for the Government of Sint Maarten, with responsibility for preparing, implementing, coordinating, and evaluating projects funded through the Sint Maarten Trust Fund and other sources.<sup>1</sup>

The contract **SX-NRPB-367264-CS-CQS** "Assessment of Seawater Quality Testing of Six (6) Areas to Establish a Baseline" is a subcomponent of the larger Project **P179067 – Sint Maarten Wastewater Management Project**.<sup>2</sup>

## 1.3 Project Timeline and Deliverables

The expected duration of the project was estimated to be eight weeks, with sampling and testing in the first four to six weeks, followed by data analysis and reporting in the remaining two weeks.

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Two main deliverables were expected from the project's outcome:

- **Deliverable 1:** Collection of Samples and
- **Deliverable 2:** Final Technical Report.

Commencement of sample collection was delayed due to several logistical constraints, including insufficient information on Customs requirements, the absence of direct broker contacts, limited flight availability, and occurrence of public holidays in both countries.

Further to these challenges, the release of this report was delayed due to unforeseen setbacks in the delivery of laboratory results by the subcontracted facility, which impacted the overall project timeline. Additionally, internal processes related to data verification, report compilation, and management review contributed to the extended timeline for finalization and release.

As a requirement for Deliverable 2, this Technical Report presents the findings of the baseline environmental assessment conducted across six key locations in Sint Maarten and includes an overview of the methodologies employed, interpretation of results against local, regional, and international standards, and recommendations based on the findings.

## 2. DESCRIPTION OF THE STUDY AREAS

To provide context for the sampling activities and analytical results, a detailed overview of each monitoring location is presented in this section. These site descriptions outline the physical, environmental, and land use characteristics of the selected areas.

The general sampling locations were pre-selected by the NRPB based on their relevance to the project objectives and proximity to known pollution sources and receiving environments. Background information on each site was obtained through a combination of online searches and desktop review of publicly available data. The most informative sources included:

- Visit St. Maarten portal<sup>3</sup>
- Nature Foundation Sint Maarten studies<sup>4</sup>
- Sint Maarten Country Environmental Analysis (CEA) Interactive e-Book<sup>5</sup>
- AIDEnvironment/EcoVision 1995 studies<sup>6</sup>
- BirdLife International IBA Factsheets<sup>7</sup>.

This preliminary information was subsequently confirmed and supplemented during the **field assessment** conducted by CARIRI personnel on **April 25-26, 2025**. This site visit allowed for verification of site characteristics, accessibility, safety/security considerations and local environmental conditions. Observations made during the site visit are summarized in the field assessment **checklists** provided in **Appendix I**.

### 2.1 Overview of sampling locations and rationale

Sampling was conducted at six strategically selected surface water bodies and one sludge drying area, reflecting a mix of **inland, coastal, and engineered environments**. The selection was based on their proximity to known or suspected pollution sources, ecological and public health relevance, and their potential exposure to treated or untreated wastewater. The selected locations include:

- **Great Salt Pond** – The largest inland water body in Philipsburg, receiving multiple inflows including from storm drains, runoff, and waste channels.
- **Fresh Pond** – An inland freshwater body within an urban setting, likely to receive runoff and greywater discharges.
- **Little Bay Pond** – A small water body situated in an urban area and next to a beach, potentially impacted by domestic waste, limited infrastructure, storm water runoff, and a proposed increased residential and commercial development.
- **Rolandus Canal** – A man-made drainage canal channeling runoff from urban areas directly into Great Salt Pond.

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- **Great Bay Beach** – A popular beach adjacent to the cruise terminal and urban centre, subject to stormwater runoff and potential marine discharges.
- **Divi Little Bay** – A coastal bay used for recreational purposes, situated near tourism infrastructure and marine traffic.
- **WWTP Drying Beds** – The facility for dewatering sludge produced from wastewater treatment operations.

Based on the scope of the project, multiple sample points were required within most of the locations to ensure adequate spatial coverage and to capture potential variability in environmental conditions. Several challenges were encountered during the identification and selection of sampling points across the project locations. Certain areas were situated on private property or otherwise inaccessible to the public, requiring adjustments to maintain legal and safe access. The absence of a designated boat or vessel—not stated as a requirement for the project—further limited access to some inland zones within the water bodies. In other cases, dense vegetation, particularly mangrove stands, obstructed entry to potential sampling zones. These constraints necessitated on-the-ground adjustments to ensure that the selected sites were accessible, representative and scientifically valid.

### 2.1.1 Great Salt Pond

**Great Salt Pond** is the largest inland water body on the island of Sint Maarten and holds significant historical, ecological, and socio-economic value. Located in the heart of Philipsburg, the pond has been central to the island’s development for centuries—first as a colonial-era salt production site and now as an urban water body facing modern environmental pressures. It serves as an important ecological habitat, particularly for migratory and resident bird species, and is designated as an Important Bird Area (IBA) due to its biodiversity significance.

Today, the pond is a key focal point in environmental management efforts, balancing conservation, urban development, and water quality concerns. Its proximity to residential, commercial, and landfill areas makes it both a critical environmental receptor and a priority site for monitoring and remediation within the broader wastewater management framework.

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## Site Profile of Great Salt Pond

- Location and General Characteristics**
- Largest inland water body on the island of Sint Maarten.
  - Situated just north of Philipsburg.
  - Coordinates:  $\sim 18.0386^{\circ}$  N,  $-63.0603^{\circ}$  W.
  - Surface area of  $\sim 188$  ha ( $1.88$  km<sup>2</sup>) and maximum depth of  $\sim 10$  m (33 ft).
- Hydrology and Water Quality**
- Exhibits hypersaline conditions with salinity levels between 27–38 ppt.
  - Receives water from stormwater runoff, limited tidal exchange, and minor groundwater seepage.
- Geology and Land Use**
- Historically, served as a major salt extraction site, dating back to the early 1600s.
  - Set within a coastal plain, consisting of unconsolidated sand, silt, and clay.
  - Surrounded by urban infrastructure—including roads, a landfill, and reclaimed land areas.
  - Parts of the pond were filled to construct Pondfill Road, the government building, and Fort Willem area.
  - In August 2023, a floating birding platform was installed.
- Ecological Importance**
- Designated as an Important Bird Area (IBA AN003) due to its role as a key habitat for waterbirds.
  - Key species include Laughing gulls, Black-necked stilts, White-cheeked pintails, Caribbean coots, Ruddy ducks, Pelicans, Herons and Frigates.
- Environmental Concerns**
- Water quality tests by the Nature Foundation post-Hurricane Irma showed high phosphate and nitrate levels, and a risk of eutrophication.
  - Fish mortality events—especially Tilapia die-offs—have been documented during dry spells and high temperatures, with dissolved oxygen measured as low as  $\sim 1$  ppm.
  - Urban runoff & landfill leachate pose ongoing threats to water quality, exacerbated by limited circulation.

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**MAP 1: Great Salt Pond with sample point markers.**



Pt #	Easting (WGS84)	Northing (WGS84)	Site ID	Description
1	495449	1993850	GSP # 1 West	Opposite Pond Island sign
2	495309	1993090	GSP # 2 West	Roundabout Salt pickers
3	495110	1993124	GSP # 3 West	RBC and Central Bank opposite trail
4	495041	1993132	GSP # 4 West	Grey glass building opposite trail
5	494939	1993149	GSP # 5 West	Wooden Hut on Trail
6	494825	1993160	GSP # 6 West	Canal drain off on trail
7	494100	1994079	GSP # 7 West	Lions Club roundabout
8	495112	1993124	GSP # 8 West	Opposite Royal Bank
9	494201	1993568	GSP # 9 West	Green container landfill road
10	494545	1993190	GSP # 10 West	Almond tree on trial – garbage; opposite balcony
11	494395	1993261	GSP # 11 West	Grassy depression area opposite Plaza China
12	495435	1992862	GSP # 1 East	Opposite Pond Island sign
13	495290	1993090	GSP # 2 East	Roundabout Salt Pickers
14	495654	1992972	GSP # 3 East	Boardwalk
15	495725	1993162	GSP # 4 East	Big Boss carwash – canal drain off
16	495561	1992964	GSP # 5 East	Behind Sabor Colombiano – discharge drain
17	495529	1992976	GSP # 6 East	Carpark opposite Printing, Sales and Rentals
18	495469	1993003	GSP # 7 East	Opposite Qredits in carpark
19	495388	1993037	GSP # 8 East	Exit to carpark – white building
20	495699	1993049	GSP # 9 East	West of electrical blue/white building
21	495676	1993016	GSP # 10 East	Behind bus shed

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### 2.1.2 Fresh Pond

**Fresh Pond** represents a dynamic urban freshwater habitat, influenced by residential runoff, limited hydrological exchange, and anthropogenic pressures. It is a highly significant ecological feature; however, its shallow depth, nutrient sensitivity, and urban pressures, pose risks to water quality, wildlife, and ecological balance.

#### Site Profile of Fresh Pond

Location and General Characteristics	<ul style="list-style-type: none"> <li>▪ Located east of Philipsburg [Coordinates: ~18°01'56" N, 63°03'32" W].</li> <li>▪ Surface area of ~14 ha (0.14 km<sup>2</sup>). Oblong shaped, approximately 2.5 km long × 1 km wide. Maximum depth: ~3 m (9–10 ft).</li> </ul>
Hydrology and Water Quality	<ul style="list-style-type: none"> <li>▪ Brackish freshwater pond with intermittent saline influence. Low salinity (2–3 ppt).</li> <li>▪ Primarily sustained by urban runoff, stormwater flows, and seasonal rainfall, with minimal groundwater seepage.</li> <li>▪ Connected to downstream water bodies via culverts or drainage pipes.</li> </ul>
Geology and Land Use	<ul style="list-style-type: none"> <li>▪ Lies within a low-lying, coastal plain.</li> <li>▪ Substrate composition includes alluvial and colluvial deposits—silt, clay, and sand from watershed drainage.</li> <li>▪ Soil permeability is moderate to low, supporting water retention.</li> <li>▪ Residential areas and commercial zones surround on multiple sides. Recreation is limited.</li> </ul>
Ecological Importance	<ul style="list-style-type: none"> <li>▪ Designated as IBA AN002, recognized for supporting breeding populations of Near Threatened Caribbean Coots, Snowy Egrets, Pied-billed Grebes, Common Moorhens, Great Egrets, and Ruddy Ducks.</li> <li>▪ Shoreline is vegetated with water grasses, red mangroves, and artificial islets planted with mangroves and coconut trees.</li> <li>▪ Serves as an educational and recreational resource, featuring a bird observation platform.</li> </ul>
Environmental Concerns	<ul style="list-style-type: none"> <li>▪ Studies indicate elevated nutrients (nitrate, phosphate), coliform bacteria presence, and periodic low dissolved oxygen—indicative of eutrophication risks.</li> </ul>

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**MAP 2: Fresh Pond with sample point markers.**



Photograph 1:  
 Fresh Pond – Zagersgut Road Bridge – top of the pond



Photograph 2:  
 Fresh Pond – Bus Shed signage by fire hydrant

Pt #	Easting (WGS84)	Northing (WGS84)	Site ID	Description
1	494121	1992946	FP # 1	Fresh Pond South
2	494001	1993527	FP # 2	Bush Shed signage by fire hydrant
3	494063	1993491	FP # 3	Traffic Light by bridge
4	493726	1994050	FP # 4	Top of the pond by bridge – Zagersgut Road
5	493965	1994068	FP # 5	Sluice gate by roundabout

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### 2.1.3 Little Bay Pond

**Little Bay Pond** (also known as Welgelegen Pond) is a small brackish wetland located near Philipsburg on the southern coast of Sint Maarten. It has significant cultural and historical value; and despite its modest size, it plays an important ecological role as a habitat for various animal species, especially birds. In addition, the Pond also serves as a catchment basin for stormwater runoff from the surrounding hills. The pond is surrounded by a mix of coastal vegetation, mangroves, and urban development, with increasing pressure from proposed residential and commercial projects.

#### Site Profile of Little Bay Pond

- |                                      |  |
|--------------------------------------|--|
| Location and General Characteristics | <ul style="list-style-type: none"> <li>▪ Located near Philipsburg; approximately 1.5 km east of the capital.</li> <li>▪ Surface Area of ~ 8 hectares (0.08 km<sup>2</sup>) and dimensions ~2.5 km in circumference with a diameter of ~250 m.</li> </ul>   |
| Hydrology and Water Quality          | <ul style="list-style-type: none"> <li>▪ Low salinity, at 4–8 ppt, characteristic of brackish environments.</li> <li>▪ Receives stormwater runoff, occasional marine input via a small outlet, and coastal seepage. The pond discharges intermittently to the neighbouring bay.</li> </ul>   |
| Geology and Land Use                 | <ul style="list-style-type: none"> <li>▪ Located in a coastal scrubland matrix with bordering red, black, and white mangroves and aquatic grasses.</li> <li>▪ Proposed developments, including marinas and high-density residential projects, pose future risk to ecological integrity.</li> </ul>   |
| Ecological Importance                | <ul style="list-style-type: none"> <li>▪ An IBA Designation (AN001): The Pond is a crucial fishing ground for Sint Maarten's National Bird, the Brown Pelican. It also serves as a significant nesting, foraging and breeding area for various other bird species, including the Near Threatened Caribbean Near-Threatened Caribbean Coot, Pied-billed Grebes, Common Moorhen, White-cheeked Pintails, Ruddy Ducks, and various restricted-range passerines. Additionally, the pond is home to all five restricted-range bird species of the Lesser Antilles Endemic Bird Areas (EBAs): the Green-throated Carib (<i>Eulampis holosericeus</i>), Antillean Crested Hummingbird (<i>Orthorhyncus cristatus</i>), Pearly-eyed Thrasher (<i>Margarops fuscatus</i>), and Lesser Antillean Bullfinch (<i>Loxigilla noctis</i>)</li> <li>▪ Surrounding vegetation, mangrove plantings, and a bird-watching hut and signage (built with Royal Caribbean funding) enhance habitat value and support eco-tourism.</li> </ul> |

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Environmental Concerns

- High nutrient levels from sewage runoff have been documented.
- Episodic fish die-offs have been reported due to eutrophication and low dissolved oxygen levels.
- Accumulation of trash along shorelines and mangroves, threatening wildlife.

**MAP 3: Little Bay Pond with sample point markers.**



Photograph 3: Little Bay Pond – Light pole west side

Pt #	Easting (WGS84)	Northing (WGS84)	Site ID	Description
1	493045	1992844	LP # 1	Bird watching Tower – west side
2	493026	1992770	LP # 2	Light pole – west side
3	493183	1992722	LP # 3	Palm Tree with house 83 opposite

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### 2.1.4 Rolandus Canal

Rolandus Canal is a historic and functional drainage channel located in Philipsburg. Constructed in the late 1800s, the canal was designed to facilitate the outflow of water from the island's inland ponds—primarily Fresh Pond and Great Salt Pond—into Great Bay. Today, it remains a critical component of the urban stormwater management system, particularly during heavy rainfall events. While largely artificial in design, the canal plays a supporting role in the island's hydrology and urban ecology, although it faces ongoing challenges related to pollution, sediment buildup, and fluctuating water quality.

