WHERE THE WASTEWATER GOES

A COMPREHENSIVE GUIDE FOR UNDERSTANDING WASTEWATER IMPACTS, CHALLENGES & RESOURCES IN ST. CROIX, US VIRGIN ISLANDS

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EXECUTIVE SUMMARY

The U.S. Virgin Islands has a complicated past with wastewater management, mitigation, and compliance. Since 1984 the Territory has been involved in numerous consent decrees and emergency hearings regarding wastewater pollution and violations of the Clean Water Act. In St. Croix, roughly half of the population relies on the centralized sewer system managed by the Virgin Islands Management Authority (VIWMA) while the other half relies on moderately to poorly functioning septic systems. Both the centralized and residential systems are prone to failure for a variety of reasons from outdated infrastructure to poor soil suitability. These failures cause raw sewage to enter the environment and coastal waters via groundwater or stormwater runoff. **The impacts of this wastewater** - or raw sewage - on St. Croix's coastal ecosystems **can have powerfully negative social and environmental impacts**.

Coral reefs are particularly sensitive to changing water conditions and thrive in clear water conditions. The pathogens and inorganic nutrients present in wastewater can have a myriad of impacts on corals' ability to reproduce, grow, and ultimately thrive. The Territory's corals are additionally compounded by global stressors such as climate change and the recent regional outbreak of Stony Coral Tissue Loss Disease in 2019. Global or regional stressors are important considerations when understanding corals' resilience and health; however, managing such stressors can be daunting. That's why it is vital to focus on local stressors that *can* be managed in order to provide a more suitable environment for corals to combat global and regional stressors.

"Coral reefs are in decline worldwide, and land-derived sources of pollution, including sewage, are a major force driving that deterioration.* And as global population and coastal development increase, i*t is thus critically important to understand the role of sewage discharge in coral reef declines and identify ways to minimize its impact on reef health"
- Wear & Thurber, Sewage pollution

What am I Reading?

This guide provides residents, businesses, environmental managers, and decision-makers an overview of *Where the Wastewater Goes* in St. Croix, U.S. Virgin Islands. It has been written to connect the vital, yet scattered, pieces of information about wastewater management and coral reef conservation into one place of reference. There is a lot of information out there, high quality and important information. With that being said this guide does not have every bit of available information. It attempts, rather, to provide an array of relevant and useful details to tell a more comprehensive and inclusive wastewater story.

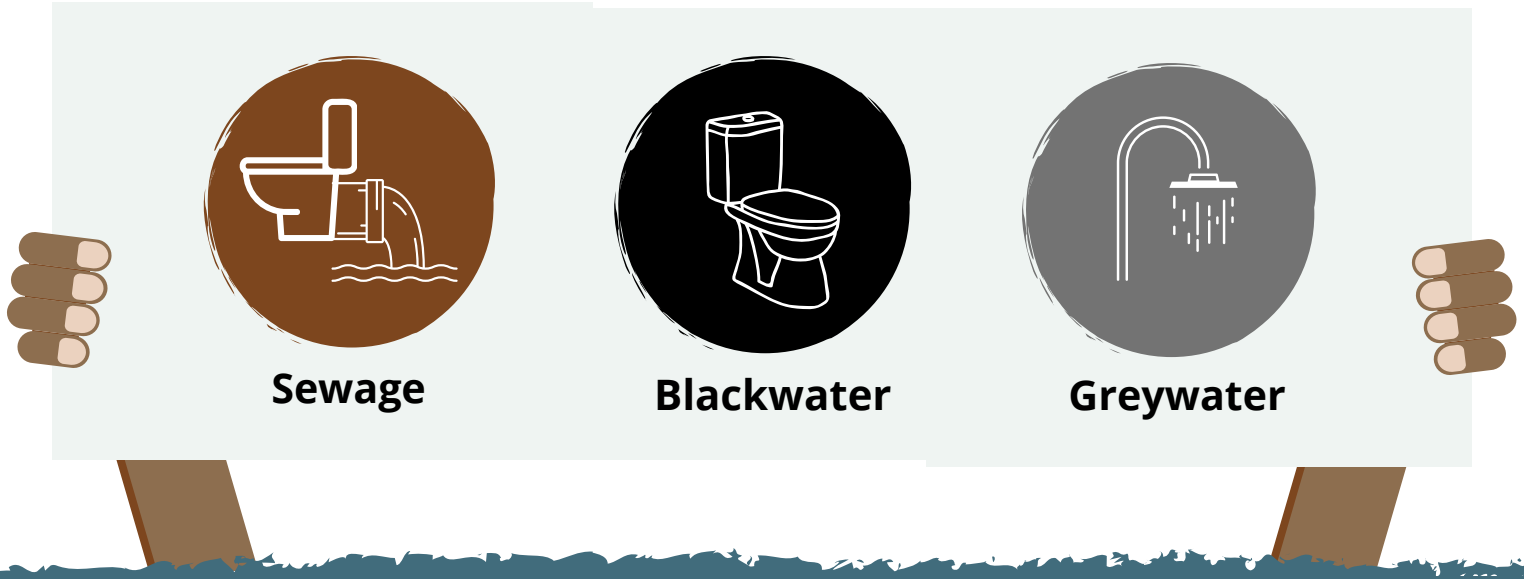
Objective: Bridge knowledge and relationship gaps to connect St. Croix residents, business owners, and decision-makers for a more unified understanding of wastewater management, challenges, and needs.

Goal: Minimize wastewater pollution in St. Croix to reduce potential impacts on coastal ecosystems, especially coral reefs, and to maintain public health and safe coastal access.

Basic Terminology

- **Wastewater** is water used by humans (residential, commercial or industrial).
- **Sewage** is human waste that is transported through a sewer system. Sewage can be a major component of wastewater, but not all wastewater is sewage.
- **Blackwater** is a product from toilets that consist of urine, feces, flush water, and or dry cleansing material. Blackwater contains harmful pathogens and nutrients.
- **Greywater** is a product from washing clothes, dishware, etc. as well as bathing. Greywater is not from toilets but may contain traces of Excreta and pathogens [1].

There are multiple wastewater concerns in St. Croix (e.g. industrial discharge from the oil refinery), but this report will be focusing on the above terminology whenever referencing "wastewater".



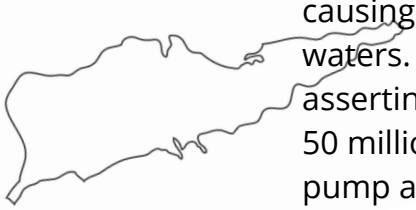
INTRODUCTION

"The largest component of coastally derived pollution is sewage." [6]

Did you know that each year an estimated 95 trillion gallons of wastewater is produced globally? Only 52% of this wastewater is treated and the remaining 48% (or **45.5 trillion** gallons) is **released into the environment untreated**, that's equivalent to 70 million Olympic sized pools [2]!

Additionally, pollution exposure increases in low to lower-middle-income nations due to living conditions, economic growth, and lack of adequate wastewater systems. In 2020, 45% of the global population did not have access to adequate sanitary systems and 6% were practicing open defecation [2]. **With rising coastal populations and stagnant wastewater management systems, human and environmental health are increasingly threatened by wastewater pollution.**

The **U.S. Virgin Islands** have historically struggled to properly manage their wastewater pollution and systems. Since 1984 the US Federal Court has ordered numerous consent decrees to push the Government of the Virgin Islands to comply with the Clean Water Act.



St. Croix - the Territory's largest island in both population and acreage - suffers from frequent wastewater infrastructure failure and septic system inadequacy causing excess nutrients and pathogenic pollutants to enter the soils and coastal waters. One particular event forced the Federal Court to file an emergency motion asserting that the Virgin Islands Waste Management Authority (VIWMA) dumped 50 million gallons of raw sewage into the Caribbean (a result of a failed house pump at the Figtree pump station in St. Croix.) It was estimated that each day the pump was broken 300,000 – 500,000 gallons of raw sewage were bypassed into coastal waters [3].

The good news is that there are plans underway to completely replace St. Croix's failing wastewater system (utilized by roughly half the population). Challenges, however, still persist in understanding the impacts on coastal ecosystems and human health and best management practices for residential septic systems.

What's Affected...or Infected?

Impacts on Local Corals

This guide will focus on the impacts of wastewater on local coral reefs as they are particularly sensitive to changing water conditions. Tropical corals thrive in nutrient-poor, clear water. Wastewater - when untreated - carries a menagerie of nutrients, heavy metals, and pathogens. Each pollutant possesses a different level of severity and impact when it interacts with coral.

Excess **nutrients** such as phosphate, nitrate, nitrite, and ammonium catalyze eutrophication [4]. Eutrophication encourages macroalgae growth which can smother corals by depriving them of oxygen, sunlight, and space. In St. Croix, the consistent contamination from land-based pollution (i.e. sedimentation, stormwater runoff, and sewage spills) has increased eutrophication events [5].

In addition, sewage carries **pathogens,** suspended solids, and sediments that may severely impair coral reproduction and or growth. Individual pollutants such as Enterococcus, fecal coliform, or inorganic nutrients can also increase another pollutant's impact severity - causing a positive feedback loop [6].

Positive Feedback Loop with Wastewater & Corals

Sedimentation from sewage stresses a coral and depletes its energy...

...with a depleted energy source the coral is less capable of combating pathogens found in sewage...

...and thus increasing its susceptibility to disease.

"The most important conclusion that can be taken away from this model is that the pathways for multiple-stressor effects generated by the multitude of component pollutants within sewage are high both in diversity and abundance, ***making sewage a potentially lethal cocktail for coral reefs.***
- Wear & Thurber, Sewage pollution

Corals in the US Virgin Islands have already been severely compromised since the discovery of Stony Coral Tissue Loss Disease (SCTLD) in 2019. Although its presence wasn't detected in St. Croix until May 2020, its persistence and lethal efficiency are extremely alarming. **With the compounding impacts of SCTLD, bleaching events, and ocean acidification, corals are susceptible to wastewater pollution now more than ever.**

Who's Affected...or Infected?