#### Site Profile of Rolandus Canal

- |                                      |  |
|--------------------------------------|--|
| Location and General Characteristics | <ul style="list-style-type: none"><li>▪ Located mid-Philipsburg, approximately at 18°01'45" N, 63°03'30" W.</li><li>▪ Spans ~500–600 m from the pump house to Great Bay. The canal features a concrete base ~4 m wide with ~2 m vertical side walls.</li><li>▪ A series of mechanical floodgates was installed in 2015 to control flow and prevent tidal backflow.</li></ul> |
| Hydrology and Water Quality          | <ul style="list-style-type: none"><li>▪ Serves as a drainage channel for stormwater and overflow from Fresh Pond and Great Salt Pond, flowing into Great Bay.</li><li>▪ Commonly low-flow or stagnant, particularly outside of rainfall events, leading to low dissolved oxygen and fish entrapment.</li></ul>   |
| Ecological Importance                | <ul style="list-style-type: none"><li>▪ Provides habitat for urban-tolerant fish like tilapia.</li><li>▪ In 2012 and 2014, Nature Foundation and municipal partners rescued stranded fish (largely tilapia) from low water zones.</li></ul>  |
| Environmental Concerns               | <ul style="list-style-type: none"><li>▪ Water quality assessments (2012) by the Nature Foundation recorded high nutrient and coliform levels near the canal's outlet, indicating poor water quality at discharge into Great Bay.</li><li>▪ Blocked culverts and unmaintained canal segments were reported to contribute to flooding and stagnation.</li></ul>                |

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**MAP 4: Rolandus Canal with sample point markers.**



Photograph 4: Rolandus Canal – Opposite electrical storage house (white and blue building)

Pt #	Easting (WGS84)	Northing (WGS84)	Site ID	Description
1	495730	1993056	Rolandus Canal	Opposite electrical storage house – white and blue building

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## 2.1.5 Great Bay Beach

Great Bay Beach is a prominent sandy shoreline located along the southern coast of Sint Maarten, fronting the capital city of Philipsburg. It is a vital recreational, tourism, and ecological asset, bordered by urban development and the island's cruise terminal. It forms part of the Great Bay estuarine system, influenced by tidal exchange and stormwater runoff from surrounding areas.

### Site Profile of Great Bay Beach

- |                                      |  |
|--------------------------------------|--|
| Location and General Characteristics | <ul style="list-style-type: none"> <li>▪ Stretches approximately 1.6 km (1 mile) along the shoreline in front of Philipsburg's cruise ship harbour.</li> </ul>   |
| Hydrology and Water Quality          | <ul style="list-style-type: none"> <li>▪ Regular tidal exchange flushes sediment and urban runoff into the nearshore zone.</li> <li>▪ During heavy rainfall, stormwater runoff from the Philipsburg area, including discharges from Rolandus Canal, introduces untreated or partially treated wastewater, sediments, and floating debris directly into the nearshore waters of Great Bay Beach.</li> </ul>   |
| Geology and Land Use                 | <ul style="list-style-type: none"> <li>▪ Characterized by a broad expanse of white sandy beach and shallow coastal seabed.</li> <li>▪ Primarily composed of Holocene marine and alluvial deposits.</li> <li>▪ Characterized by calcareous sands, predominantly composed of coral fragments, mollusk shells, and foraminiferal debris, which are typical of high-energy tropical coastal zones.</li> <li>▪ Backshore is urbanized, and natural dune systems are either severely degraded or absent, replaced by revetments, concrete embankments, and paved surfaces. Receives heavy recreational use.</li> </ul> |
| Ecological Importance                | <ul style="list-style-type: none"> <li>▪ Supports marine biodiversity such as seagrasses and small reef communities. It serves as foraging grounds for juvenile fish and supports transient marine life.</li> </ul>  |
| Environmental Concerns               | <ul style="list-style-type: none"> <li>▪ Post-rainfall sampling by the Nature Foundation in 2019 identified sewage contamination, flagged by elevated coliform bacterial levels following stormwater runoff and floodgate discharge events.</li> </ul>   |

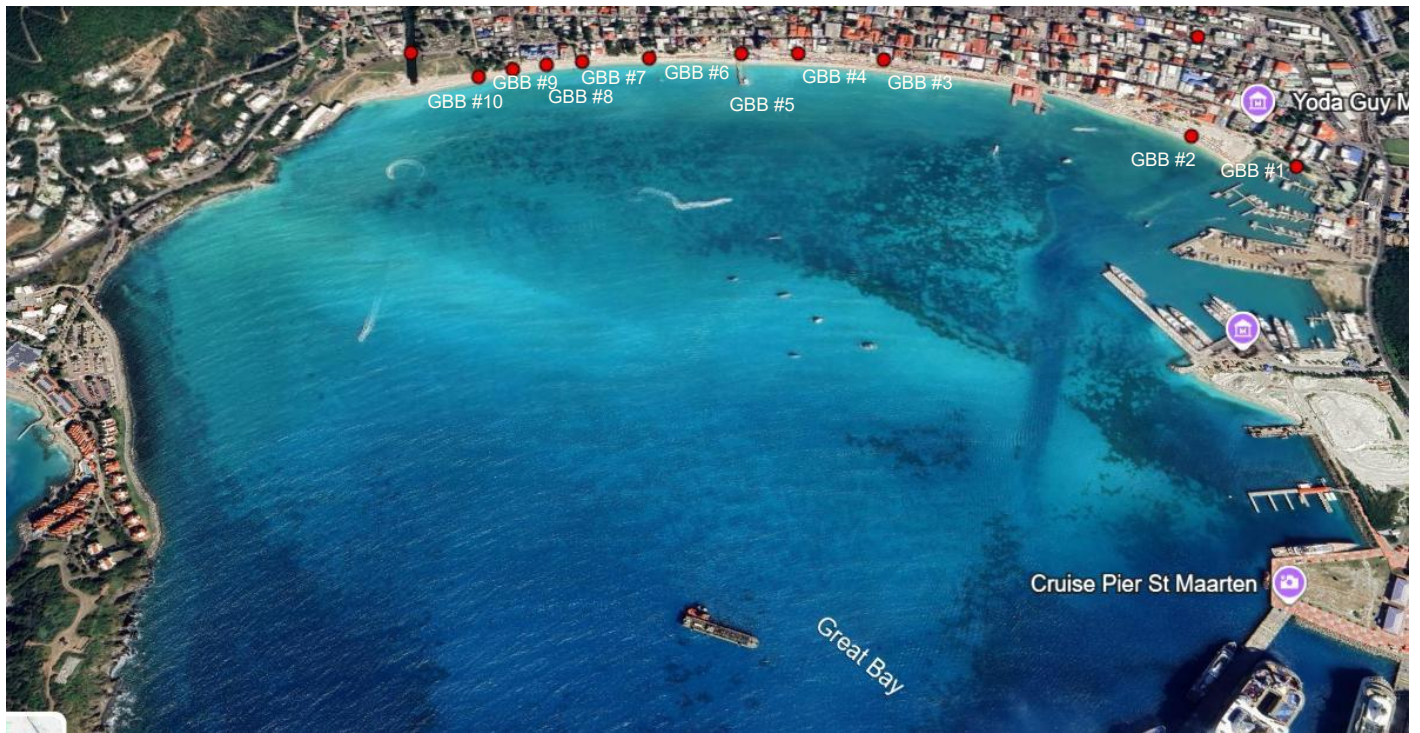
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**MAP 5: Great Bay Beach with sample point markers.**



Photograph 5: Big Beach Bay – Eastern View



Photograph 6: Great Beach Bay – Jetty opp. Flagpole

Pt #	Easting (WGS84)	Northing (WGS84)	Site ID	Description
1	495461	1992515	GBB # 1	Lazy Lizard
2	495330	1992607	GBB # 2	Oualichi
3	494897	1992853	GBB # 3	Lizzy's Bar and Grill
4	494759	1992882	GBB # 4	Khushi Indian restaurant
5	494666	1992894	GBB # 5	Jetty – Opposite Flagpole
6	494512	1992895	GBB # 6	Jet Ski Storage between coconut trees
7	494401	1992897	GBB # 7	Rum and Reggae Backyard Café beach entrance
8	494342	1992897	GBB # 8	The Villas on Great Bay – beach entrance
9	494286	1992890	GBB # 9	Yellow Building – opposite
10	494229	1992876	GBB # 10	Security camera – private property sign

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### 2.1.6 Divi Little Bay

Divi Little Bay is a small, scenic cove on Sint Maarten's coast that benefits from tidal flushing and limited documented pollution. The bay plays a key role in tourism and local recreation, with potential ecological value as a nursery habitat. While generally well-maintained, it remains vulnerable to stormwater impact and lacks formal environmental monitoring—highlighting the need for continued water quality and habitat assessment.

#### Site Profile of Divi Little Bay

- |                                      |  |
|--------------------------------------|--|
| Location and General Characteristics | <ul style="list-style-type: none"> <li>▪ Situated just east of Philipsburg's central area. Coordinates: 18°01'37" N, 63°03'53" W.</li> <li>▪ A sheltered cove roughly 300 m wide and 150 m deep, with mostly shallow water &lt; 1 m depth, deepening to 2–3 m near the centre.</li> </ul>  |
| Hydrology and Water Quality          | <ul style="list-style-type: none"> <li>▪ Experiences tidal flushing into Great Bay via a narrow entrance, helping maintain water circulation.</li> <li>▪ Generally, water is clear and turquoise with generally stable salinity due to limited freshwater input.</li> </ul>  |
| Geology and Land Use                 | <ul style="list-style-type: none"> <li>▪ Beach is made up of fine calcareous sand and a seabed of sand and scattered reef rock.</li> <li>▪ Bordered by the Divi Little Bay Beach Resort and public beach access, with mixed land use including tourism, marinas, and natural pockets of vegetation.</li> <li>▪ Heavily oriented toward tourism and hospitality.</li> </ul> |
| Ecological Importance                | <ul style="list-style-type: none"> <li>▪ Shallow, sheltered conditions support juvenile fish recruitment, small reef fish and crustaceans.</li> <li>▪ The presence of seagrass beds or coral rubble may support biodiversity.</li> </ul>   |
| Environmental Concerns               | <ul style="list-style-type: none"> <li>▪ Water testing is limited; however, there is no documented evidence of regular pollution incidents within the bay.</li> </ul>  |

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**MAP 6: Little Bay with sample point markers.**



Photograph 7: Divi Little Bay – Opposite Green Building by the rocks



Photograph 8: DIVI Little Bay – Old Concrete staircase

Pt #	Easting (WGS84)	Northing (WGS84)	Site ID	Description
1	493262	1992345	Divi LB # 1	Opposite Green Building by rocks – Belair Beach House
2	493242	1992345	Divi LB # 2	Old staircase concrete
3	493196	1992363	Divi LB # 3	Beach sign – about 2 ft from this point
4	493053	1992349	Divi LB # 4	Mangrove trees – Little Bay Pond discharge
5	493015	1992345	Divi LB # 5	Opposite Rock pile

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### 2.1.7 A.Th. Illidge Road Wastewater Treatment Plant (WWTP)

The A.Th. Illidge Road WWTP is a medium scale activated sludge wastewater treatment facility that is a central component of Sint Maarten's water infrastructure strategy. The WWTP has a nominal capacity to treat 4750 m<sup>3</sup> of sewage/day (up to 60,000 population equivalent) and is currently operating at approx. 50% of its designed hydraulic load. An unknown part of these flows originates from the intrusion of stormwater, and incidentally from cruise ships docking at Sint Maarten. Additionally, it receives about 450 m<sup>3</sup>/d of household septic sludge delivered by trucks to the plant. The infrastructure work will upgrade existing WWTP and extend the sewerage connections to enable connection of approximately 10,500 new customers (about 25% coverage).

As part of the broader Sint Maarten Wastewater Management Project (P179067), the WWTP will receive enhancements to bolster treatment efficiency, sludge management, climate resilience, monitoring, and regulatory compliance.

The WWTP utilizes a mechanical, conventional activated sludge process that includes:

- Influent screening,
- Primary sedimentation (clarifiers),
- Aeration basins with surface aerators and mixers,
- Secondary clarification and
- Sludge thickening and dewatering.

The potential for sludge reuse in Sint Maarten depends on several factors including sludge composition, regulatory framework, and available infrastructure.



Photograph 9: WWTP Drying beds

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### 3. FIELD SAMPLING METHODOLOGY

The sampling approach utilized in this study was designed to ensure representative collection of water, sediment, and sludge samples by following standard environmental monitoring protocols. This section outlines the procedures used for sample collection, equipment handling, preservation techniques, and quality assurance measures to ensure sample integrity.

#### 3.1 Sampling design and schedule

The goal of the sampling campaign was to obtain representative data on surface water, sediment, and sludge conditions in a manner that reflects both spatial and environmental variability.

Site-specific sampling points were identified based on desktop review, client input, and field reconnaissance. To identify potential sampling zones, each water body was divided into logical segments, based on drainage patterns and land use activities. This study focussed on point sources of pollutants (e.g. wastewater drains and outlets).

Based on the number and type of samples as well as the scope and frequency of testing, field sample collection was conducted over the course of four events. See Table 1 below.

Table 1: Details of the Field Sample Collection Schedule

EVENT NO. & DATE	SITE	NO. & TYPE OF SAMPLES	SAMPLE ID	MATRIX	*ANALYSES REQUIRED
Event 1A: 2025.04.28 to 2025.04.29	FRESH POND	3 grab samples	V 1699/25: FP-G1-BW V 1700/25: FP-G2-BW V 1701/25: FP-G3-BW	Water	BW
		1 composite sample from 5 locations	V 1702/25: FP-C1-NP	Water	NP (PCB included)
	ROLANDUS CANAL	1 grab sample	V 1703/25: RC-G1-BW V 1703/25: RC-G1-NP	Water	BW, NP
Event 1B: 2025.05.02 to 2025.05.03	LITTLE BAY POND	3 grab samples	V 1721/25: LP-G1-BW V 1722/25: LP-G2-BW V 1723/25: LP-G3-BW	Water	BW
		1 composite sample from 3 locations	V 1724/25: LP-C1-NP	Water	NP

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Table 1 continued: Details of the Field Sample Collection Schedule

EVENT NO. & DATE	SITE	NO. & TYPE OF SAMPLES	SAMPLE ID	MATRIX	*ANALYSES REQUIRED	
Event 1B: 2025.05.02 to 2025.05.03	GREAT SALT POND	5 grab samples	V 1704/25: GSP-G1-BW V 1705/25: GSP-G2-BW V 1706/25: GSP-G3-BW V 1707/25: GSP-G4-BW V 1708/25: GSP-G5-BW	Water	BW	
		2 composite samples taken from 10 locations each (eastern and western side of Pond Island)	V 1709/25: GSP-C1-NP V 1710/25: GSP-C2-NP	Water	NP	
	DIVI LITTLE BAY	3 grab samples	V 1717/25: DLB-G1-BW V 1718/25: DLB-G2-BW V 1719/25: DLB-G3-BW	Water	BW	
		1 composite sample from 5 locations	V 1720/25: DLB-C1-NP	Water	NP	
	GREAT BAY BEACH	5 grab samples	V 1711/25: GBB-G1-BW V 1712/25: GBB-G2-BW V 1713/25: GBB-G3-BW V 1714/25: GBB-G4-BW V 1715/25: GBB-G5-BW	Water	BW	
		1 composite sample from 10 locations	V 1716/25: GBB-G1-NP	Water	NP	
	Event 2: 2025.05.12 to 2025.05.13	FRESH POND	1 composite sample from 5 locations	V 1773/25: FP-C1-NP	Water	NP
			1 composite sample from 5 locations	V 1759/25: Fresh Pond sediment	Sediment	HM
		LITTLE BAY POND	1 composite sample from 3 locations	V 1760/25: Little Pond sediment	Sediment	HM
		GREAT SALT POND	1 composite sample from 10 locations.	V 1762/25: Great Salt Pond sediment	Sediment	HM
WWTP		1 representative sample	V 1761/25: Sludge from WWTP	Sludge	SLDG	
GREAT BAY BEACH		5 grab samples	V 1763/25: GBB-G1-BW V 1764/25: GBB-G2-BW V 1765/25: GBB-G3-BW V 1766/25: GBB-G4-BW V 1767/25: GBB-G5-BW	Water	BW	
		1 composite sample from 10 locations.	V 1768/25: Great Bay Beach sediment	Sediment	HM	
DIVI LITTLE BAY		3 grab samples	V 1769/25: DLB-G1-BW V 1770/25: DLB-G2-BW V 1771/25: DLB-G3-BW	Water	BW	
		1 composite sample from 5 locations	V 1772/25: Little Bay sediment	Sediment	HM	

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Table 1 continued: Details of the Field Sample Collection Schedule

EVENT NO. & DATE	SITE	NO. & TYPE OF SAMPLES	SAMPLE ID	MATRIX	*ANALYSES REQUIRED
Event 3: 2025.05.26 to 2025.05.27	LITTLE BAY POND	3 grab samples	V 1879/25: LP-G1-BW V 1880/25: LP-G2-BW V 1881/25: LP-G3-BW	Water	BW
		1 composite sample from 3 locations	V 1882/25: LP-G3-NP	Water	NP
	DIVI LITTLE BAY	3 grab samples	V 1883/25: DLB-G1-BW V 1884/25: DLB-G2-BW V 1885/25: DLB-G3-BW	Water	BW
		1 composite sample from 5 locations	V 1886/25: DLB-C1-NP	Water	NP
	GREAT BAY BEACH	5 grab samples	V 1887/25: GBB-G1-BW V 1888/25: GBB-G2-BW V 1889/25: GBB-G3-BW V 1890/25: GBB-G4-BW V 1891/25: GBB-G5-BW	Water	BW
		1 composite sample from 10 locations	V 1892/25: GBB-C1-NP	Water	NP
	ROLANDUS CANAL	1 grab sample	V 1893/25: RC-G1-BW V 1893/25: RC-G1-NP	Water	BW, NP
	GREAT SALT POND	5 grab samples	V 1894/25: GSP-G1-BW V 1895/25: GSP-G2-BW V 1896/25: GSP-G3-BW V 1897/25: GSP-G4-BW V 1898/25: GSP-G5-BW	Water	BW
		2 composite samples taken from	V 1899/25: GSP-C1-NP V 1900/25: GSP-C2-NP	Water	NP
	FRESH POND	3 grab samples	V 1901/25: FP-G1-BW V 1902/25: FP-G2-BW V 1903/25: FP-G3-BW	Water	BW
1 composite sample from 5 locations		V 1904/25: FP-C1-NP V 1907/25: FP-C1-PCB	Water	NP (including PCB)	
Event 4: 2025.06.09 to 2025.06.10	DIVI LITTLE BAY	3 grab samples	V 1978/25: DLB-G1-BW V 1979/25: DLB-G2-BW V 1980/25: DLB-G3-BW	Water	BW
	GREAT BAY BEACH	5 grab samples	V 1981/25: GBB-G1-BW V 1982/25: GBB-G2-BW V 1983/25: GBB-G3-BW V 1984/25: GBB-G4-BW V 1985/25: GBB-G5-BW	Water	BW
	WWTP	1 representative sample	V 1986/25: Sludge from WWTP	Sludge	SLDG
	FRESH POND	1 composite sample from 5 locations	V 1987/25: FP-C1-NP	Water	NP (including PCB)
<b>*ANALYSES</b>					
<b>Bacteria in Water (BW):</b> Enterococci, Faecal Coliform, E. Coli, pH, Oxygen, Water Temperature					
<b>Nutrients &amp; Pollutants in water (NP):</b> Electric Conductivity, Total Nitrogen, Total Suspended Solids (TSS), Total Phosphorus, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD5), oil & grease, (plus polychlorinated biphenyls for the Fresh Pond)					
<b>Heavy Metals in sediment (HM):</b> Cadmium, Copper, Nickel, Lead, Zinc, Mercury, Chromium					
<b>Sludge from WWTP (SLGD):</b> Dry matter, Percentage of water, Organic matter, pH, Nitrogen, Phosphorus, Cadmium, Copper, Nickel, Lead, Zinc, Mercury, Chromium					

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### **3.2 Sampling equipment and techniques**

Field activities included the collection of samples from multiple environmental matrices—namely water, sediment, and sludge—as well as the in-situ measurement of key field parameters such as pH, temperature, and dissolved oxygen.

Samples were retrieved using appropriate field techniques, in accordance with the following standard guidelines:

- APHA - Standard Methods for the Examination of Wastewater and Waters<sup>8</sup>,
- EU Directive Testing Surface Water such as Ponds/Canals 91/271/EEC directive concerning urban wastewater treatment<sup>9</sup>,
- EU Directive Testing Surface Water such as beaches 2006/7/EC (repealed 76/160/EEC) directive concerning bathing water quality<sup>10</sup>,
- EU Directive Testing Sludge 86/278/EEC directive concerning sewage sludge use in agriculture<sup>11</sup>.

#### **3.2.1 Collection of water samples and field measurements**

Grab samples were collected within 1-3 meters from the shoreline at a surface depth within 30 cm, using a sampling pole outfitted with an attachment to hold sample vessels. The exception were samples retrieved for Oil & Grease analyses, as these samples were collected first and by skimming the surface of the water.

Aseptic techniques were used for collection of samples requiring microbiological analysis. This included the use of sterile sample collection vessels and cleaning equipment with 70% alcohol solution between samples to avoid cross contamination.

Composite samples were created from multiple sub-grabs within a defined area by mixing equal volumes from each grab in a clean bucket, homogenizing and then filling respective sample vessels.

The minimum sample volumes collected were:

- Bacteria in Water: 1 x 250ml sterile, plastic bottle.
- Nutrients & Pollutants: 1 x 500ml wide-mouth, amber bottle (Oil & Grease), 2 x 2L amber, glass bottles (PCB) and 1 x 1L plastic bottle (all other parameters).

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Field measurements were taken on-site with the following pre-calibrated meters:

- Dissolved Oxygen – YSI DO meter (YSI Model 5100),
- pH and Temperature – Portable pH meter (Orion Model A321).

### 3.2.2 Collection of sediment samples

Sediment samples were collected within 3 meters from the shoreline, using a corer or spade depending on substrate type, at an average depth within 5 cm (top layer). Large stones and debris were discarded.

Composite samples were created by mixings equal fractions of discrete grab samples in clean bucket, mixing thoroughly using a trowel and then placing approximately 100-500 g of sediment in a sealed, plastic. bag.

### 3.2.3 Collection of sludge samples

Sludge samples were collected from the top 30 cm of the sludge drying beds, using a trowel to obtain representative grab samples from different areas of the bed. Similar to the sediment samples, approximately 100-500 g of each representative sludge sample was placed in a plastic bag and sealed.

## 3.3 Sample handling, preservation, and transport procedures

Chain-of-Custody documentation was maintained for each event to ensure traceability of the sample collection process. Refer to **Appendix II**.

Samples were stored in coolers with ice packs to maintain temperature at or below 6°C. Sample vessels were secured and prepared for the return flight to Trinidad. For example, sediment samples were double bagged in the event of punctures and glass vessels were wrapped in bubble-wrap to avoid breakage during transit.

Samples were delivered to each laboratory within the required holding times. This includes the shipping of samples for PCB analysis to the outsourced US-based accredited laboratory (EMSL Analytical Inc, USA).

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### ***3.4 Quality Assurance/Quality Control measures***

To ensure the integrity of samples:

- All samples were placed in clean, contaminant-free, pre-labelled containers. Each vessel was labelled with: unique sample ID, date/time, location, matrix, sampler initials.
- Samples requiring cooling were stored in ice-filled coolers and maintained at  $\leq 6^{\circ}\text{C}$ . Temperature control bottles were placed in each cooler and temperature recorded upon receipt at the laboratory.
- Chain of custody forms were maintained for each sample event.
- Samples were delivered to the laboratory within the recommended holding time.

## 4. LABORATORY ANALYTICAL METHODOLOGY

Laboratory analyses were conducted using internationally recognized methods for each parameter, such as the American Public Health Association (APHA), British Standards (BS), and AOAC methods, to ensure consistency and comparability across sites. The parameters requested and the associated method references are summarized in Tables 2-5.

### 4.1 TEST SUITE 1: Bacteria in Water

Table 2: Method Reference, Summary and QC – Bacteria in Water parameters

Parameter	Method	Method Summary & QC
<b>Enterococci</b>	SMEWW 9230C; Environment Agency Part 4 Section A	Samples were filtered, incubated on selective media, then colonies were counted and subjected to confirmatory tests.  Sterility and Positive Controls (using reference culture) were run in parallel with each batch of samples.
<b>Escherichia coli (E. coli)</b>	SMEWW 9225	Membrane filtration was performed, followed by incubation on selective media and confirmation testing.  Sterility and Positive Controls (using reference culture) were run in parallel with each batch of samples.
<b>Faecal Coliforms</b>	SMEWW 9222D	Samples were filtered and incubated on selective media at 44.5°C, and colonies were counted then confirmed.  Sterility and Positive Controls (using reference culture) were run in parallel with each batch of samples.
<b>Dissolved Oxygen (DO)</b>	SMEWW 4500-G (Membrane Electrode Method)	DO was measured in the field using a membrane probe that was calibrated at 0% and checked at 100% DO saturation.
<b>pH</b>	SMEWW 4500-H+	pH was measured in the field using a calibrated electrode pH meter, which was calibrated using reference buffers (pH 4, 7 and 10).
<b>Water Temperature</b>	SMEWW 2550 B	Temperature was measured in the field using the calibrated temperature probe of the portable pH meter.

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**4.2 TEST SUITE 2: Nutrients & Pollutants in Water**

Table 3: Method Reference, Summary and QC – Nutrients & Pollutants in Water parameters

Parameter	Method	Method Summary & QC
<b>Biological Oxygen Demand (BOD<sub>5</sub>)</b>	SMEWW 5210B	Samples were incubated in sealed bottles for 5 days at 20°C, and dissolved oxygen was measured before and after incubation.  A series of controls were run with each batch of samples: unseeded dilution water, seeded dilution water, seed controls, and glucose-glutamic acid controls.
<b>Chemical Oxygen Demand (COD)</b>	HACH Method 8000 – SMEWW 5220D	Samples were digested with potassium dichromate in acidic conditions, followed by titration to determine oxygen demand.
<b>Electrical Conductivity (EC)</b>	SMEWW 2510 B by probe	Conductivity was measured using a calibrated EC meter.
<b>Polychlorinated Biphenyls (PCBs)</b>	EPA SW-846 3510C/8082A	Sample analysis outsourced to EMSL Analytical Inc. Based on the method reference, samples were extracted with solvent, cleaned up, and analyzed via gas chromatography with electron capture detection.
<b>Total Phosphorus (TP)</b>	SMEWW 4500-P E and HACH TNT 844+843	Samples were digested with persulfate and analyzed using a colorimetric ascorbic acid method.
<b>Total Nitrogen (TN)</b>	Derived from: TKN + Nitrate-N + Nitrite-N	Total nitrogen was calculated as the sum of TKN, nitrate, and nitrite determined by respective standard methods.
<b>Total Oil and Grease (TOG)</b>	SMEWW 5520 B & E	Samples were extracted with hexane, the solvent was evaporated, and the residue was weighed.
<b>Total Suspended Solids (TSS)</b>	SMEWW 2540 A, B.2, C.2, D	A known volume of sample was filtered, the filter was dried and weighed to determine solids.

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**4.3 TEST SUITE 3: Heavy Metals in Sediment**

Table 4: Method Reference, Summary and QC – Heavy Metals in Sediment parameters

Parameter	Method	Method Summary & QC
<b>Chromium, Cadmium, Copper, Nickel, Zinc, Lead</b>	SMEWW 3112 A, B (Graphite Furnace Atomic Absorption)	Sediment samples were digested with acid and analyzed using graphite furnace atomic absorption.
<b>Mercury</b>	SMEWW 3120 A, B (Cold Vapor Atomic Absorption)	Mercury was measured after acid digestion using cold vapor atomic absorption spectroscopy.
<b>pH (Sediment)</b>	BS 1377 Part 3: 1990; SMEWW 4500-H+	A sediment-water suspension was prepared and pH was measured using a calibrated pH meter.

**4.4 TEST SUITE 4: Sludge from WWTP**

Table 5: Method Reference, Summary and QC – Heavy Metals in Sediment parameters

Parameter	Method	Method Summary & QC
<b>Heavy Metals (Cd, Cu, Ni, Pb, Zn, Hg, Cr)</b>	X-Ray Fluorescence (XRF)	Sludge samples were air-dried, ground, and analyzed using XRF for elemental composition.
<b>Moisture Content (Water %) / Dry Matter</b>	BS 1377 Part 2: 1990	A known mass of sludge was oven-dried at 105°C to determine moisture content and calculate dry mass.
<b>Nitrogen (Total)</b>	BS 1377 Part 3: 1990	Nitrogen content was determined after digestion, followed by distillation and titration.
<b>Organic Matter</b>	BS 1377 Part 3: 1990	Organic matter was estimated by igniting the dried sample at 440–550°C and measuring mass loss.
<b>pH (Sediment/Sludge)</b>	BS 1377 Part 3: 1990; SMEWW 4500-H+	A sludge-to-water suspension was prepared and pH was measured using a glass electrode.
<b>Phosphorus (Total)</b>	AOAC 965.17	Samples were digested using acid, and phosphorus was measured colorimetrically via molybdovanadate.

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## 5. PRESENTATION AND INTERPRETATION OF RESULTS

This section presents the results of the laboratory analyses conducted on the water, sediment, and sludge samples collected during the field assessment activities. The findings are organized by site, matrix and parameter group. In addition to the current data, historical monitoring information provided by the client has been reviewed to identify trends and patterns.

Based on the requirements for interpretation, test results were compared to best available local, regional and international standards/guidelines. Detailed test reports are available for reference in **Appendix III**.

### 5.1 *Review of Available Data*

The Client provided historical data on the environmental monitoring studies conducted on beach water quality and pond water bodies in Sint Maarten (refer to **Appendix IV**). The main testing agency was identified as Nature Foundation. The studies usually focused on seven sites including: Great Salt Pond, Fresh Pond, Belair Pond, Mullet Pond, Simpson Bay Lagoon, Great Bay Beach, and Kim Sha Beach. Data spanned a period of 2011 to 2022 but there are gaps as monitoring was not conducted continuously or based on a routine schedule.

Table 6 summarizes the data from the studies consistent with the sites included in this baseline environmental monitoring assessment.