Do any of the following apply to YOU?

HUMAN? Because *everyone* poops which means it's *everyone's* problem.

Human Health

Wastewater pollution poses a serious threat to human health. Those who come in contact with polluted waters carrying toxins and or bacteria (such as *Enterococcus*) are at a higher risk of developing gastrointestinal infections, chest, ear, or eye infections, and or hepatitis [7]. Additional health risks include eating contaminated seafood and drinking polluted water. (For additional details on human health impacts see *A Practioner's guide for Ocean Wastewater Pollution* by the Ocean Sewage Alliance.)

Economics

Territory-wide coral reefs are worth an estimated $275,617,000 [8]. Wastewater pollution, however, threatens this economic value and reef-related tourism. St. Croix is especially susceptible to economic loss as they rely heavily on direct and nondirect reef tourism such as snorkeling and scuba diving. Wastewater will only contribute to the degradation of local reefs and subsequently the degradation of St. Croix's tourism industry.

In addition, healthy coral reefs provide underwater barriers that absorb wave and storm energy. This underwater barrier provides substantial flood protection and has already saved the USVI $47 million from averted damage [9].

BACKGROUND

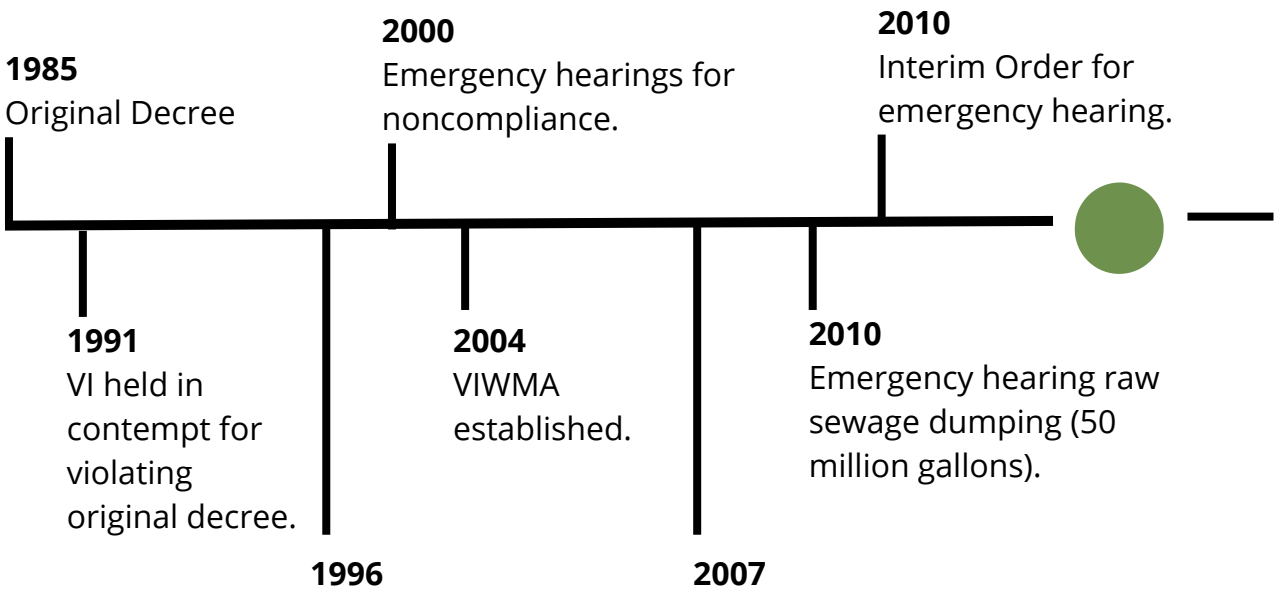
History of Wastewater Compliance

On March 21st, 1984 the Environmental Protection Agency (EPA) took action against the Government of the Virgin Islands for continuously violating the Clean Water Act (CWA) 33 U.S.C. § 1251 [10].

In 1985 the US Federal Court ordered a decent decree, also known as the "Original Decree" based on the failures of wastewater treatment plants (WWTP) and pump stations. This began four decades of noncompliance and case law between the Government of the Virgin Islands, the EPA, and the US Department of justice.

After years of noncompliance and frustration, in 2004 the VI established the Virgin Islands Waste Management Authority (VIWMA). Since then VIWMA has been in charge of improving the Territory's solid waste and wastewater systems. They have made progress over time, but are still limited by decaying infrastructure, federal and local funding dependency, and capacity challenges [10].

Starting Timeline of CWA Compliance & Consent Decrees



Measuring Water Quality

In the Virgin Islands, water quality is assessed based on the **classification** of a body of water. The Virgin Islands Code defines the classification for all territorial waters from coastal and marine waters to inland waters. **Class A, B, and C** are marine and coastal waters within the jurisdiction of the USVI. The classes are further defined by their designated uses and water quality standards. Class A, B, and C all have the same foundation for designated use:

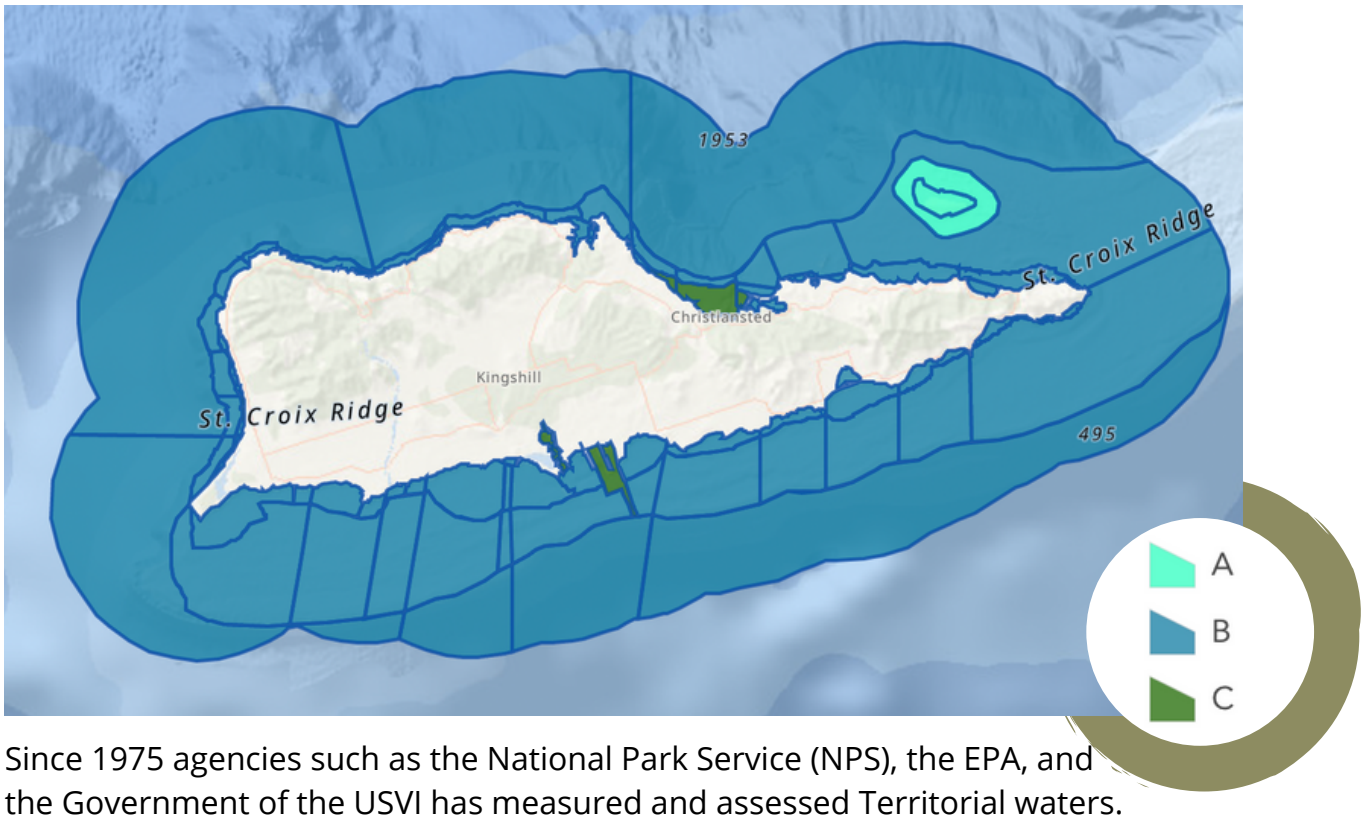
> *"Maintenance and propagation of desirable species of wildlife and aquatic life (including any threatened or endangered species), primary contact recreation, and for the use as potable water sources for those waters being used currently or that could be used in the future as potable water sources."*
> *- V.I. Code tit. 12, § 182 (2019)*

Building upon this foundation the three classes vary slightly in their description and other designated uses. The table below illustrates the location and any designated use additions or exceptions of each class. The following map outlines the exact bodies of water within St. Croix.

Territorial Marine & Coastal Waters Classification

Classification	Description	Designated Use Additions or Exceptions
A	Outstanding National Resource Waters *Buck Island*	No new or increased discharges.
B	Waters that are not Class A nor Class C.	-
C	Waters located in industrial harbors and ports with less stringent water quality standards. *Christiansted & Limetree Terminal*	Industrial water supplies, shipping and navigation.