The correlation between this historical data provided and this current baseline study is limited given the differences in sample locations and analytical methodology used. However, the historical data does confirm that water quality issues have been an ongoing concern in Sint Maarten, impacting coastal areas, as evidenced by the microbial indicators present in the beaches/bays assessed and levels of nitrates and phosphates.

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Table 6: Summary of Historical Data

Year	Location	Testing Agency & Method	Parameters & Results
2012 to 2018	Great Bay	Nature Foundation	Nitrates: 0.2ppm, Phosphates: 0.2ppm, Nitrogen: <1ppm, DO 7ppm, Faecal Coliform: Absent, pH: 8.0, Temp: 23°C.
	Great Salt Pond	[Lamotte Water Pollution Kit & Oakton	Nitrates: 0.7ppm, Phosphates: 0.5ppm, Nitrogen: 6ppm, DO 5.2ppm, Faecal Coliform: Present, pH: 6.0, Temp: 27.5°C.
	Fresh Pond	Acord Series pH meter]	Nitrates: 0.4ppm, Phosphates: 0.3ppm, Nitrogen: 1ppm, DO 7ppm, Faecal Coliform: Present, pH: 8.6, Temp: 25.6°C.
2014 to 2019	Simpson Bay Bridge	Nature Foundation	Faecal Coliform: Present
	Cole Bay	[Most Probable	Faecal Coliform: Present
	Kim Shah	Number]	Faecal Coliform: Present
2020	Great Bay Beach	Nature Foundation [US EPA methods]	BOD (ppm): 23 to 42, COD (ppm): 179-187, TN (ppm): 11.2-13.7, TP (ppm): <1, EC: 0-4 CFU/100ml, pH: 8.06 to 8.16, Conductivity: 55600 to 56400, Entero: 24 to 96 CFU/100ml.
2022	Mullet Bay	Nature Foundation	Enterococcus: 3.11 – 82.67 CFU/100ml
	Cupecoy	[Method 160 US EPA]	Enterococcus: 18 – 56 CFU/100ml
	Kim Shah		Enterococcus: 11.33 – 297 CFU/100ml
	Simpson Bay		Enterococcus: 5.11 – 5.67 CFU/100ml
2022	WWTP		N/A

## 5.2 Water Quality Assessment

### 5.2.1 Water Quality Results

Sint Maarten has no local standalone water quality standards; EU/Netherlands values are commonly used as benchmarks. Blue Flag criteria can be used for recreational water but tend to be more stringent for E. coli and enterococci than EU "excellent" thresholds. Generally, physicochemical parameters (e.g. DO, BOD, COD, nutrients) typically lack recreational standards; these serve as ecological indicators rather than immediate health thresholds.

The water quality criteria applied to interpret results are summarized in Table 7 (Beach/Recreational Bathing Water) and Table 8 (Inland Surface Waters). The values **bolded** were selected for use in data interpretation and were selected based on their relevance and/or stringency.

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Table 7: Beach (Recreational/Bathing) Water Quality Criteria

Parameter	Local: Sint Maarten/Netherlands (EU Directive & Water Framework Directive) <sup>12,13,</sup>	Regional: (CARPHA, CEHI, PAHO) <sup>14</sup>	International: (EPA, WHO, Blue Flag) <sup>15,16,17</sup>
<b>Faecal Coliforms</b>	Not used in latest EU criteria	Not used as recreational criterion since replaced by E. coli/enterococci.	Not used
<b>E. coli</b>	<b>Excellent: ≤250 CFU/100 mL</b> (geomean) Sufficient: ≤ 500 CFU/100 mL	No numeric limit; studies rely on EPA thresholds	BF: ≤250 CFU/100 mL (95%)
<b>Enterococcus sp.</b>	<b>Excellent: ≤100 CFU/100 mL</b> (geomean) Sufficient: ≤ 200 CFU/100 mL	No numeric limit; local agencies reference EPA/WHO values.	BF: ≤100 CFU/100 mL (95%)
<b>pH</b>	<b>Natural range (usually 6.5–8.5)</b>	6.5–8.5	EPA: 6.5–9, BF: Natural range (typically 6.5–8.5)
<b>Water Temperature (°C)</b>	Monitor only – no fixed limits	Monitored only, with no numeric limits	Not specified
<b>Dissolved Oxygen (DO)</b>	Not specified	>5 mg/L	<b>&gt;5 mg/L</b>
<b>Electrical Conductivity</b>	Not regulated	No numeric guideline	Not specified
<b>Total Nitrogen</b>	WFD: As inorganic N, good ≤ 0.25 mg/L	Nitrate <10 mg/L	EPA: <b>~1.5 mg/L total N</b>
<b>Total Suspended Solids</b>	Not specified	No numeric guidance	EPA: target <b>25–30 mg/L</b>
<b>Total Phosphorus</b>	WFD: High ≤ 0.025 MRP mg P/L; good ≤ 0.035 MRP mg P/L (mean)	Not specified	EPA: <b>≤ 0.1 mg/L</b>
<b>COD</b>	Not regulated	Not specified	Not specified
<b>BOD5</b>	WFD: Moderate <b>≤ 4.0 mg/L</b> (95th percentile)	Not specified	Not specified
<b>Oil &amp; Grease</b>	Not regulated	Not specified	EPA: No visible oil sheen or odor, <b>≤ 10 mg/L</b>

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Table 8: Inland Surface (Canals, Ponds, Drains) Water Quality Criteria

Parameter	Local / Netherlands (WFD - Desired "Good/Ecological" Status) <sup>18</sup>	Regional (CARPHA/CATS & CEHI/PAHO) <sup>14</sup>	International (EPA AWQS) <sup>19</sup>
<b>Faecal Coliforms</b>	<b>&lt;500 CFU/100 mL</b>	Not specified	No current numeric value. replaced by E. coli/ Enterococcus
<b>E. coli</b>	≤500 CFU/100 mL	Not specified	Geomean ≤ <b>126 CFU/100 mL</b> , Single sample ≤ 410 CFU
<b>Enterococcus sp.</b>	≤200 CFU/100 mL	Not specified	Geomean ≤ <b>33 CFU/100 mL</b> , Single sample ≤ 61 CFU
<b>pH</b>	<b>6.5–9.0</b>	6.5–8.5 (PAHO)	6.5–9
<b>Water Temperature (°C)</b>	No direct limit, monitored	No limit, monitored	No limit, monitored
<b>Dissolved Oxygen (DO)</b>	≥6 mg/L	>5 mg/L	<b>≥5 mg/L</b>
<b>Electrical Conductivity</b>	< 1,000 µS/cm	Not specified	WHO: <b>&lt;400 µS/cm</b> typical freshwater
<b>Total Nitrogen</b>	≤2 mg/L	<10 mg/L nitrate (Dominica CATS)	<b>≤1.5 mg/L</b> (total N)
<b>Total Suspended Solids (TSS)</b>	≤50 mg/L	Not specified	<b>≤25–30 mg/L</b>
<b>Total Phosphorus</b>	≤0.15 mg/L	Not specified	<b>≤0.1 mg/L</b>
<b>COD</b>	≤125 mg/L	Not specified	<b>≤50 mg/L</b> (EPA guidance)
<b>BOD5</b>	≤7 mg/L	Not specified	<b>≤3–5 mg/L</b>
<b>Oil &amp; Grease</b>	No sheen, <10 mg/L	Not specified	<b>&lt;10 mg/L</b> , no sheen
<b>PCBs</b>	≤ 0.0005 mg/L (sum of priority PCBs)	Not specified	Human Health (Water + Fish): <b>0.064 µg/L</b>

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### 5.2.1.1 Great Salt Pond

For Events 1B and 3 at Great Salt Pond, the following samples were collected:

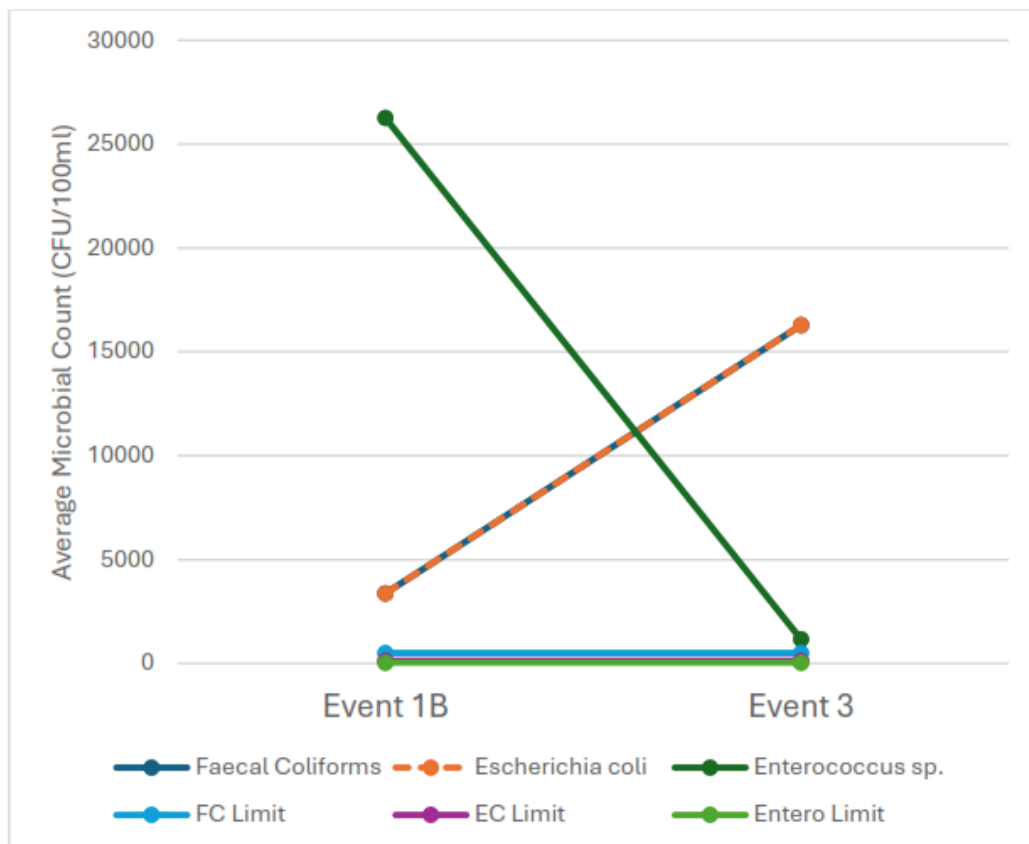
- Five discrete grab samples for Bacteria in Water testing and
- Two composite samples from ten locations each – East and West of Pond Island – for analysis of Nutrients & Pollutants.

Microbial Indicators:

Figure 1 shows the average concentration of the key microbial indicators for both Events. All microbial counts consistently and significantly exceeded the acceptable limits for Faecal Coliforms (<400 CFU/100ml), E.coli ( $\leq 126$  CFU/100ml) and Enterococcus ( $\leq 33$  CFU/100ml).

Generally, the average Enterococcus sp. level (13,715 CFU/100ml) was higher than the average Coliform group (9,826 CFU/100ml). Between Event 1B and Event 3, Coliform levels increased, whereas Enterococcus levels exhibited the opposite trend, showing a decrease.

Figure 1: Average concentration of key microbial indicators at Great Salt Pond, Events 1B and 3.

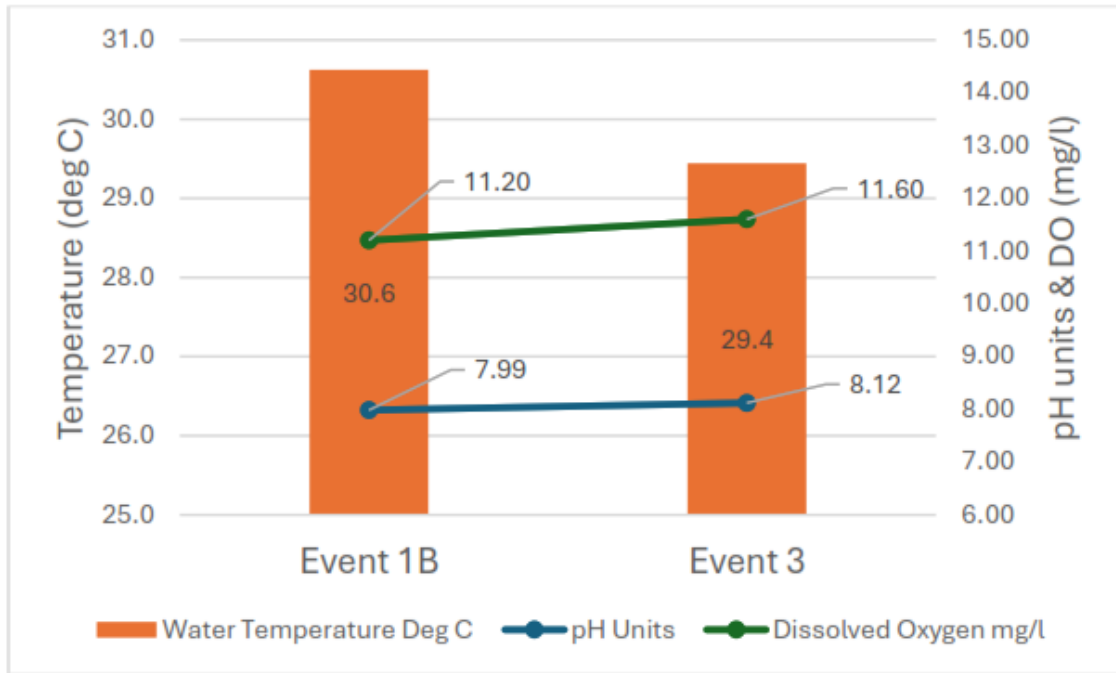


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Field parameters:

All pH and dissolved oxygen readings were within acceptable limits of pH 6.5-9 and DO  $\geq 5$ mg/l. Temperatures recorded were consistent for such water bodies in the region and did not show any abnormalities.

Figure 2: Average field measurements recorded at Great Salt Pond, Events 1B and 3.



Nutrients & Pollutants:

All parameters, with the exception of oil & grease, significantly exceeded acceptable levels. High levels of the red-listed parameters in Table 9 generally indicate poor water quality and can point to pollution, nutrient loading, or organic contamination.

Table 9: Results for physicochemical parameters at Great Salt Pond, Events 1B and 3.

	Electrical Conductivity (uScm-1)	Total Nitrogen (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorous (mg/l)	Chemical Oxygen Demand (mg/l)	Biological Oxygen Demand (mg/l)	Oil & Grease (mg/l)
Event 1B: GSP-C1-NP	19,120	19.45	34	2.96	828.5	201.1	1.43
Event 1B: GSP-C2-NP	14,017	21.18	52.67	2.65	487.5	63.3	1.07
Event 3: GSP-C1-NP	9,440	22.8	134.29	1.92	740	17.4	4
Event 3: GSP-C2-NP	9,239	20.8	101.43	1.7	407.5	19.5	4
<b>Average levels:</b>	<b>12,954</b>	<b>21.06</b>	<b>80.60</b>	<b>2.31</b>	<b>615.88</b>	<b>75.33</b>	<b>2.63</b>
<b>Acceptable levels:</b>	<b>&lt;400</b>	<b><math>\leq 1.5</math></b>	<b><math>\leq 25-30</math></b>	<b>&lt;0.1</b>	<b><math>\leq 50</math></b>	<b><math>\leq 3-5</math></b>	<b>&lt;10</b>

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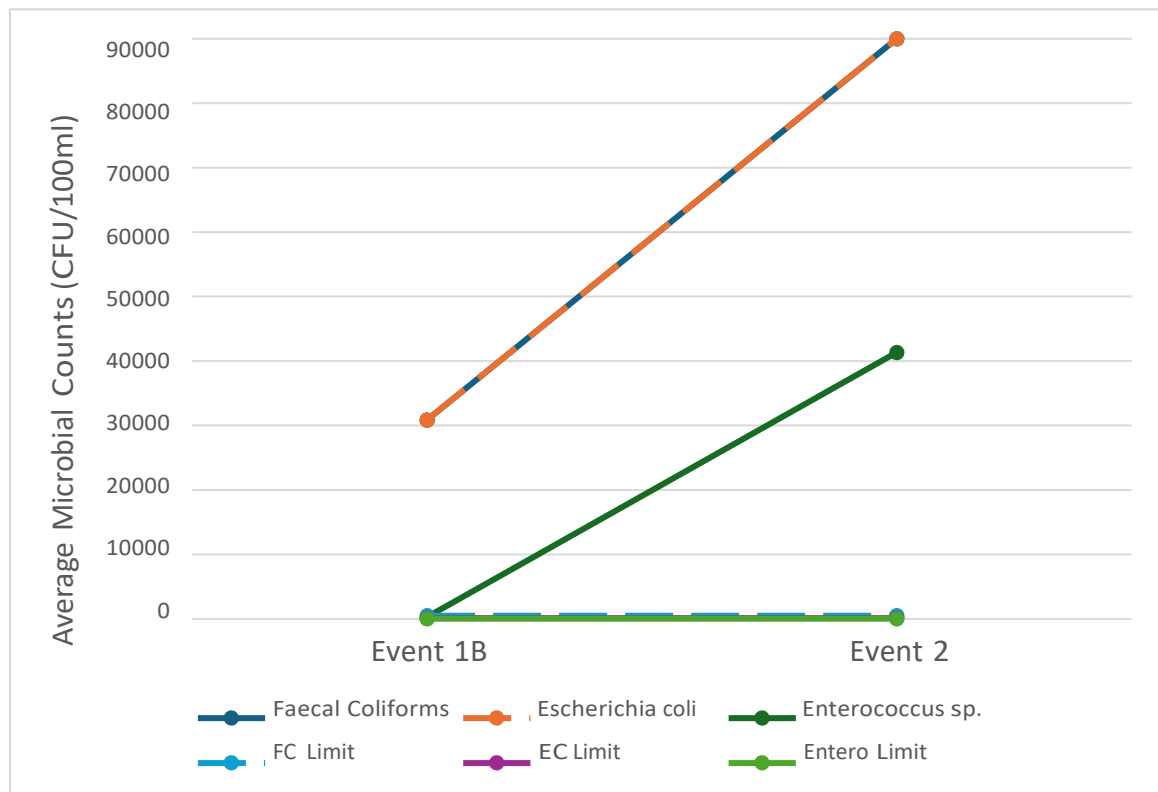
### 5.2.1.2 Little Bay Pond

For Events 1B and 2 at Little Bay Pond, the samples included: three discrete grab samples for Bacteria in Water testing and one composite sample from the same three locations for Nutrients & Pollutants testing.

#### Microbial Indicators:

Figure 3 shows the average concentration of the key microbial indicators for both Events. All microbial counts significantly exceeded the acceptable limits, with average Coliform group levels ranging from 30,867 to 90,000 CFU/100ml and Enterococcus levels ranging from 273 to 41,333 CFU/100ml. Generally, the average Coliform counts were greater than the Enterococcus counts, and in both cases, there was an increase from Event 1B to Event 2.

Figure 3: Average concentration of key microbial indicators at Little Bay Pond, Events 1B and 2.

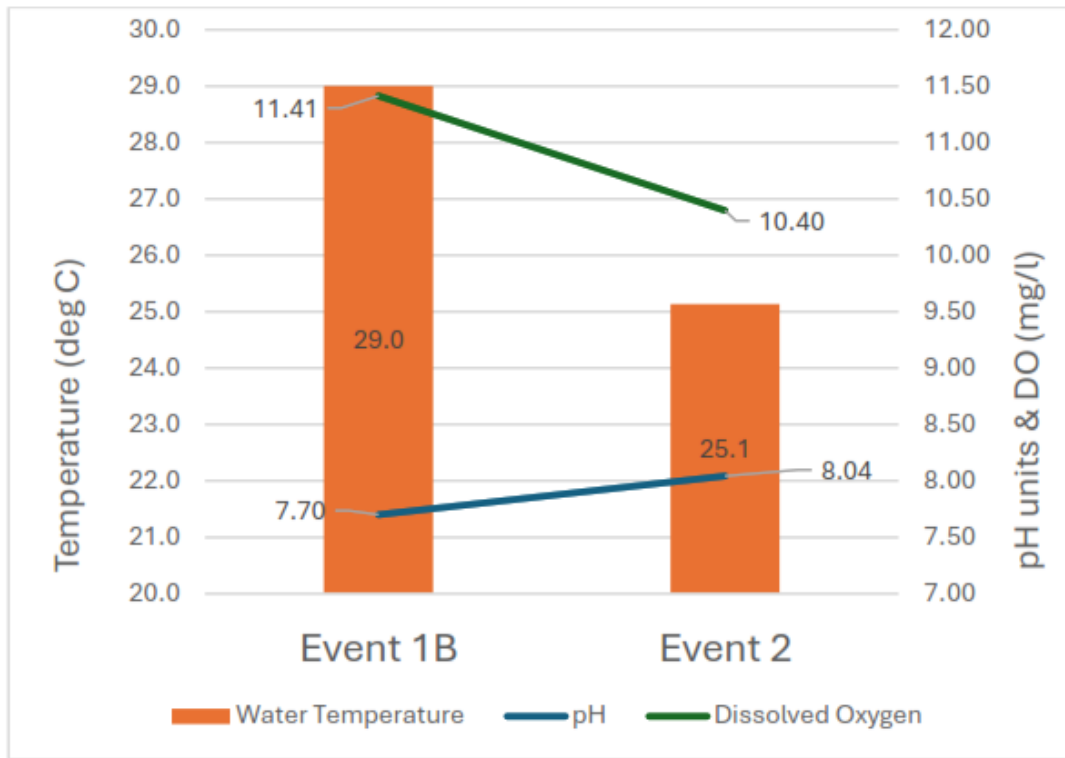


#### Field parameters:

Similar to the Great Salt Pond, all pH and dissolved oxygen readings were within acceptable limits of pH 6.5-9 and DO  $\geq$ 5mg/l. Temperatures recorded were consistent for such water bodies in the region and did not show any abnormalities.

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Figure 4: Average field measurements recorded at Little Bay Pond, Events 1B and 2



Nutrients & Pollutants:

All parameters exceeded the acceptable limits, with the exception of Total Suspended Solids and Oil & Grease. Notably, the levels of all parameters increased from Event 1B to Event 3.

Table 10: Results for physicochemical parameters at Little Bay Pond, Events 1B and 2.

	Electrical Conductivity (uScm-1)	Total Nitrogen (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorous (mg/l)	Chemical Oxygen Demand (mg/l)	Biological Oxygen Demand (mg/l)	Oil & Grease (mg/l)
Event 1B: LP-C1-NP	2,158	5.457	18.67	2.91	70.1	12.9	1.16
Event 3: LP-C1-NP	3,048	21.4	17	6.49	98.05	17.5	1.5
<b>Average Levels</b>	<b>2,603</b>	<b>13.43</b>	<b>17.84</b>	<b>4.7</b>	<b>84.08</b>	<b>15.2</b>	<b>1.33</b>
<b>Acceptable Levels</b>	<b>&lt;400</b>	<b>≤1.5</b>	<b>≤25-30</b>	<b>&lt;0.1</b>	<b>≤50</b>	<b>≤3-5</b>	<b>&lt;10</b>

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### 5.2.1.3 Fresh Pond

Monitoring of Fresh Pond was conducted over all Events:

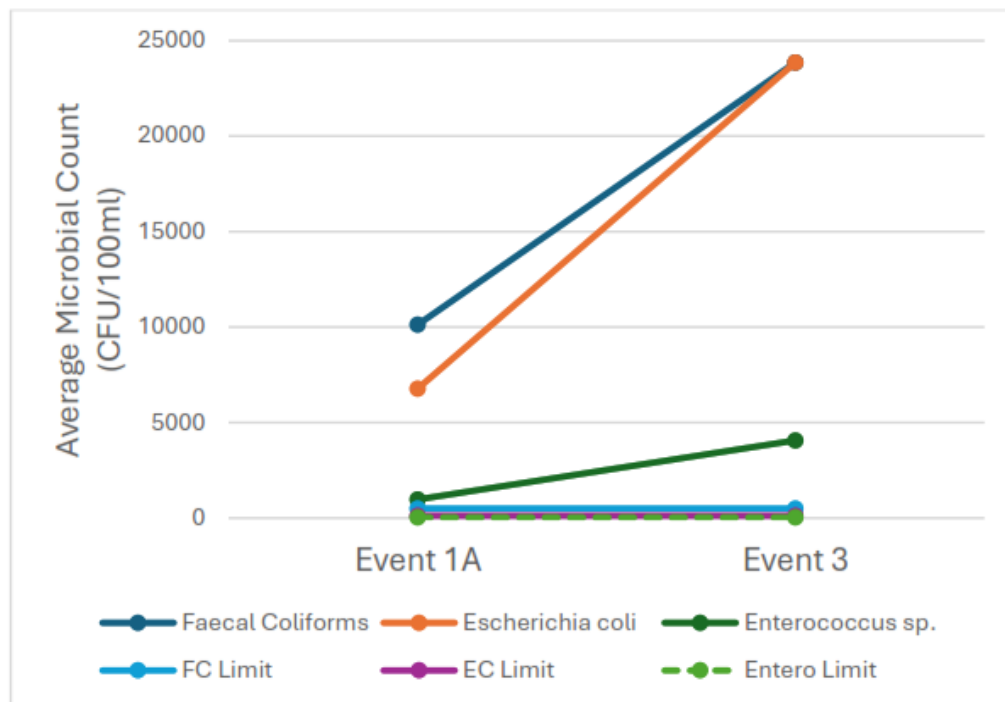
- Events 1A and 3: three grabs and one composite sample,
- Events 2 and 4: one composite sample.

Grab samples were analysed for Bacteria in Water suite and the composite samples were tested for Nutrients & Pollutants (including PCBs).

Microbial Indicators:

Figure 5 shows the average concentration of the key microbial indicators for both Events. All microbial counts significantly exceeded the acceptable limits, with average Faecal Coliform levels ranging from 10,123 to 23,857 CFU/100ml and Enterococcus levels ranging from 973 to 4,067 CFU/100ml. Generally, the average Coliform counts were greater than the Enterococcus counts, and in both cases, there was an increase from Event 1A to Event 3.

Figure 5: Average concentration of key microbial indicators at Fresh Pond, Events 1A and 3.

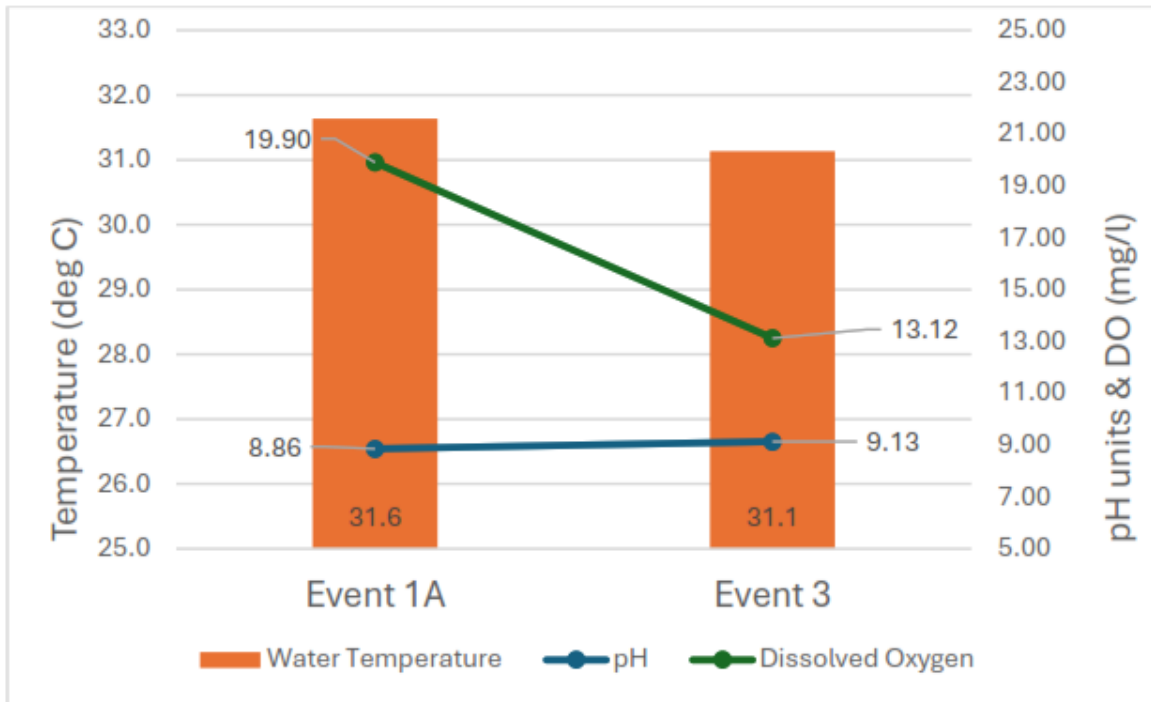


#### Field parameters:

All pH and dissolved oxygen readings were within acceptable limits of pH 6.5-9 and DO >5mg/l. Temperatures recorded were as expected for this type of water body and for the time of day measured.

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Figure 6: Average field measurements recorded at Little Bay Pond, Events 1B and 2.



Nutrients & Pollutants:

All parameters exceeded the acceptable limits, with the exception of Oil & Grease. There were no discernible trends in pollutant levels from Event to Event.

Test result for the Event 2 PCB sample is not available, as the glass sample bottles broke during transit to the outsourced US-based laboratory. Two out of the three data sets for PCB analysis are compliant (i.e. within <0.064 µg/L). The result <0.065 µg/L exceeds the target screening level of 0.064 µg/L. Due to the method detection limit being higher than the guideline, compliance cannot be confirmed. A more sensitive analytical method is recommended for more conclusive determination.

Table 11: Results for physicochemical parameters at Little Bay Pond, Events 1B to 4.

	Electrical Conductivity (uScm-1)	Total Nitrogen (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorous (mg/l)	Chemical Oxygen Demand (mg/l)	Biological Oxygen Demand (mg/l)	Oil & Grease (mg/l)	PCB (µg/l)
Event 1B	2,158	5.457	54.67	2.91	70.1	48.2	<0.2	<0.053
Event 2	1,038	3.33	57.33	2.98	79.15	16.3	1.43	Not
Event 3	938	26.5	60	3.05	86	24	3.5	<0.054
Event 4	1,640	19.25	84.83	4.15	113.5	19.7	1.3	<0.065
<b>Average Levels</b>	<b>1443.5</b>	<b>13.63</b>	<b>64.21</b>	<b>3.27</b>	<b>87.19</b>	<b>27.05</b>	<b>1.56</b>	<b>&lt;0.057</b>
<b>Acceptable Levels</b>	<b>&lt;400</b>	<b>&lt;1.5</b>	<b>&lt;25-30</b>	<b>&lt;0.1</b>	<b>&lt;50</b>	<b>&lt;3-5</b>	<b>&lt;10</b>	<b>&lt; 0.064</b>

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### 5.2.1.4 Great Bay Beach

Five discrete grab samples were collected at Great Bay Beach during each of the four Events for Bacteria in Water testing. In addition, one composite sample (constituted from 10 separate sub-locations) was taken in Event 1B and Event 2 for analysis of Nutrients & Pollutants.