St. Croix Coastal Water Classification



Since 1975 agencies such as the National Park Service (NPS), the EPA, and the Government of the USVI has measured and assessed Territorial waters. For nearly 50 years periodic measurements of dissolved oxygen (DO), temperature, salinity, pH, Secchi depth, fecal coliform, and turbidity. In more recent years inorganic dissolved nutrients such as nitrite, nitrate, and phosphate have also been measured. Many of these stressors are known pollutants and threaten the health St. Croix's coral reefs coastal communities:

- ***Enterococcus*** is a bacteria found in digestive tracks and contains pathogenic microorganisms that cause waterborne illness and increase corals' susceptibility to disease and stress [11].
- **Fecal Coliform** is a group of coliform bacteria (inclusive of *E. coli*) that also contains pathogenic microorganisms that threaten human and reef health [12].
- **Inorganic nutrients** (nitrate, nitrite, ammonium, and phosphate) encourage eutrophication and cause Harmful Algae Blooms (HAB) which are hazardous to humans [4].
- **pH** is an important environmental condition for coral reefs. When it becomes too acidic (or below 7) the calcification rate of corals will decline [13].
- **Total Suspended Solids** are solids that float in water consisting of organic or inorganic material. High levels of TSS can reduce water clarity and available sunlight for corals to utilize [14].
- **Turbidity** is a measurement of water clarity. Tropical corals thrive in nutrient-poor, clear waters; high turbidity means there is less clarity and less available sunlight.

THE CURRENT SITUATION

Water Quality Monitoring Programs

Water quality in St. Croix is currently monitored and measured by the Department of Planning and Natural Resources (DPNR) and the University of the Virgin Islands (UVI). These programs help to better understand the island's present water conditions, prevent pollution, and provide an opportunity to inform the public of impaired waters.

The Division of Environmental Protection, DPNR

Water Pollution Control Program
WPCP

Territorial Pollutant Discharge Elimination System (TPDES)

Beach Water Quality Monitoring Program
BWQMP

Weekly Beach Advisory & Data

Water Quality Management Program
WQMP

Integrated Water Quality Monitoring and Assessment Reports

Water Quality Standards

The University of the Virgin Islands + Partners

Territorial Coral Reef Monitoring Program
TCRMP

Basic Ambient Water Quality Monitoring Program
BAWQMP

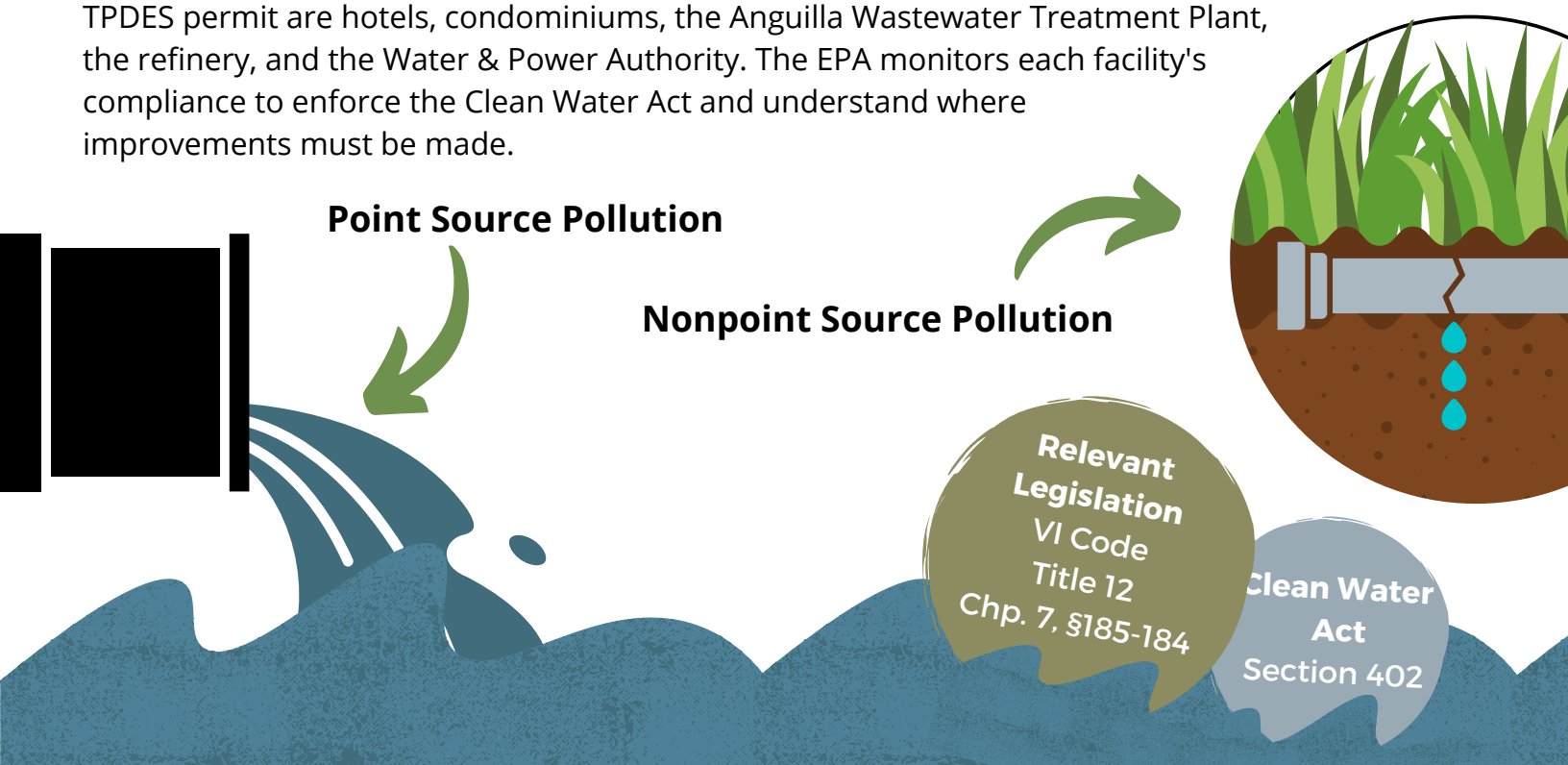
Water Pollution Control Program WPCP

The Water Pollution Control Program's main objectives are to comply with the Territory's water quality standards, prevent marine water degradation, and ensure that the CWA and TPDES permitting program requirements are met [15].

The **Territorial Pollutant Discharge Elimination Systems (TPDES)** permitting program is an extension of the National Pollutant Discharge Elimination Systems (NPDES) permit program put in place by the federal Clean Water Act (CWA) [16]. A TPDES permit is required for a person or facility (excluding transportation watercrafts and vessels) that may contribute pollutants or a combination of pollutants into Territorial waters from any point source inclusive of:

> *Surface runoff which is collected or channeled by man; discharges through pipes, sewers, or other conveyances owned by a State, municipality, or other person which do not lead to a treatment works; and discharges through pipes, sewers, or other conveyances, leading into privately owned treatment works.* ***This term does not include an addition of pollutants by any 'indirect discharger'.***
>
> *- V.I. Code tit. 12, § 184 (2019)*

TPDES monitor the **direct discharge** of pollutants, otherwise called **point source pollution**. The issue is that **indirect discharge** or **nonpoint source pollution** from, for example, stormwater runoff, broken sewage lines or a seeping septic tank are not enforced through the TPDES program. Common facilities in St. Croix that require a TPDES permit are hotels, condominiums, the Anguilla Wastewater Treatment Plant, the refinery, and the Water & Power Authority. The EPA monitors each facility's compliance to enforce the Clean Water Act and understand where improvements must be made.



Beach Water Quality Monitoring Program

The Beach Water Quality Monitoring Program releases weekly beach advisories to assess popular swimming beaches for *Enterococci* and water clarity. On St. Croix, the BWQMP considers 20 different beaches; if sampled, the beach is considered "impaired" when *Enterococci* is greater than 70/100mL. The following beaches are periodically or consistently monitored [17]:

- Buccaneer
- Cane Bay
- Chenay Bay
- Columbus Landing
- Cramer's Park
- Davis Bay
- Dorsch Beach
- Frederiksted Beach
- Gentle Winds
- Grapetree Bay
- Protestant Cay
- Rainbow Beach
- Shoy's
- Sprat Hall
- Stony Ground
- Teague Bay
- Halfpenny Beach
- New Fort/Ft. Louise Augusta
- Pelican Cove/Comorant
- Princess/Condo Row

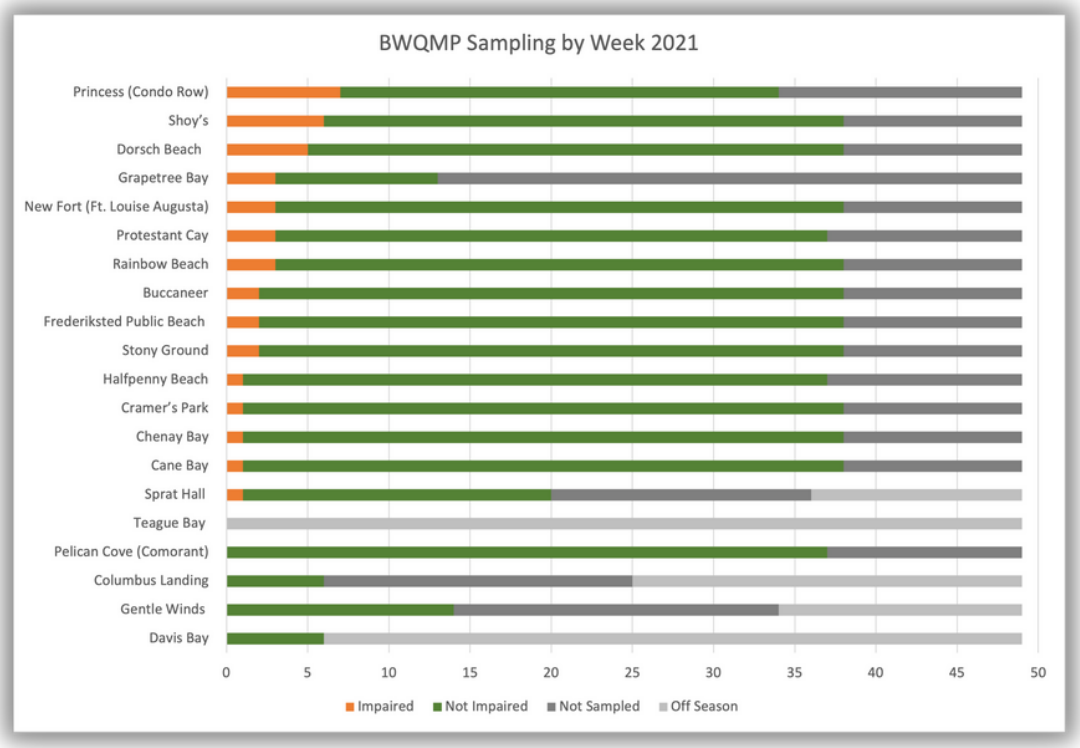
Although this program is well-intentioned, it lacks key elements to truly be successful. When you view the data in the figures below you'll notice that many beaches have not been **consistently** sampled. The lack of sampling can be attributed to challenges - depending on the week - related to weather, the lab, or staffing capacity. Additionally, when a body of water *is* impaired it's difficult to inform the public in a **timely** and **relevant** matter. For example, if Cane Bay were to be impaired on Tuesday, but the weekly beach advisory comes out every Friday, that's three days of unknown impairment and a public health hazard. The water conditions could also change by the time the report is released depending upon physical characteristics (i.e. bay or channel, strong vs. weak currents). Lastly, the DPNR *does* release a weekly beach advisory report, however, there is little **enforcement** in shutting down a beach or providing physical warning signs.