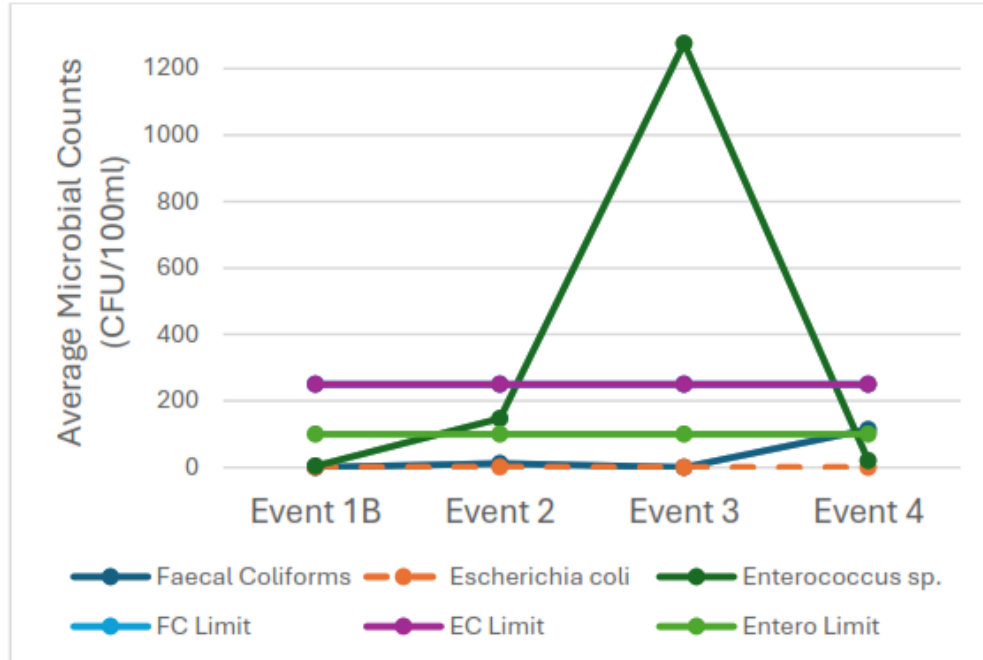
#### Microbial Indicators:

Figure 7 shows the average concentrations of the key microbial indicators over each Event. E.coli levels were consistently below the acceptable level of 250 CFU/100ml in all Events. Out of the 20 data sets, only one grab sample exceeded the Coliform limit (E.coli). This was Event 4: GBB-G1-BW with a Faecal Coliform Count of 259 CFU/100ml.

Generally, Enterococcus sp. was the most predominant microbial indicator, with concentrations exceeding the acceptable limit of 100 CFU/100ml during the following events:

- Event 2 – Grab 2 (498 CFU/100ml) and Grab 3 (127 CFU/100ml),
- Event 3 – All Grabs with levels ranging from 152 to 2,200 CFU/100ml.

Figure 7: Average concentrations of key microbial indicators at Great Bay Beach, Events 1-4

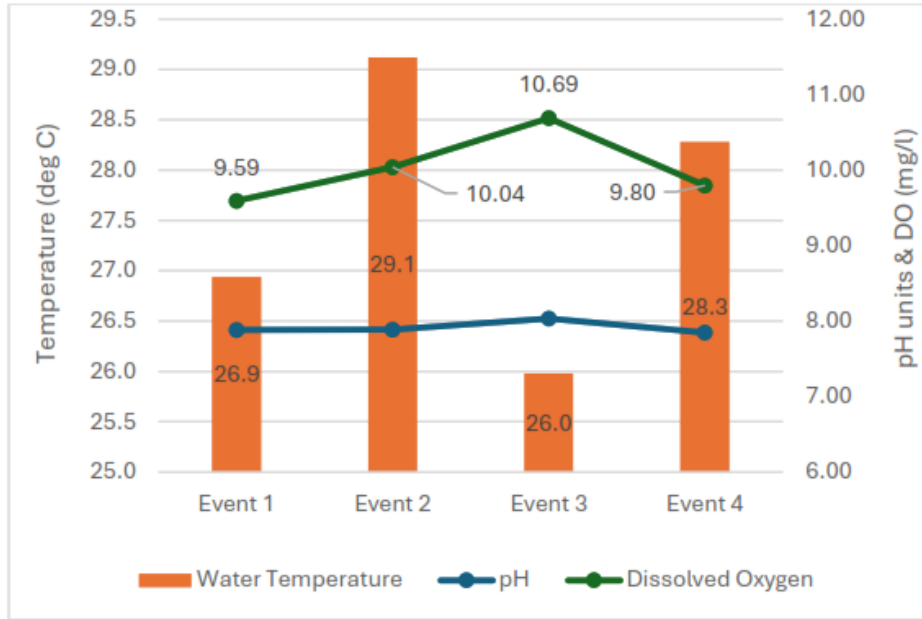


#### Field parameters:

All pH and dissolved oxygen readings were within acceptable limits of pH 6.5-8.5 and DO >5mg/l. Measured temperatures were consistent with typical ambient conditions for the region.

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Figure 8: Average field measurements recorded at Great Bay Beach, Events 1-4



Nutrients & Pollutants:

All parameters were within the specified acceptable limits, with the exception of the following:

- Event 1B and 2: Both samples for total nitrogen (3.361 to 6.73 mg/l) and
- Event 2: TSS measuring at 88 mg/l.

The measured BOD concentration of <6 mg/l exceeds the recommended threshold of ≤4 mg/l, suggesting a moderate level of organic pollution. While the result is expressed as a non-detect above a certain threshold, it still indicates potential oxygen depletion concerns.

Table 12: Results for physicochemical parameters at Great Bay Beach, Events 1B to 2.

	Electrical Conductivity (uScm-1)	Total Nitrogen (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorous (mg/l)	Chemical Oxygen Demand (mg/l)	Biological Oxygen Demand (mg/l)	Oil & Grease (mg/l)
Event 1B: GBB-C1-NP	44,396	3.361	20	<0.10	254	<6	0.7
Event 2: GBB-C1-NP	44,955	6.73	88	< 0.10	1811	<6	2
<b>Average Levels</b>	44,675.5	<b>5.05</b>	<b>54</b>	<0.10	1032.5	<6	1.35
<b>Acceptable Levels</b>	<b>Not specified</b>	<b>≤1.5</b>	<b>≤25-30</b>	<b>≤0.1</b>	<b>Not specified</b>	<b>≤4</b>	<b>≤10</b>

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### 5.2.1.5 Divi Little Bay

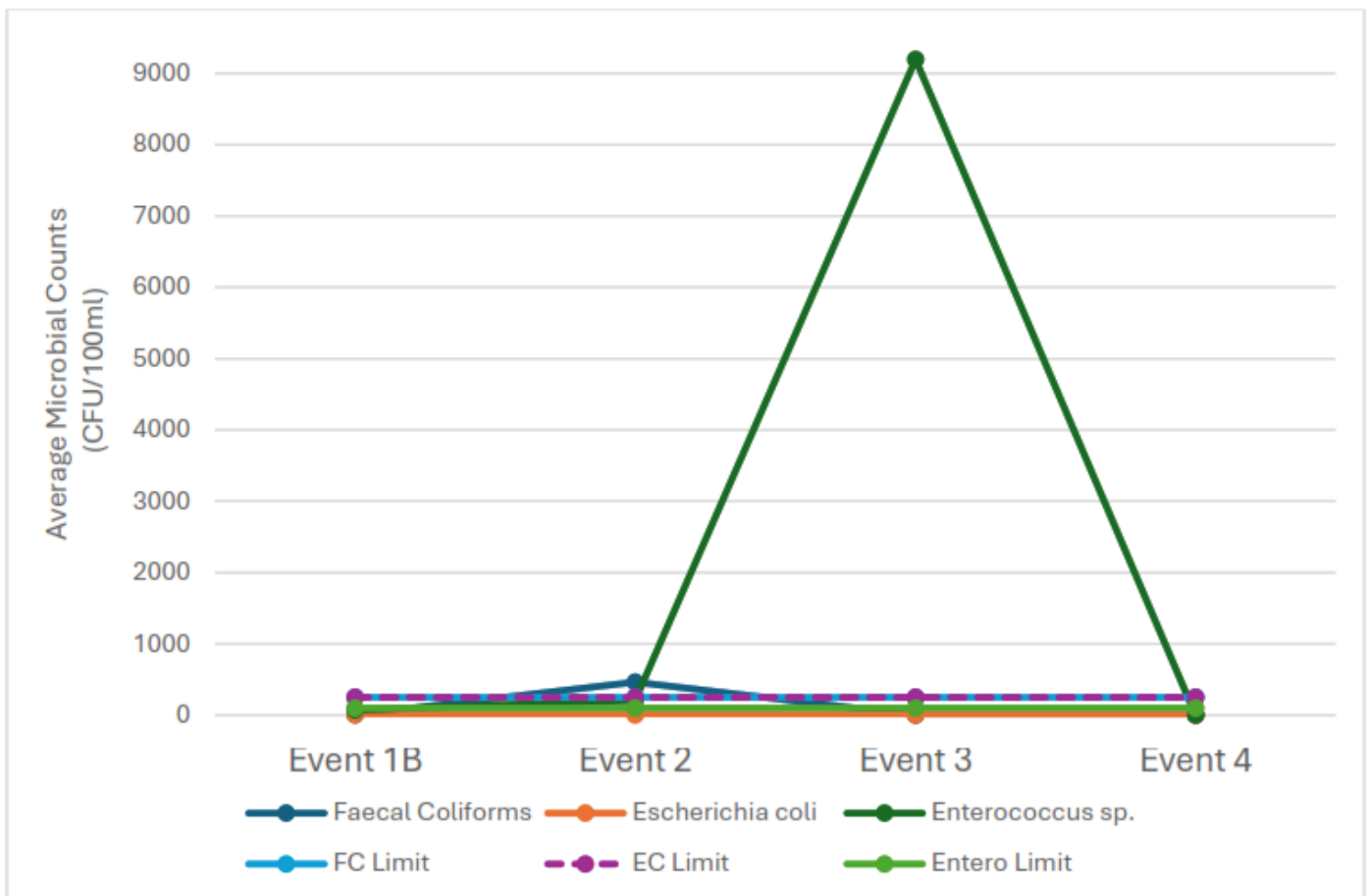
At Divi Little Bay, three discrete grab samples were collected during each of the four Events for Bacteria in Water analyses. In addition, one composite sample prepared from 5 sub-locations was taken in Event 1B and Event 3 for analysis of Nutrients & Pollutants.

#### Microbial Indicators:

Elevated Faecal Coliform levels were detected in 2/3 grabs in Event 2 (average: 464 CFU/100ml); however, these did not confirm to be E.coli at levels above the acceptable limit (E.coli:  $\leq 250$  CFU/100ml). E.coli was within limit for all samples, with levels ranging from Not detected to 10 CFU/100ml.

Enterococcus was the primary indicator detected, with elevated levels in Event 2 (average: 211 CFU/100ml) and Event 4 (average: 9,125 CFU/100ml).

Figure 9: Average concentrations of key microbial indicators at Divi Little Bay, Events 1-4

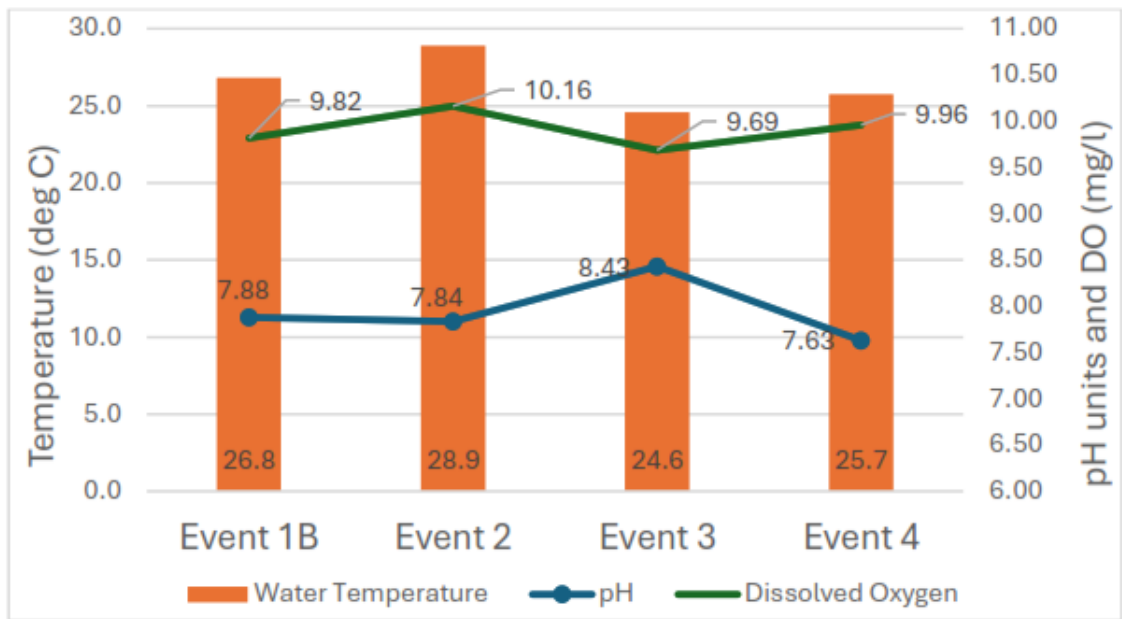


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**Field parameters:**

All field readings were well within acceptable limits, except for one pH reading; Event 3: DLB-G2-BW pH 8.63.

Figure 10: Average field measurements recorded at Great Bay Beach, Events 1-4



**Nutrients & Pollutants:**

All parameters were within the specified acceptable limits, except Total Nitrogen (average 5.61 mg/l) and Total Suspended Solids (58.17 mg/l).

The measured BOD concentration of <6 mg/l exceeds the recommended threshold of ≤4 mg/l, indicating a minimal, potential moderate level of organic pollution.

Table 13: Results for physicochemical parameters at Great Bay Beach, Events 1B to 2.

	Electrical Conductivity (uScm-1)	Total Nitrogen (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorous (mg/l)	Chemical Oxygen Demand (mg/l)	Biological Oxygen Demand (mg/l)	Oil & Grease (mg/l)
Event 1B: DLB-C1-NP	44,275.00	2.70	17.33	<0.10	243.00	<6	0.90
Event 3: DLB-C1-NP	44,989.00	8.53	99.00	<0.10	<30	<6	1.00
<b>Average Levels</b>	<b>44,632.00</b>	<b>5.61</b>	<b>58.17</b>	<b>&lt;0.10</b>	<b>136.50</b>	<b>&lt;6</b>	<b>0.95</b>
<b>Acceptable Levels</b>	<b>Not specified</b>	<b>≤1.5</b>	<b>≤25-30</b>	<b>≤0.1</b>	<b>Not specified</b>	<b>≤4</b>	<b>≤10</b>

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### 5.2.1.6 Rolandus Canal

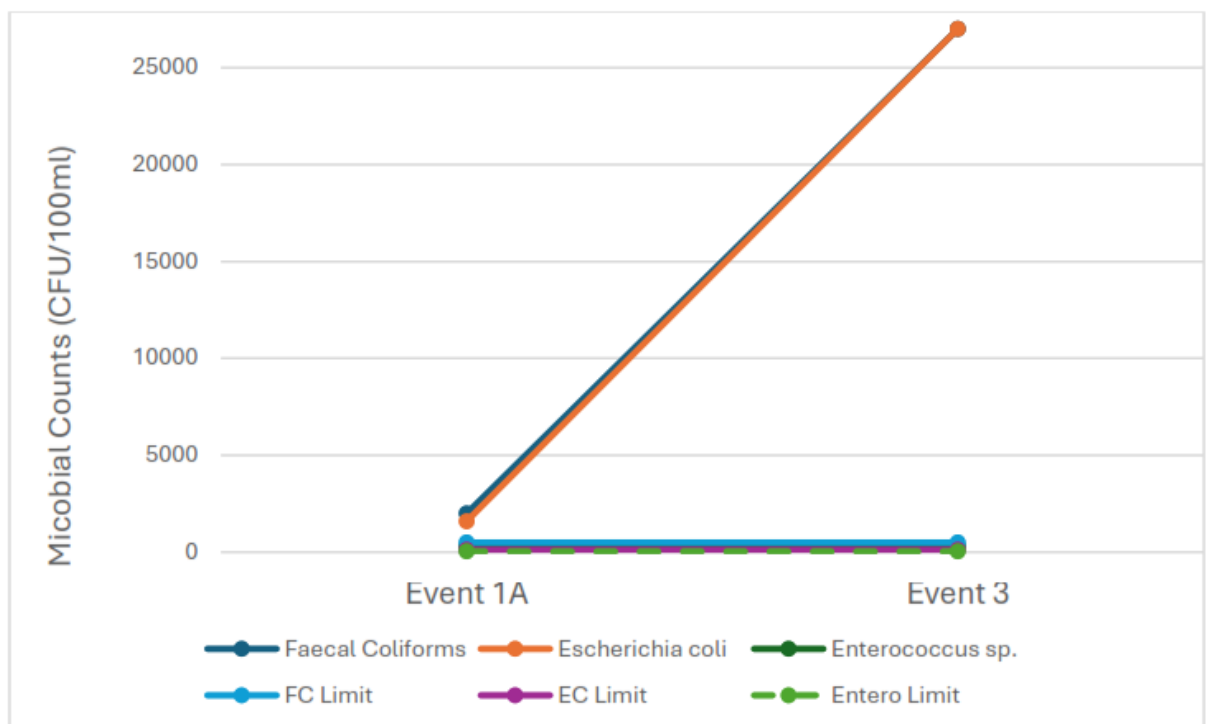
Two grab samples were collected from Rolandus Canal; one during Event 1A and the other in Event 3. Both samples were tested for the Bacteria in Water as well as Nutrients & Pollutants.

#### Microbial Indicators:

All bacterial types significantly exceeded the acceptable limits for inland surface waters with counts being higher in Event 3 than Event 1A:

- Faecal Coliforms (spec: <500 CFU/100ml) ranged from 1,990 to 27,000 CFU/100ml,
- E.coli (spec: <126 CFU/100ml) ranged from 1,592 to 27,000 CFU/100ml, and
- Enterococcus (spec: <33 CFU/100ml) ranged from 304 to 310 CFU/100ml.

Figure 11: Microbial Counts recovered at Rolandus Canal during Events 1A and 3.

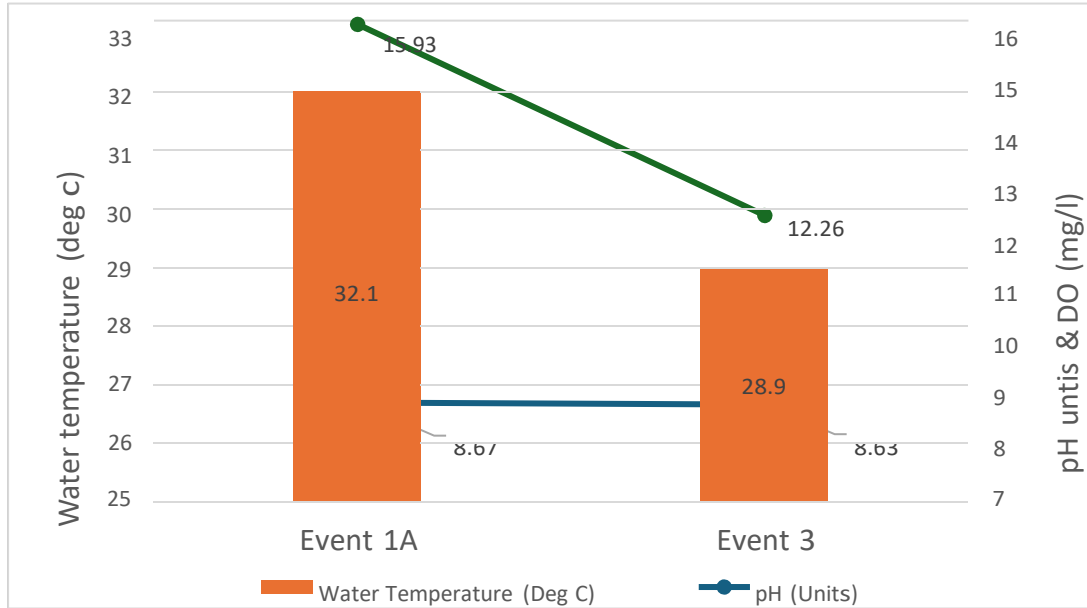


#### Field Measurements:

Both pH and Dissolved Oxygen readings were within acceptable limits. Water temperature did not deviate from values characteristic of similar surface water bodies in the area.

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Figure 12: Field measurements recorded at Rolandus Canal, Events 1A and 3.



Nutrients & Pollutants:

The average results for all parameters exceeded the acceptable limits, with the exception of Oil & Grease. There was no major trend noted in pollutant levels between Events.

Table 14: Results for physicochemical parameters at Rolandus Canal, Events 1A and 3.

	Electrical Conductivity (uScm-1)	Total Nitrogen (mg/l)	Total Suspended Solids (mg/l)	Total Phosphorous (mg/l)	Chemical Oxygen Demand (mg/l)	Biological Oxygen Demand (mg/l)	Oil & Grease (mg/l)
Event 1A	738	2.613	40.67	0.78	70.1	45.2	0.22
Event 3	2,698	1.06	42	0.618	164	24	3.5
<b>Average Levels</b>	<b>1,718</b>	<b>1.84</b>	<b>41.34</b>	<b>0.699</b>	<b>117.05</b>	<b>34.6</b>	<b>1.86</b>
<b>Acceptable Levels</b>	<b>&lt;400</b>	<b>≤1.5</b>	<b>≤25-30</b>	<b>&lt;0.1</b>	<b>≤50</b>	<b>≤3-5</b>	<b>&lt;10</b>

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## 5.2.2 Comparative Analysis

### 5.2.2.1 Parameter-Specific Results

This section provides a parameter-specific overview of the test results obtained. The interpretation considers observed concentrations, their environmental significance and potential implications for public health.

#### Microbiological Indicators

Faecal Coliforms are bacterial indicators of contamination by faecal matter, suggesting the potential presence of harmful pathogens from human and/or animal waste. *Escherichia coli* (*E.coli*) is a specific type of faecal coliform, that serves as a strong indicator of recent faecal pollution and possible presence of disease-causing organisms. *Enterococcus* spp. is another bacterial indicator group but with a higher tolerance for marine environments than *E. coli*. It is a reliable indicator of faecal contamination in saltwater, linked to gastrointestinal illness risk in swimmers.

Most areas assessed showed gross microbial contamination, in particular Great Salt Pond, Little Bay Pond, Fresh Pond and Rolandus Canal. The highest concentration of the Coliform group was detected in Little Bay Pond ( $>6.0 \times 10^4$  CFU/100ml) and Fresh Pond (570 – 54,000 CFU/100ml).

Generally, *Enterococcus* sp. was most predominant in the marine and saline type environments such as Great Salt Pond, Little Bay Pond, Great Bay Beach and Divi Little Bay. This is expected given their tolerance for higher salinity levels than the Coliform group. The highest concentration of the *Enterococcus* sp. was detected in Great Salt Pond ( $>6.0 \times 10^4$  CFU/100ml) and Little Bay Pond (200 – 51,000 CFU/100ml).

#### Physicochemical Parameters

Testing for parameters such as pH, dissolved oxygen (DO), electrical conductivity, and temperature are essential to assess the overall health and balance of aquatic environments. pH indicates the water's acidity or alkalinity, which can affect the toxicity of substances and the wellbeing of aquatic organisms. DO levels are critical for the survival of fish and other aerobic organisms, and low values may signal pollution. Electrical conductivity reveals the presence of dissolved ions and salts, often pointing to runoff or industrial discharge. Temperature influences chemical reactions, biological processes, and oxygen solubility, making it a key parameter in understanding ecosystem stability and water quality.

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For each Event, all field readings were well within acceptable limits, except for one pH reading (Event 3: Divi Little Bay Grab 2-BW pH 8.63) which was just above the limit of pH 6.5 to 8.5.

### Nutrients and Pollutants

Monitoring of the following parameters helps identify contamination sources and support efforts to protect water quality and ecosystem integrity:

- High TSS can reduce light penetration and harm aquatic life by clogging fish gills and smothering habitats.
- Elevated TN and TP contribute to nutrient pollution, leading to algal blooms and oxygen depletion.
- BOD and COD indicate the amount of organic matter in the water; high values suggest excessive pollution that can deplete oxygen and harm aquatic organisms.
- PCBs are toxic and persistent industrial chemicals, that pose serious risks to both wildlife and human health through bioaccumulation and long-term exposure.

Generally, Oil and Grease was the only parameter in which average results were consistently within acceptable limit for all sites tested. All other parameters, most importantly, BOD, COD, TN and TP exceeded acceptable levels. Data indicates high pollutant loading levels in the majority of water bodies assessed, sources which include urban and storm water runoff, landfill leachate, inadequate waste management and industrial discharge.

#### 5.2.2.2 Spatial Trends and Site Comparisons

Based on the site visit observations and the known hydrological network, there is a relationship among the urban drainage systems (Rolandus Canal), inland water bodies (Ponds), and coastal environments (Beaches).

Great Salt Pond serves as the primary stormwater retention basin and receives significant runoff from surrounding urban areas, including untreated domestic wastewater, sediment, and leachate from the adjacent landfill. This accounts for why the Great Salt Pond had the highest results for the parameters tested.

The Rolandus Canal is connected to the Great Salt Pond and acts as a channel directing overflow towards Great Bay. This explains the similar, though less pronounced, exceedances in test results compared to those observed in Great Salt Pond.

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Fresh Pond and Little Bay Pond both receive stormwater inflows and urban discharges from their respective catchments. Although these water bodies do not exhibit direct hydraulic connectivity, their similar exposure to urban runoff and stormwater inputs may result in comparable contaminant profiles. This parallel in pollutant sources likely accounts for the observed similarities in contamination levels between Fresh Pond and Little Bay Pond.

The water quality at Great Bay Beach is affected by land use activities at the coast as well as the pollutant loading received from the outflow of the Rolandus Canal, particularly following intense rainfall events. Nearby Divi Little Bay, while more isolated, may be affected by marine circulation patterns that redistribute contaminants from Great Bay. Beaches generally have better water quality due to greater water circulation patterns, lower pollutant loading, as well as larger volume and dilution capacity.

#### 5.2.2.3 Temporal Trends Across Sampling Events

Varying local weather conditions were noted during the four events:

- Event 1A: Sunny conditions. No rainfall occurred.
- Event 1B: Rain fell the night before sampling and on the morning of.
- Event 2: Rain fell just prior to sample collection.
- Event 3: Sunny conditions. No rainfall occurred.
- Event 4: Rain fell just prior to sample collection.

No consistent trends were observed across events for specific parameters or locations, which may be attributed to delayed rainfall influence and dilution effects. Furthermore, the practice of combining multiple grab samples into composite samples may have obscured time-based variability.

### 5.3 Sediment Quality Assessment

Sint Maarten does not have local sediment quality standards. In the absence of formal national sediment quality standards in Sint Maarten, the following internationally accepted guidelines were used to assess sediment contaminant concentrations:

1. MacDonald TEC/PEC thresholds for trace metals to indicate potential for ecological effects.
2. ANZECC Default Guideline Values for marine and estuarine sediments.

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3. A qualitative screening based on the Netherlands' sediment assessment framework, to evaluate potential impact on ecological and chemical status under principles of the EU Water Framework Directive.

For the Fresh Pond composite sample (FP-C1-HM), the cadmium level (1.83 mg/kg) and zinc level (129 mg/kg), though still below PEC, exceeded the conservative TEC equivalent. This suggests potential ecological impairment and warrants further evaluation and risk analysis.

In the Little Bay Pond sample LP-C1-HM, cadmium (1.55 mg/kg) slightly exceeded the lower threshold; other metals were within low-to-moderate risk levels. Likely requires follow-up but poses minimal immediate risk under Dutch screening.

Zinc in Fresh Pond sample FP-C1-HM was also above TEC but below PEC indicating a low-to-moderate concern.

For Great Salt Pond (GSP-C1-HM) and Great Bay Beach (GBB-C1-HM), all metals measurements were well below concern thresholds. In particular, Great Bay Beach shows very low background levels, indicating a reference-quality site and no likely risk under the Dutch framework.

Cadmium (Cd) and Zinc (Zn) may appear elevated in comparison to other heavy metals due to several possible environmental and anthropogenic reasons:

- Source-Specific Pollution – Cd and Zn are common in urban runoff due to corrosion of galvanized sheets and pipes, batteries, paints, tires, and coatings, Informal disposal or leaching from electronic waste.
- Contaminant fate and transport – Cd and Zn are more mobile in aquatic environments, in comparison to heavier, particle-bound metals like Lead and Chromium.

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Table 15: Sediment analysis tests results and comparative standards/guidelines

HEAVY METALS	TEST RESULTS (mg/kg)				SEDIMENT QUALITY CRITERIA (mg/kg d.w.) <sup>20,21,22</sup>			
	Fresh Pond FP-C1-HM	Little Pond LP-C1-HM	Great Salt Pond GSP-C1-HM	Great Bay Beach GBB-C1-HM	MacDonald TEC	MacDonald PEC	ANZECC DGV-Low	ANZECC GV-High
Cadmium	1.83	1.55	0.86	*<0.10	0.99	4.98	1.5	10
Copper	52.77	29.38	26.10	0.76	31.6	149	65	270
Nickel	6.39	11.76	2.34	0.24	22.7	48.6	21	52
Lead	16.53	3.80	6.99	0.65	35	128	50	220
Zinc	129.22	49.83	66.15	2.73	121	459	200	410
Mercury	0.019	0.0007	0.018	*<0.005	0.18	1.06	0.15	1.0
Chromium	13.83	5.09	4.59	3.39	43.4	111	80	370

NOTES:

**ANZECC** – Australia/New Zealand Environment and Conservation Council default guideline values (DGV) and upper "GV-High" values for sediment protection.