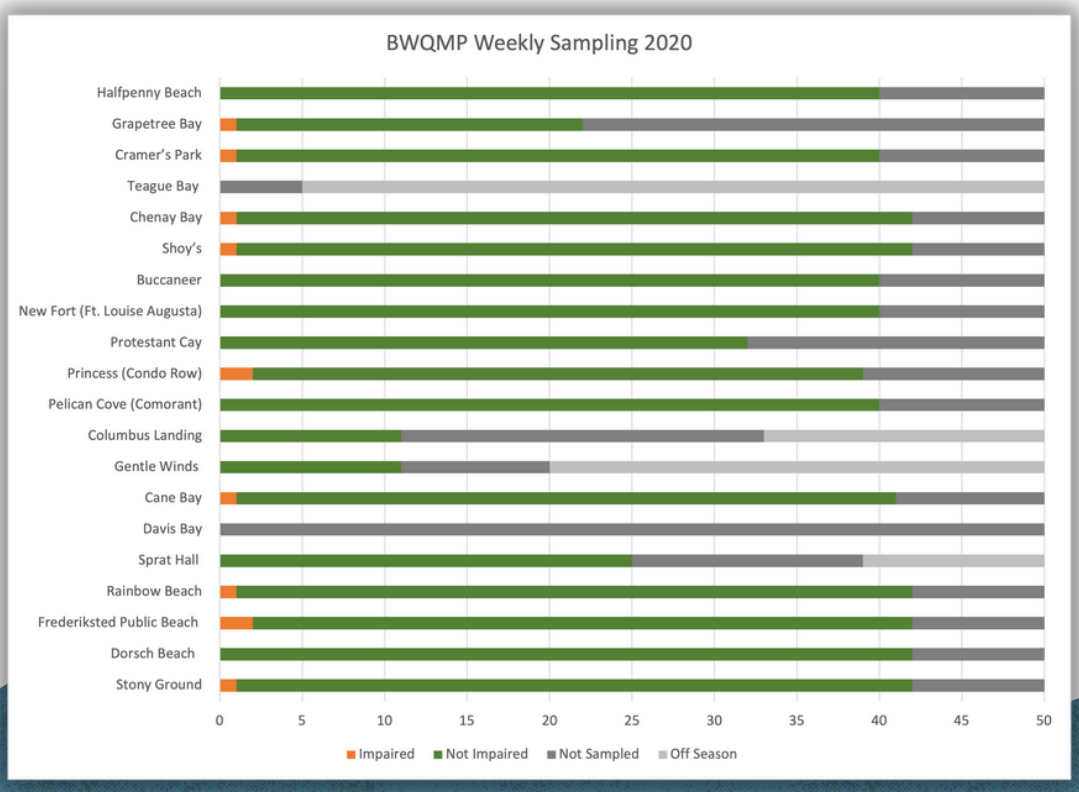
Nonetheless, the Beach Water Quality Monitoring Program is an important program to better understand local water quality conditions, analyze water quality patterns, assess for potential pollution sources and provide public awareness.

Opinion: It's important to note that there are complications in warning the public of impaired waters, particularly for tourism. On the one hand, public health should absolutely be prioritized, however, how successful is a business if their beach or waters are impaired? How would a warning sign impact their visitor's experience and business reputation? What are the solutions to maintaining public health and local business?

BWQMP Sampling Results 2020 & 2021

The graphs below show the number of weeks a site is either "impaired" (with over 70 counts/mL of *Enterococcus*), "not impaired" (below 70), "not sampled" or "off-season". Note that some sites that are marked as "off-season" (or areas that are not intended to be sampled during that particular season) do not seem accurate. For example, in 2021 Teague Bay was considered "off season" for the entire year.





Water Quality Management Program WQMP

The Water Quality Management Program focuses on enforcing Water Quality Standards and creating Integrated Water Quality Monitoring and Assessment Reports (IWQMAR) every two years.

The **Water Quality Standards** outline "the physical, chemical, biological, and ecological limits to support designated uses" of bodies of water and provide "a framework for protecting, maintaining, and improving water quality" [18]. The Water Quality Standards are periodically revised in order to maintain high water quality standards in a changing environment, best protect public health, and consistently comply with the Clean Water Act requirements.

The **Integrated Water Quality Monitoring and Assessment Reports** combine requirements from the Clean Water Act sections 305(b) and 303(d) into one comprehensive report. Section 303(b) of the CWA requires written water quality standards while 303(d) requires states and territories to report impaired waters and Total Maximum Daily Loads (TMDLs) [18]. A **TMDL** is the maximum allowable amount of a pollutant to enter a body of water so that the waterbody will be in continuous compliance with water quality standards. A TMDL may also determine the reduction target for a pollutant [19].

The IWQMA Reports provide important information about impaired waters in the Virgin Islands. They do not provide details of exact measurement parameters (for example, stating the measured amount of nitrogen or enterococcus found in the impaired water), but provide a foundation for water quality conditions and management in St. Croix.

Relevant Legislation
Clean Water Act Sec. 303(b), 303(c) & 303(d)

VI Code
Title 12
Chp. 7
§186

THE CURRENT SITUATION

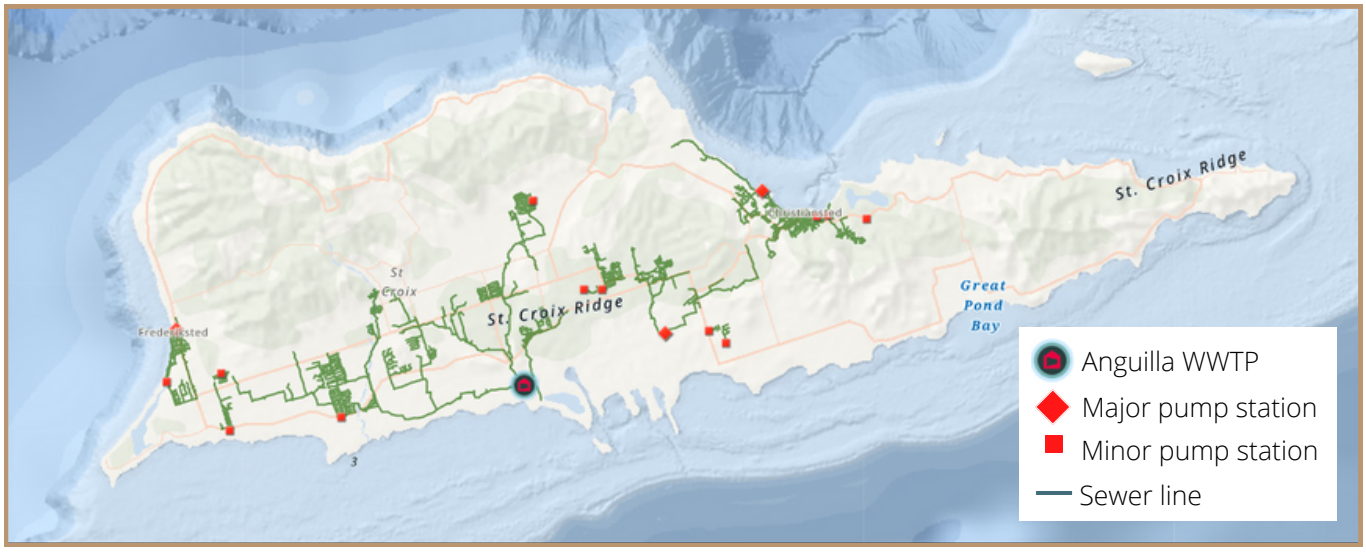
Wastewater Management Systems

St. Croix utilizes two very different systems to manage and treat its black and grey wastewater. 40-60%* of residents rely on the Virgin Islands Waste Management Authority's (VIWMA) centralized sewer system. The remaining 40-60%* of the population rely on septic systems also referred to as Onsite Sewage Disposal Systems (OSDS). VIWMA's centralized system uses a series of pump stations and underground pipes to transport wastewater away from its point of origin to the Anguilla Wastewater Treatment Plant (WWTP). The Anguilla WWTP processes 1.6 million gallons of domestic, commercial, and industrial wastewater per day [20]. OSDS process and treat wastewater precisely where it describes, *onsite*. Depending upon the household, the volume of wastewater stored and processed will vary.

Virgin Islands Waste Management Authority

VIWMA or WMA was established in 2004 in response to a federal-ordered consent decree for violations against the Clean Water Act. VIWMA has since been responsible for updating both the solid waste and wastewater systems to comply with federal regulations and improve territory-wide water quality [21]. WMA has an estimated 200 miles of public sewers, 30 pump stations, and 8 wastewater treatment plants processing 4.5 million gallons per day across the Territory. In St. Croix, there are 3 major pump stations, 12 minor stations, and 92 miles (at least) of sewers transporting wastewater to the Anguilla WWTP [22].