Values above DGV but below GV-High — cause for monitoring.  
 Above GV-High — indicate potential ecotoxicological risk.

**MacDonald et al. (2000)** consensus Sediment Quality Guidelines (SQGs):  
 TEC = threshold effect concentration (below which adverse effects unlikely)  
 PEC = probable effect concentration (above which likely toxic effects requiring action)

- Below TEC / DGV** → likely safe.
- Between TEC & PEC / DGV & GV-High** → caution, monitor trends.
- Above PEC / GV-High** → likely ecological impact, needs intervention.

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### 5.4 Sludge Content Assessment

Representative sludge samples (WWTP-RS1-SLDG) were collected from the A.Th. Illidge Road Wastewater Treatment Plant (WWTP) during Event 2 (2025.05.12) and 4 (2025.06.10). Each sludge sample was subjected to a suite of tests aimed at determining the physical properties, nutrient content, and potential environmental and health risk.

Currently there are no locally available sludge evaluation criteria. For the purposes of this baseline assessment, US EPA 503 was applied as the primary benchmark since it is an internationally recognized and well-defined sludge standard. In addition, supplementary criteria from the European Council and the Canadian Council of Ministers of the Environment (CCME) were included for contextual analysis with respect to agronomic value and environmental safety.

All heavy metals were well below the international regulatory limits outlined in US EPA 503. There were no exceedances were observed for the other parameters compared. pH, Organic Matter, and Nutrients were in normal ranges and do not indicate any concern.

The sludge may be considered suitable for beneficial reuse (e.g., land application) depending on local policy and soil conditions. The Total Phosphorus (TP) and Total Nitrogen (TN) content in fertile agricultural soils can vary widely depending on crop type, soil texture, and climate. General target ranges considered adequate for most agricultural purposes: Total Phosphorus (TP): 300 – 1000 mg/kg and Total Nitrogen (TN): 1000 – 3000 mg/kg.<sup>26</sup>

Table 16: Sludge analysis tests results and comparative standards/guidelines

Parameter	Event 2 (WWTP-RS1-SLDG)	Event 4 (WWTP-RS1-SLDG)	EPA 503 Limit <sup>23</sup>	EU Directive Range <sup>24</sup>	Canada CCME Limit <sup>25</sup>
Dry Matter (%)	23.21	46.34	Not specified	Not specified	Not specified
Water Content (%)	76.68	53.66	Not specified	Not specified	Not specified
Organic Matter (%)	48.80	50.01	Not specified	Not specified	Not specified
pH (units)	7.57	8.78	pH 5.5–9.0 required before land-application	Soil pH ≥5 when applied	5–8 (soil pH range)

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Table 16 continued: Sludge analysis tests results and comparative standards/guidelines

Parameter	Event 2 (WWTP- RS1-SLDG)	Event 4 (WWTP-RS1- SLDG)	EPA 503 Limit <sup>23</sup>	EU Directive Range <sup>24</sup>	Canada CCMELimit <sup>25</sup>
Nitrogen (mg/kg)	1064.72	506.08	Not specified	Minimize nutrient overload	Guidance for agronomic application
Phosphorus (mg/kg)	23.90	9.00	Not specified	Minimize nutrient overload	Guidance for agronomic application
Cadmium (mg/kg)	ND	ND	85	20–40 (soil-based action)	39 (unrestricted use)
Copper (mg/kg)	69	109	4300	1000–1750	1500 (unrestricted use)
Nickel (mg/kg)	ND	ND	420	300–600	420 (unrestricted use)
Lead (mg/kg)	ND	ND	840	750–1200	300 (unrestricted use)
Zinc (mg/kg)	680	907	7500	2500–4500	2800 (unrestricted use)
Mercury (mg/kg)	ND	ND	57	16–25	17 (unrestricted use)
Chromium (mg/kg)	182	87	3000	500–1000	1200 (unrestricted use)

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## 6. CONCLUSION AND RECOMMENDATIONS

This baseline assessment executed over the course of four events [Started: 2025.04.29 & Ended: 2025.06.10] and conducted across selected sites in Sint Maarten has provided a comprehensive overview of the physical, chemical, and microbiological characteristics of both inland and coastal waters, sediment and WWTP sludge.

The water quality results confirmed elevated concentrations of nutrients, suspended solids, and organic matter—particularly in the inland water bodies (Great Salt Pond, Little Bay Pond, Fresh Pond and Rolandus Canal) —indicating anthropogenic pressures such as urban runoff and wastewater discharge. In contrast, beach sites (Great Bay Beach and Divi Little Bay) exhibited generally better water quality, likely due to natural dilution and tidal flushing. Microbial indicators showed varying levels of faecal contamination, with some grab samples exceeding recommended thresholds.

The results of the sediment assessment revealed:

- Fresh Pond – Levels of cadmium and zinc suggest potential ecological impairment, warranting further evaluation and risk analysis.
- Little Bay Pond – Level of cadmium slightly exceeded the lower acceptable threshold but not posing immediate risk.
- Great Salt Pond and Great Bay Beach, all metals measurements were well below concern thresholds.

The sludge assessment indicated that the sludge may be considered suitable for beneficial reuse. All heavy metals were well below the international regulatory limits outlined in US EPA 503. No exceedances were observed for the other parameters; pH, Organic Matter, and Nutrients were detected in normal ranges.

These findings establish a critical reference point for ongoing monitoring and management, highlighting the need for targeted interventions to improve water quality, especially in enclosed and high-risk areas such as the Great Salt Pond and surrounding canals. The following are some recommendations provided for consideration:

### 1. Expansion of Assessment Scope

To gain a more comprehensive understanding of water conditions, sediment quality and sludge characteristics, it is recommended that future assessments expand the number of sampling sites and frequency of sampling events.

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Expand the current water quality monitoring efforts to cover more geographic areas, including under-sampled or high-risk zones. In addition, the inclusion of seasonal variability through sampling in both wet and dry seasons will provide a more comprehensive picture of pollutant fluctuations.

## **2. Blue Flag Certification Pursuit**

Pursuing Blue Flag certification for selected beaches can enhance Sint Maarten's global recognition. This international eco-label aligns with NRPB's objectives of promoting sustainable livelihoods, enhancing tourism standards, and increasing international confidence in Sint Maarten's environmental stewardship.

The process requires regular compliance with microbiological and physicochemical water quality standards, environmental management practices, and public education components. Supporting infrastructure improvements (e.g., sanitation, waste bins, signage) will be necessary to achieve and retain certification. Great Bay Beach and Divi Little Bay can be considered as potential areas of interest.

## **3. Exploration of Sludge Reuse Options**

Given the WWTP process and current sludge composition, there is potential for evaluating safe and sustainable reuse options. Investigating sustainable sludge reuse options (e.g., composting, land application, energy conversion) can support circular economy practices and reduce environmental burdens from waste disposal. Provisions would need to be made for appropriate treatment and risk assessments to prevent secondary contamination.

## **4. Establishment of Local Standards and Enforcement**

During this baseline assessment, it was noted that there was a general lack of information and gaps in established national standards and guidelines. There is a need to develop and formalize national water quality standards, aligned with international benchmarks, to reflect the unique environmental, social, and economic context of Sint Maarten.

Institutional strengthening is necessary to ensure that existing legislation is enforced effectively, including through penalties for non-compliance and regular inspections.

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## 5. Integrated Watershed and Coastal Zone Management

Historical data as well as this baseline assessment confirms that measures are required to control pollutant levels. The interconnection of inland freshwater and coastal systems in Sint Maarten requires an integrated management approach.

Such an approach involves coordinated planning and implementation across land use, stormwater management, habitat protection, and pollution abatement to ensure long-term ecological integrity and water quality.

## 6. Public Education and Awareness Campaigns

Launching targeted public education campaigns can foster behavioural changes and stakeholder ownership of environmental outcomes. Such programmes can include information about pollution sources, proper waste disposal practices, and the importance of protecting water resources. This recommendation can support the NRPB's social cohesion and environmental resilience mandates.

Public health and safety should be prioritized through the issuance of bulletins and signage restricting recreational or consumption-related use of areas found to be heavily contaminated. These measures should be supported by clear communication and visible enforcement until remediation is completed and safety has been assured.

## 7. Strengthening Local Monitoring Capabilities

Enhancing local laboratory and field monitoring capabilities are critical to ensure ongoing environmental surveillance and WWTP performance. This may include investments in equipment, consumables, space/infrastructure, personnel and training.

CARIRI is prepared to provide additional sampling and analytical support, as well as on-site consultation and training to support capacity development.

## 8. Optimization and Monitoring of Wastewater Treatment Plants (WWTPs)

The WWTP should be routinely assessed and optimized to ensure efficient removal of pollutants. Implementation of regular monitoring programs and process audits can improve performance, reduce discharge loads, and prevent untreated or partially treated wastewater from reaching sensitive downstream environments.

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Such routine monitoring should be expanded to include composite sample collection of influent and treated effluent as well as sludge characterization for both physicochemical and microbiological parameters.

## 9. Landfill Assessment and Management

The influence of landfill leachate on water quality warrants further investigation. A thorough environmental assessment of the landfill's containment, drainage, and monitoring systems should be conducted, with recommendations for upgrades or mitigation as needed to prevent groundwater and surface water contamination.

## 10. Remediation Using Green Alternatives

Where pollution hotspots are identified, remediation strategies should prioritize eco-friendly solutions such as:

**Phytoremediation** – The use of plants to remove, degrade, or stabilize contaminants in soil and water. This method is especially suitable for tropical and subtropical climates like Sint Maarten's, where year-round plant growth is possible. Wetland plants such as cattails (*Typha* spp.), reeds (*Phragmites* spp.), and water hyacinth (*Eichhornia crassipes*) are effective at absorbing excess nutrients (nitrogen and phosphorus), heavy metals, and some organic pollutants.

**Constructed wetlands** – Engineered systems that simulate the functions of natural wetlands to treat wastewater or runoff. These systems can be designed as surface flow or subsurface flow wetlands and utilize plants, soil, and microbial interactions to reduce pollutants. Strategic implementation can be considered near high-loading outfalls (e.g., Rolandus Canal) or adjacent to the landfill to capture leachate and nutrient-rich runoff before entering aquatic ecosystems.

**Bioremediation** – The use of microorganisms (bacteria, fungi, or algae) to break down or neutralize pollutants in water and sediments. This can be applied through natural attenuation, bioaugmentation (adding specific strains), or biostimulation (adding nutrients to boost native microbial activity).

These nature-based approaches can provide cost-effective and sustainable means of improving water quality while enhancing habitat value.

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## References

1. World Bank Group. 2025. Projects and Operations: Sint Maarten: Wastewater Management Project. Available from: <https://projects.worldbank.org/pt/projects-operations/project-detail/P179067>
2. National Recovery Programme Bureau. 2023. Request for Expressions of Interest - Reference No. SX-NRPB-367264-CS-CQS: Assessment of Seawater Quality Testing of Six (6) Areas to Establish a Baseline.
3. Visit St. Maarten. 2025. Accessed from: <https://www.visitstmaarten.com/>
4. Nature Foundation Sint Maarten. 2025. Accessible from: <https://naturefoundationsxm.org/>
5. Sint Maarten Country Environmental Analysis (CEA) Interactive e-Book. Accessed from: <https://appolutelydigital.com/SintMaarten/index.html>
6. AIDEnvironment-EcoVision N.V. 1995. The Ponds of Sint-Maarten – Sustainable Development and Management. Available from: <https://www.sintmaartengov.org/Documents/Reports/EcoVision%201995%20The%20Ponds%20of%20Sint%20Maarten.pdf>
7. BirdLife International. 2025. Site factsheets. Accessed from: <https://datazone.birdlife.org/06/07/2025>.
8. American Public Health Association, American Water Works Association, & Water Environment Federation. (2017). Standard Methods for the Examination of Water and Wastewater (23rd ed.). Washington, DC: American Public Health Association.
9. Council of the European Communities. (1991). Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment. Official Journal of the European Communities, L135, 40–52.
10. European Parliament and Council of the European Union. (2006). Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC. Official Journal of the European Union, L64, 37–51.
11. Council of the European Communities. (1986). Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture. Official Journal of the European Communities, L181, 6–12.
12. Environmental Protection in the Caribbean (EPIC) Foundation. (2021, November). Water quality in the Simpson Bay Lagoon [Internship report].
13. Netherlands Ministry of Infrastructure and Water Management. (2021). Water Quality Guidelines and Environmental Objectives under the WFD.
14. Caribbean Environmental Health Institute (CEHI). (2001). Water Quality Guidelines for Recreational Waters in the Caribbean. CEHI.

---

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4. Tests/Calibrations marked "Not IAS Accredited" in this report are not in the IAS Accreditation schedule for our Laboratory.

15. United States Environmental Protection Agency (EPA). (2012). Recreational Water Quality Criteria (EPA 820-F-12-058). Washington, D.C.: Office of Water.
16. World Health Organization (WHO). 2003. Guidelines for Safe Recreational Water Environments: Volume 1 — Coastal and Fresh Waters. Geneva: World Health Organization. ISBN: 92-4-154580-1. Available from: <https://www.who.int/publications/i/item/9241545801>
17. Foundation for Environmental Education (FEE). (2022). Blue Flag Beach Criteria and Explanatory Notes. Retrieved from <https://www.blueflag.global/storage/app/media/Criteria/2022/BF%20Beach%20Criteria%202022.pdf>
18. National Institute for Public Health and the Environment (RIVM). (2018). Technical Guidance for Deriving Environmental Quality Standards (Guidance Document No. 27). Bilthoven, The Netherlands: RIVM. Retrieved from RIVM repository.
19. United States. Environmental Protection Agency. (2023). Ambient Water Quality Criteria to Address Nutrient Pollution in Lakes and Reservoirs (EPA 820-R-23-008).
20. MacDonald, D.D., Ingersoll, C.G., & Berger, T.A. (2000). Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Arch Environ Contam Toxicol 39(1), 20–31.
21. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy. Available at: <https://www.waterquality.gov.au/anz-guidelines>
22. Ministry of Infrastructure and the Environment. (2013). Guidance document for sediment assessment: Dutch implementation of the Water Framework Directive and Soil Protection Policy. SedNet. [https://sednet.org/download/guidance\\_document\\_for\\_sediment\\_assessment.pdf](https://sednet.org/download/guidance_document_for_sediment_assessment.pdf)
23. US EPA. (1993). 40 CFR Part 503 – Standards for the Use or Disposal of Sewage Sludge. <https://www.ecfr.gov/current/title-40/chapter-I/subchapter-O/part-503>
24. European Council. (1986). Council Directive 86/278/EEC on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31986L0278>
25. Canadian Council of Ministers of the Environment (CCME). (2009). A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. [https://ccme.ca/en/res/protocol\\_soil\\_quality\\_guidelines\\_1.0\\_e.pdf](https://ccme.ca/en/res/protocol_soil_quality_guidelines_1.0_e.pdf)
26. WHO. (2006). Guidelines for the safe use of wastewater, excreta and greywater. Vol. 4: Excreta and greywater use in agriculture. <https://www.who.int/publications/i/item/9241546859>

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