VIWMA Infrastructure in St. Croix



**Estimate only based on the location of sewer network and nearby population density.*

Infrastructure Challenges

VIWMA has inherited major wastewater management challenges. The challenges discussed here pertain to the **outdated infrastructure**, **combined sewer system**, **personnel capacity,** and the aftermath of **hurricanes** and **tropical storms.**

When VIWMA was established the wastewater **infrastructure** had already surpassed its design lifetime [21]. The sewer system still suffers from corrosion, leaks, and breaks while the pump stations have frequent failures. The inadequate infrastructure causes wastewater effluent (including sewage) to discharge into the environment via the soils, runoff, or - although less often - direct outflow to coastal waters. Corroded and leaky pipes are of considerable concern during dry weather which allows **highly** concentrated wastewater to infiltrate surrounding soils and groundwater [23].

WMA also took on a **combined sewer system** that utilizes the same pipelines to transport sewage and stormwater runoff. The Anguilla WWTP (built-in 2007) was constructed to handle the increased volume of stormwater. The older sewer lines and pump stations, however, were not. This subsequently causes backups and overflow of raw sewage. Due to St. Croix's topography much of this sewage concentrates in low-lying flood zones [23].

Hurricanes and the **increased intensity of tropical storms** also pose serious threats to WMA operations and infrastructure. In 2017, hurricanes Irma and Maria completely overwhelmed the wastewater system and caused widespread damage and system failures. Repairs to the wastewater and solid waste system cost at least $40.9 Territory-wide [24].

> *Looking to the future, VIWMAs infrastructure must be replaced and updated as "stronger—though not necessarily more frequent—storms will pose risks to the systems' physical infrastructure (especially wastewater pumping stations and treatment plants); storm surges—especially exacerbated by sea-level rise—will threaten the systems' low-lying facilities..."*
>
> *- USVI Hurricane and Recovey Task Force Report 2018*

The Good News!

After three years of negotiations with VIWMA and the Office of Disaster Recovery, FEMA, in 2021, approved a $1.5 - $2 billion replacement of St. Croix's entire wastewater system [25].

Financial Challenges

WMA is a government-funded entity that relies upon annual budgeting from the General Fund and Special Fund of the Virgins Islands Government. From the General Fund VIWMA historically received $25 million annually for all VIWMA-related operations, but for the fiscal year 2022, Governor Bryan increased the allotment to $35 million. With the addition of $7 million from Special Funds, WMA's grand total for FY2022 (excluding federal funding) is $42 million* [26]. Other minor funding comes from the Wastewater User Fee (WUF) of about $120 charged per Equivalent Residential Unit (ERU) [27]. For St. Croix, if *each* individual person was charged that would still only come to a $2.4 - $3.6 million in annual revenue.

The takeaway: VIWMA relies heavily on local and federal government funding.

Federal funding is available and is provided, but sometimes the amount is not sufficient or may take years to obtain (estimated 5 - 7 years to obtain funding and complete a project) [24].

Additionally, the reliance on federal funding perpetually places VIWMA in triage mode, lacking self-sufficiency and the capacity to plan for preventative measures. **VIWMA Executive Director Roger Merritt stated** in 2021 that:

> *While the grants and other available funding sources we discussed will assist with improvements, we must take the necessary steps toward the goal of self-sufficiency by charging fees and creating additional revenue streams to become a* ***truly autonomous agency*** [24]."

While some argue there is a financial inefficiency, others, such as **Senator Janelle Sarauw** of St. Thomas, would argue (from 2021) that it's a capacity and personnel issue:

> *"There was an increase in the budget appropriated to VIWMA...Therefore, vacancies should be filled. Currently, VIWMA lacks an enforcement director, compliance officers, and additional staff is required. We cannot want progress when we are not doing what's necessary to achieve it* [24].

The Good News!

Additional funding is on its way! The new Bipartisan Infrastructure Law will provide the Virgin Islands with $31,883,000 for water-related infrastructure projects [28].

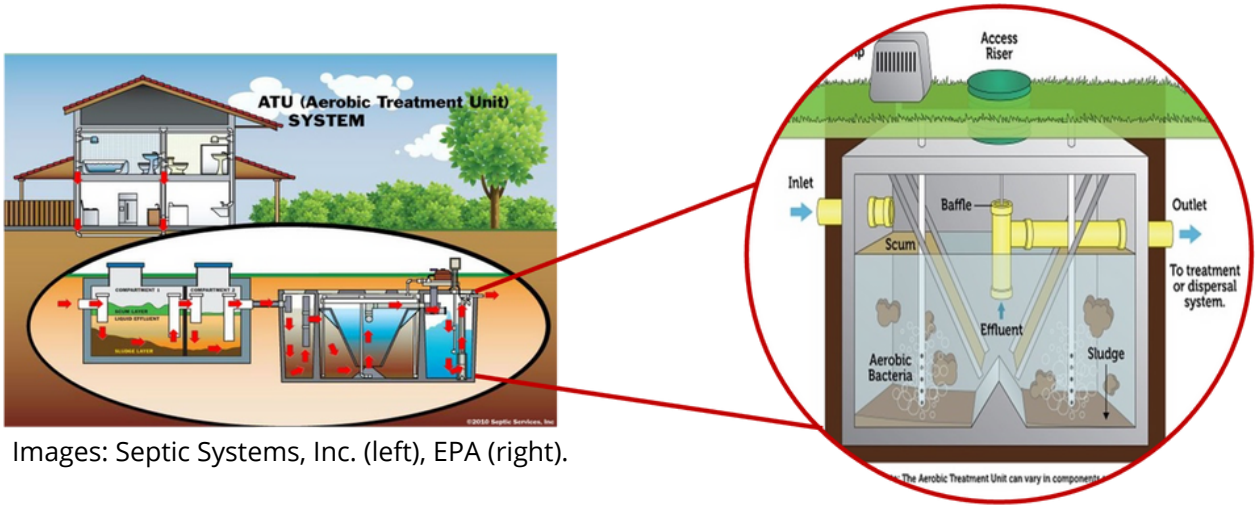
*$42 million plus federal funding may seem like a lot of money (that's because it is!) However, the changes needed to bring VIWMA into compliance for both their wastewater and solid waste crisis are expensive. Just to remove the Bovoni and Anguilla landfills (both under consent decrees) would cost an estimated $65 million! [22]

Residential Wastewater Systems

A residential wastewater treatment system is also referred to as an Onsite Sewage Disposal System (OSDS). Roughly 40-60%* of St. Croix residents depend on OSD Systems to treat their domestic black and grey wastewater.

There are various types of OSD Systems, the basic and most widely utilized are **conventional** systems that typically consist of a septic tank and drainage field. **Alternative systems** require additional technology to process the wastewater and can be engineered in a variety of ways – typically utilizing an Aerobic Treatment Unit (ATU) [29]. A conventional system uses anaerobic processes to break down organic solids whereas an ATU will utilize oxygen to break down organic dissolved solids. ATUs can be an effective method for treating domestic wastewater in areas where conventional systems are not appropriate due to either soil suitability or space [30]. A septic tank and an ATU can be utilized together for an anaerobic and aerobic breakdown of wastewater in what's called a combined system or an ATU system.

Aerobic Treatment Unit & System



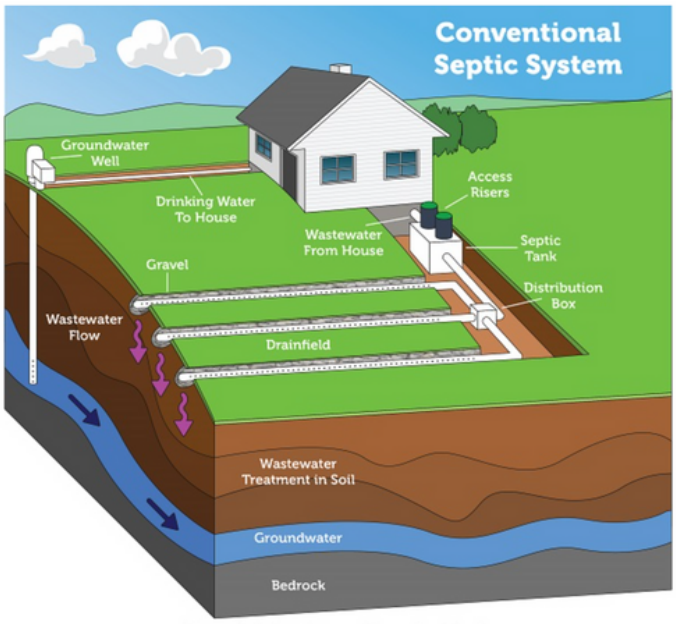
Images: Septic Systems, Inc. (left), EPA (right).

Do YOU know what type of system you're using?
How well it treats your residential waste?
How often it must be serviced?

**Estimate only based on the location of sewer network and nearby population density.*

Onsite Sewage Disposal System Schematics & Descriptions

The images below define different types of Onsite Sewage Disposal Systems. This list is not exhaustive but represents systems that have been studied for suitability in St.Croix.



Please note: Septic systems vary. Diagram is not to scale.

Conventional System

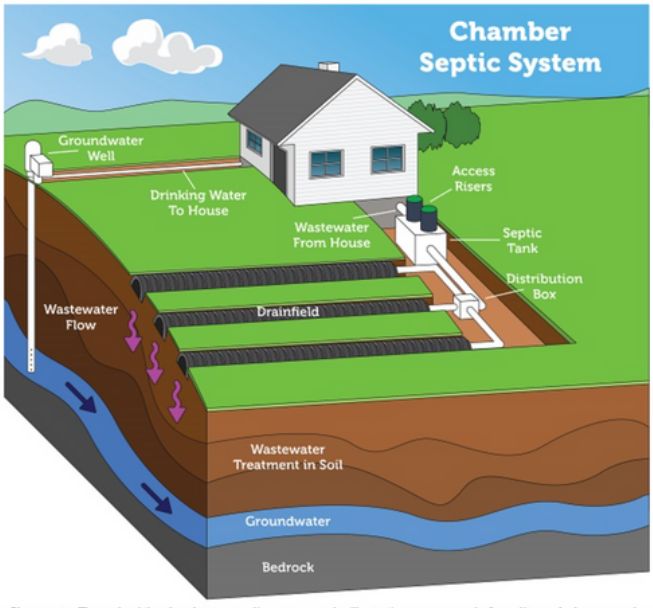
Consists of a septic tank and drain field.

"With this design, effluent is piped from the septic tank to a shallow underground trench of stone or gravel. A geofabric or similar material is then placed on top of the trench so sand, dirt, and other contaminants do not enter the clean stone. Effluent filters through the stone and is then further treated by microbes once it reaches the soil below the gravel/stone trench.

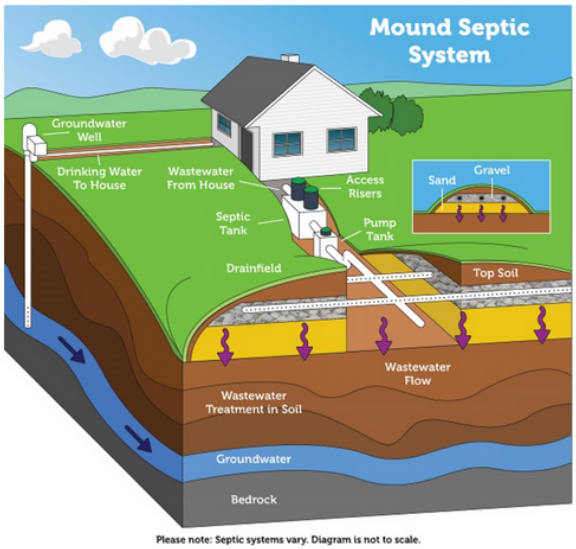
Gravel/stone systems are relatively large in overall footprint and may not be suitable for all residential sites or conditions."

Chamber System - *Alternative OSDS*

"The chamber system serves as an alternative design to the gravel/stone system. The primary advantage of the chamber system is increased ease of delivery and construction. They are also **well suited** to areas with high groundwater tables, where the **volume of influent to the septic system is variable (e.g., at a vacation home or seasonal inn**), in an area where gravel is scarce, or in areas where other technologies such as plastic chambers are readily available. This type of system consists of a series of connected chambers...Pipes carry wastewater from the septic tank to the chambers. In the chambers, the wastewater comes into contact with the soil. Microbes on or near the soil treat the effluent."



Please note: The ends of the chamber system lines are open for illustrative purposes only. In reality, and when properly installed, these lines are closed at the end. Septic systems vary. Diagram is not to scale.



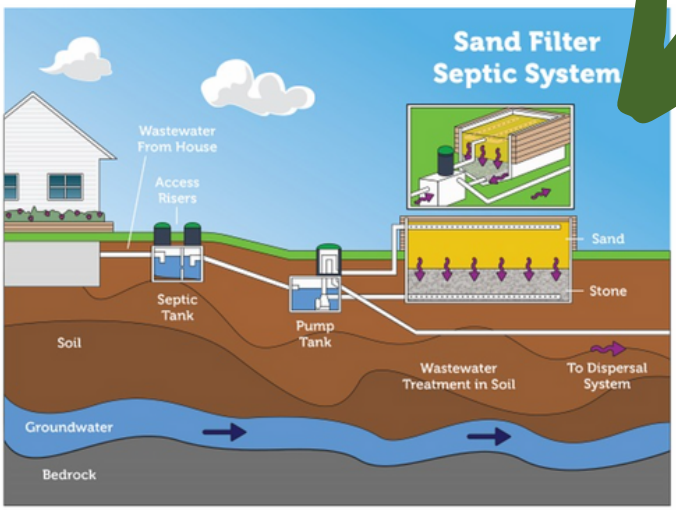
Please note: Septic systems vary. Diagram is not to scale.

Mound System - *Alternative OSDS*

"Mound systems are an option in areas of **shallow soil depth, high groundwater, or shallow bedrock**. The constructed sand mound contains a drain field trench. Effluent from the septic tank flows to a pump chamber where it is pumped to the mound in prescribed doses. Treatment of the effluent occurs as it discharges to the trench and filters through the sand, and then disperses into the native soil. While **mound systems can be a good solution for certain soil conditions, they require a substantial amount of space and periodic maintenance."**

Sand Filter System - *Alternative OSDS*

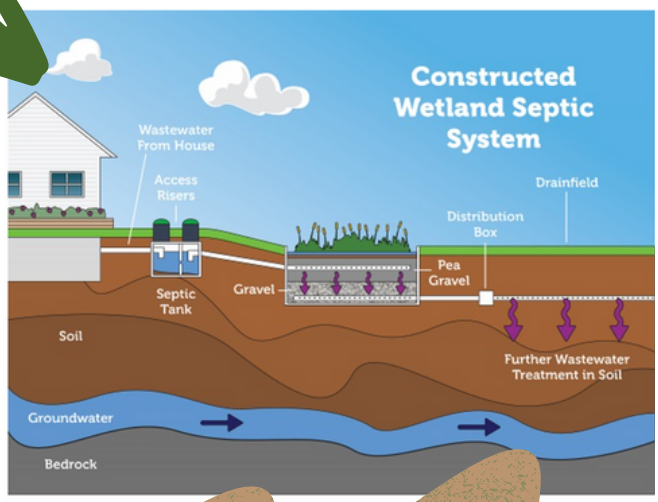
"Sand and filter systems can be constructed above or below ground. Effluent flows from the septic tank to a pump chamber. It is then pumped to the sand filter...The effluent leaves the pipes and is treated as it filters through the sand. The treated wastewater is then discharged to the drain field. Sand filters provide a **high level of treatment for nutrients** and are **good for sites with high water tables or that are close to water bodies**, but they are **more expensive** than a conventional septic system."



Please note: Septic systems vary. Diagram is not to scale.

Recommended for USVI!

Recommended for USVI!



Constructed Wetland System - *Alternative OSDS*

"...Mimics the treatment processes that occur in natural wetlands. Wastewater flows from the septic tank and enters the wetland cell. The wastewater then passes through the media and is treated by microbes, plants, and other media that remove pathogens and nutrients...As wastewater flows through the wetland, it may exit the wetland and flow into a drain field for further wastewater treatment into the soil."

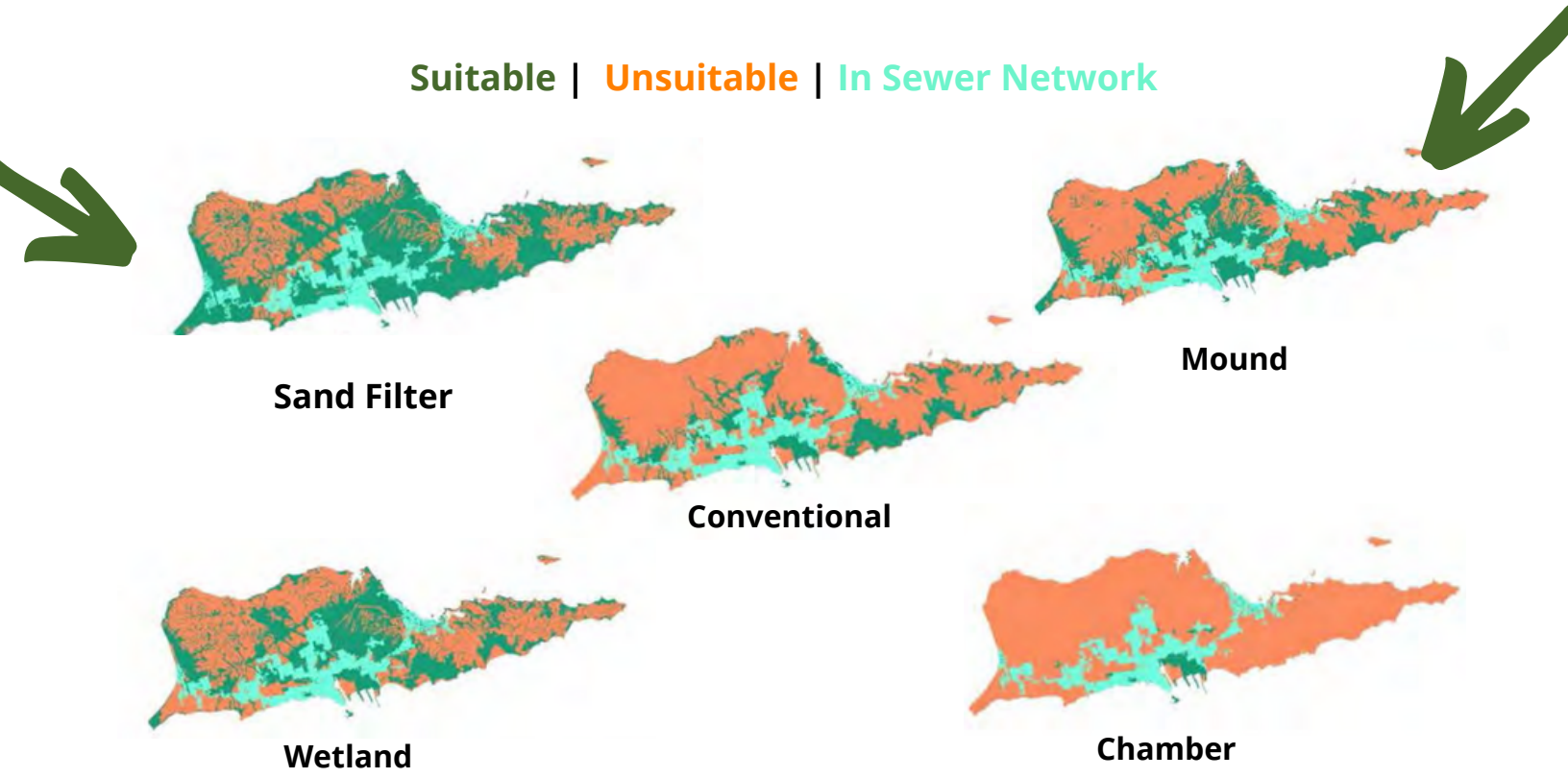
OSDS can range in expense and maintenance. Generally, the more technology utilized, the greater the upkeep and costs. This, however, is also accompanied by adequately treated wastewater and healthier communities. In their report *Advancing Onsite Wastewater Treatment* the Coral Bay Community Council writes:

> *Given the unique characteristics of the wastewater, geology, and soil conditions in the USVI,* ***proper performance of OSDS is imperative to protect human health and the environment****. Failing OSDS can be a significant contributing source of impairment to USVI coastal waters."*

Soil Suitability

Soil suitability is an essential component to ensuring your OSDS functions properly and does its job. A **conventional system,** in particular, relies heavily on soil type as the system itself does a poor job of filtering pathogens and nutrients [29]. The type and depth of a drain field will determine how effectively the wastewater is treated, if soil conditions are poor then the wastewater will not be sufficiently treated. Below is an assessment of OSDS suitability based on soils. (Notice that the Sand Filter and Mound System are the most compatible with St. Croix soils.)

Suitable | Unsuitable | In Sewer Network



Images: Watershed Characterization Planning for Pathogen Sources in the USVI, Cadmus Group

Helpful Legislation

A **conventional OSDS** relies heavily on soil suitability and are thus widely ineffective throughout the US Virgin Islands. In the early 2000s, DPNR recognized the systems' inadequacies and amended the **Virgin Islands Rules and Regulations to include a "Conventional Septic System Design Criteria and Requirements"** including:

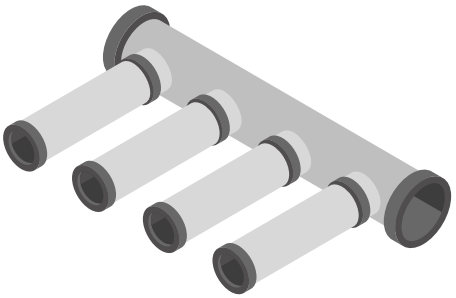
A septic or treatment tank must be pumped at least **once every five years** by a licensed septic tank cleaner.

If a Conventional OSDS is not suitable for a site or if it malfunctions and cannot be repaired to standards, then it must be **replaced with a constructed wetland system** or **alternative OSDS**.

Space can be a serious limiting factor. When homes are built closely together there is limited space to build a drainage field that can properly treat the volume of wastewater.

Cluster or community systems cannot exceed 1000 gallons per day of sewage flow *unless* they are utilizing a constructed wetland system.

Wastewater from a septic tank must be discharged to an **in-ground** discharge system.



Relevant Legislation
VI Rules & Regs
Title 12
Chp. 21, §910-1(e)

Considerations for Onsite Sewage Disposal Systems

There are several factors that may determine the effectiveness of your OSDS. According to the 2022 Wastewater Workshop hosted by Coral Bay Community Council, you should consider the following:

Highly Concentrated Wastewater: Does the phrase "if it's yellow let it mellow, if it's brown flush it down" sound familiar? This is a great everyday water conservation practice. It also means there is a higher concentration of nutrients and pathogens in your OSDS effluent. If your OSDS isn't functioning properly, higher concentrations of black wastewater will enter the environment.

Tourist Season: During the off-season, the bacteria in a less utilized OSDS will need to go through a "start-up period before they are efficient at treating wastewater." Additionally, the cleaners utilized for guest turnovers may "overwhelm the OSDS and eliminate bacteria needed to break down the wastewater" [31].

FOG: Fats, Oil, and Grease - do NOT put them down your drain! They will clog pipes, cause backflow, and possibly a very smelly situation for your property.

Leaving the Grid: People migrating either to St. Croix or from VIWMA's centralized system to their own OSDS may not be aware of how to best manage their system.

Chlorinated Cisterns: If chlorine is not measured and or overutilized when cleaning a cistern it can enter your OSDS and kill essential bacteria.

Unreliable electricity: Alternative OSDS needs electricity to operate and treat wastewater. If there are prolonged power outages then the system reverts back to a conventional operation - requiring a septic tank and drainage field. However, if no drainage field was constructed because the property intended to have an alternative system that means your raw wastewater is discharged into the environment.

Don't Set it and Forget it! Many people think that once a system is in the ground it will be completely self-sufficient or it is quite literally forgotten. These systems *need* ongoing maintenance in order to function properly.

This section provides a snapshot of global and local resources related to a variety of topics within the theme of this report (i.e. coral disease, water quality conditions, land-based pollution, and sewage mitigation). The resources are organized into *types of literature:*

- **Relevant Reports:** investigative official documents
- **Pertinent Papers:** academic literature showcasing original research or a research review.
- **Management Plans:** plans of action related to coral reef and or wastewater management.
- **Legislation & Policy:** laws and regulations related to wastewater management and water quality.
- **Online Resources:** data, databases, interactive maps, references, and dedicated wastewater and or coral-related websites and organizations.

Within each section the supporting entity or author, date and or focus area identified. The focus area is indicated by symbol(s) and is the *general and major* focus of the resource.

Symbol	Meaning
	Directly related to the U.S. Virgin Islands.
	**Focus:** Water Quality/Watershed Management
	**Focus:** Wastewater/Land-Based Pollution
	**Focus**: Corals/Coral Reefs

Relevant Reports

Investigative official documents.

Title	Date	Entity	Focus
A Synthesis of Issues Affecting the Management of Coral Reefs and Recommendations for Long-Term Capacity Building in U.S. Jurisdictions	2014	NOAA	
An Analysis of Issues Affecting the Management of Coral Reefs and the Associated Capacity Building Needs in the USVI	2012	NOAA	
An assessment of chemical contaminants, toxicity and benthic infauna in sediments from the Salt River Bay National Historical Park and Ecological Preserve, St. Croix, ISVI	2020	NOAA	
An Assessment of Nutrients, Sedimentation, and Total Suspended Solids (TSS) in the St. Thomas East End Reserves (STEER)	2015	NOAA	
Comparative Analysis of Risks Faced by the World's Coral Reefs	2021	TNC	
Conditions in the USVI Warrant EPA Withdrawing Approval and Taking Over Management of Some Environmental Programs and Improving Oversight of Others	2015	EPA	
Coral Assessment and restoration in the USVI after 2017 hurricanes	2019	NOAA	
Coral Reef Condition: a status report for the USVI	2020	NOAA	
Coral Reef Habitat Assessment for U.S. Marine Protected Areas: USVI	2009	NOAA	

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Relevant Reports

Title	Date	Entity	Focus
Integrated Water Quality Assessment and Monitoring Reports	Biennial 2004 - 2020	DPNR	
Land-based sources of pollution implementation plan, FY 2011-FY 2015	2011	NOAA	
National Coral Reef Monitoring Program Biological monitoring summary USVI and Puerto Rico: 2019	2019	NOAA	
Permit Quaity Review: USVI	2014	EPA	
St. Croix Coral Reef System: Area of Particular Concern (APC) and Area of Preservation and Restoration	1993	DPNR	
St. Croix east end watersheds existing conditions report	2011	DPNR, Horsley group	
State of the World's Sanitation	2020	WHO	
The state of coral reef ecosystems of the United States and Pacific Freely Associated States	2002	NOAA	
The state of coral reef ecosystems of the United States and Pacific Freely Associated States	2005	NOAA	
The state of coral reef ecosystems of the United States and Pacific Freely Associated States	2008	NOAA	

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Relevant Reports

Title	Date	Entity	Focus
The USVI Territorial Coral Reef Monitoring Program Annual Report	Annually 2001 - 2019	UVI/CMES, DPNR, NOAA	
US Coral Reef Monitoring Data Summary 2018	2018	NOAA	
USVI Hurricane Recovery and Resilience Task Force Report (*Solid Waste & Wastewater, p. 123*)	2018	USVI Hurricane Recovery & Resilience Task Force	
Watershed Characterization and Planning for Pathogen Source Reduction in the USVI	2011	CBCC, The Cadmus Group	
Watershed Scale Planning to Reduce Land-Based Sources of Pollution (LBSP) for the Protection of Coral Reefs in Southeast Florida	2015	NOAA	
A Practioner's Guide for Ocean Wastewater Pollution	2021	Ocean Sewage Alliance	

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Pertinent Papers

Academic literature showcasing original research or research review.

Title	Date	Authors	Focus
Chronic disturbance modulates symbiont (Symbiodiniaceae) beta diversity on a coral reef	2020	Danielle C.Claar, Kristina L. Tietjen, Kieran D. Cox, Ruth D. Gates & Julia K. Baum	
Coral disease time series highlight size-dependent risk and other drivers of White Syndrome in a multi-species model	2020	Greene A., Donahue M., Caldwell J. M.,Heron S. F., Geiger E., Raymundo L. J.	
Country-level and gridded estimates of wastewater production, collection, treatment, and reuse	2021	Edward R. Jones, Michelle T. H. van Vliet, Manzoor Qadir, Marc FP Bierkens	
Global priority areas for incorporating land–sea connections in marine conservation	2009	Benjamin S. Halpern, Colin M. Ebert, Carrie V. Kappel, Elizabeth M.P. Madin, et. al	
Impact of pollution on marine environment: A case study of coastal Chennai	2011	Tuholske C., Halpern B.S., Blasco G., Villasenor J.C., Frazier M., Caylor	
Is there a relationship between proximity to sewage effluent and the prevalence of coral disease?	2005	Longin Kaczmarsky, Ernest H. Williams, Jr	
Managing marine disease emergencies in an era of rapid change	2016	Groner M. L., Maynard J., Breyta, R., Carnegie R. B., Dobson A., et. al.	

Based in St. Croix!

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Pertinent Papers

Title	Date	Authors	Focus
Managing watersheds for coral reefs and public health	2022	Ama Wakwella, Amelia Wenger, Stacy Jupiter, Joleah Lamb, et. al	
Mapping global inputs and impacts from human sewage in coastal ecosystems	2021	Tuholske C., Halpern B.S., Blasco G., Villasenor J.C., Frazier M., Caylor K.	
Sewage pollution: mitigation is key for coral reef stewardship	2015	Stephanie L. Wear and Rebecca Vega Thurber	

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Management Plans

Plans of action.

Title	Date	Entity	Focus
A Manager's Guide to Coral Reef Restoration Planning and Design	2020	NOAA	
Coral Disease Outbreak Response Plan for the United States Virgin Islands	2020	DPNR, UVI - CMES	
Coral Reef Conservation Program Strategic Plan	2018	NOAA	
NOAA Action Plan on Coral Interventions	2020	NOAA Vardi T., et. al	
St. Croix East End Watershed Management Plan	2011	East End Marine Park DPNR, Horsley Witten Group	
Stormwater management in Pacific and Caribbean islands : a practitioner's guide to implementing LID	2014	NOAA Chaston, Kathy	
Strategy for Stony Coral Tissue Loss Disease Response and Prevention	2020	NOAA Skrivanek, Alexandra	
Territorial Hazard Mitigation Plan 2019	2019	FEMA, ODR	
USVI Coral Reef Management Priorities	2010	NOAA	
USVI Coral Reef Management Priorities 2020 - 2025	2019	DPNR	
US Coral Reef Task Force	2016	NOAA	

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Legislation & Policy

Laws and regulations.

Document	Title	Chapter & Subsection	Relevence
US Virgin Islands Code	12 - Conservation	Chp. 7 - Water Pollution Control, §186 - Standards of Water Quality	Water quality standards
US Virgin Islands Code	12 - Conservation	Chp. 7 - Water Pollution Control, §184 - Powers & Duties	TPDES
US Virgin Islands Code	12 - Conservation	Chp. 21 - VI Coastal Management, §910 - Coastal Zone Permit, §902 - Definitions	Onsite Sewage Disposal Systems
US Virgin Islands Code	29 - Public Planning & Development	Chp. 8 - VIWMA, §494 - 500q - Establishment	VIWMA establishment
US Virgin Islands Code	19 - Health	Chps. 53 - Sanitation, 55- Sewage Disposal, 56 - Solid & Haz. Waste Management	VIWMA rules and regulations
Clean Water Act	-	Section 402	NPDES/TPDES
Clean Water Act	-	Section 303(b)	Bodies of water assessment - DPNR's *IWQMA Reports.*
Clean Water Act	-	Section 303(c)	Water quality standards - DPNR's *IWQMA Reports.*
Clean Water Act	-	Section 303(d)	Impaired waters list - DPNR's IWQMA Reports

Online Resources

Websites, archives, databases and maps.

Title	Entity	Description	URL
AGGRA *Atlantic and Gulf Rapid Reef Assessment*	AGGRA	Interactive map of coral data.	agrra.org/data-explorer
Allen Coral Atlas	Allen Coral Atlas	Interactive map of coral data.	allencoralatlas.org
CARICOOS *Caribbean Coastal Ocean Observing System*	Integrated Ocean Observing System (IOOS)	Interactive map of coral data.	caricoos.org
ECHO *Enforcement and Compliance History Online*	EPA	Interactive maps of TPDES compliance and permits.	echo.epa.gov/facilities/facility-search/results
Healthy Reefs for Healthy People	Healthy Reefs for Healthy People	Dedicated website to coral conservation.	healthyreefs.org
How's my Waterway?	EPA	EPA waterway ratings based on aquatic life and recreation.	mywaterway.epa.gov/state/VI/water-quality-overview
MERMAID *Marine Ecological Research Management Aid*	MERMAID	Interactive map of coral data.	datamermaid.org
NOAA Archive CRCP *Coral Reef Conservation Program*	NOAA CRCP	CRCP publications archive.	www.coris.noaa.gov/activities/archive21.html
NOAA CoRIS USVI Portal *Coral Reef Information Science*	NOAA CoRIS	Direct database for USVI coral reefs.	coris.noaa.gov/portals/virginislands

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Online Resources

Title	Entity	Description	URL
Ocean Sewage Alliance	Ocean Sewage Alliance	Dedicated website to ocean sewage mitigation.	www.oceansewagealliance.org
Prioritizing Sites for Coral Reef Conservation	NOAA NCCOS	Reference to reef prioritization from 2013 - 2016.	coastalscience.noaa.gov/project/prioritizing-sites-coral-reef-conservation-us-virgin-islands
Reef Resilience Network	Reef Resilience Network	Dedicated website to coral conservation.	reefresilience.org
Ridge to Reefs	Ridge to Reefs	Dedicated website to coral conservation.	ridgetoreefs.org
St. Croix East End Marine Park Story Map	St. Croix East End Marine Park, DPNR	Interactive map of the park's natural resources and tourism activities.	http://arcg.is/295Hzbx
Sustainable Sanitation and Water Management Toolbox (SSWM)	SSWM	Dedicated website to understanding wastewater management.	sswm.info/home
Types of Septic Systems	EPA	Reference for understanding septic systems.	www.epa.gov/septic/types-septicsystems#conventional
USVI Beach Advisories	DPNR	Weekly beach advisories for the Territory.	dpnr.vi.gov/home/weekly-beach-advisory

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Online Resources

Title	Entity	Type	URL
USVI Coral Reef Prioritization Digital Atlas	NOAA NCCOS	Interactive map of coral data.	https://tinyurl.com/4p4w42ee
US Virgin Islands Code	Justia Law	Online portal for the VI Code.	law.justia.com/codes/virgin-islands/2019
USVI TCRMP *Territorial Coral Reef Monitoring Program*	UVI, DPNR, NOAA	Dedicated website for coral reef monitoring in the USVI	sites.google.com/site/usvitcrmp
VI Coral Disease	VI-DAC	Dedicated website for coral disease in the USVI.	vicoraldisease.org
Wastewater Alternatives & Innovations	Wastewater Alternatives & Innovations	Dedicated website for wastewater mitigation.	waicleanwater.org
Wastewater Pollution Course	Reef Resilience Network	FREE online wastewater pollution course for marine managers.	reefresilience.org/wastewater-pollution-mentored-course-virtual-2021
Coral Bay Community Council - Water and Wastewater	CBCC	Dedicated webpage for improving water quality and wastewater pollution in the USVI.	coralbaycommunitycouncil.org/water-and-waste-water
Water Quality Data	Nat'l Water Quality Monitoring Council	Database and archive for water quality measurements.	waterqualitydata.us
Watershed Management Plans	Watershed Consulting, DPNR	Dedicated website for watershed management plans.	https://tinyurl.com/7r4ydesv

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A CONCLUSION

From the author.

You have the resources. Whether you're wondering about St. Croix's water quality or how soil suitability may impact your OSDS, the information is available. The next step is to understand how to best utilize this information as there are many...

"...practical challenges of dealing with...[wastewater], the diversity of pollutants involved, the high cost of water-treatment facilities, and bureaucracy. The solutions to reducing and understanding the exact impacts of coastal pollution...have been lacking because of the inherent difficulties of monitoring and evaluating nonpoint sources of pollution, along with jurisdictional issues such as agency and private land conflicts." [6]

It sounds like a lot to overcome, but with these challenges come various solutions. During my informal interviews and literature review, I came across ideas and recommendations for managing land-based pollution and wastewater. Ideas such as establishing a Wastewater Resilience Council that initiates projects and provides resources for the public [32]. I read about recommended studies for alternative OSDS in St. Croix; studies that could better evaluate OSDS functionality and the best available alternatives [29]. I've perused coral reef conservation priorities as written by both NOAA and the DPNR. I've heard about the need for better OSDS regulations and long-term enforcement, for more trained and dedicated engineers in VIWMA and EPA Region 2, for an increase in ownership and decrease in blame, and for the execution of already written plans.

In order to meet these needs and see solutions come to fruition, we must bridge the many gaps and think more...

"...creatively to solve this problem, by forging partnerships among human health organizations, sewage infrastructure and treatment experts, entrepreneurial groups, and development and environmental conservation organizations. Sewage pollution is a global threat that humans and coral reefs share. **Combining forces across organizations in traditionally non-interacting sectors...is essential if we are to address the strain of human sewage in our reef systems and their associated human communities**. " [6]

ACKNOWLEDGEMENTS

I would like to thank the individuals, organizations, and agencies who took the time to answer my questions and to provide additional references. Thank you for your time, encouragement, and resources.

The US Virgin Islands Department of Planning and Natural Resources
Department of Environmental Protection
St. Croix East End Marine Park

The Coral Bay Community Council
Wastewater Workshops 2020 & 2022

The University of the Virgin Islands
MMES Program & Environmental Analysis Lab

EPA Region 2
Wastewater Workshop Attendees

Individual consultants, representatives and St. Croix residents!

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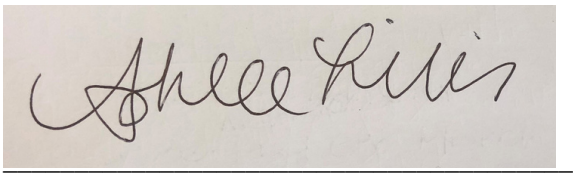
Capstone Committee Signatures

Ashlee Lillis

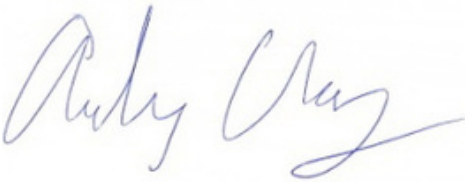


Signature

6/13/2022

Date

Amelia Wegner

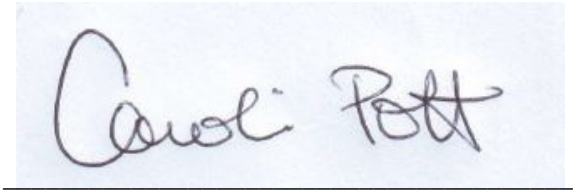


Signature

6/13/2022

Date

Caroline Pott



Signature

6/13/2022

Date

Brian Zgliczynski

Signature

6/13/2022

Date