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BUILDING RESILIENCE IN THE WATER & WASTE INDUSTRIES
CWWA CARIBBEAN WATER AND WASTEWATER ASSOCIATION 30th Annual Conference and Exhibition
THE CAYMAN ISLANDS
3-8 OCTOBER 2021

The Benefits of NB-IoT for Non-Revenue Water Reduction Implementation

Paul Fanner, Director, Fanner & Associates Ltd.

Fanner & Associates
Specialists in Optimizing Water System Operations

Agenda

- NRW in the Caribbean
- Data Requirements
- Telemetry Options
- Conclusions

NRW in the Caribbean

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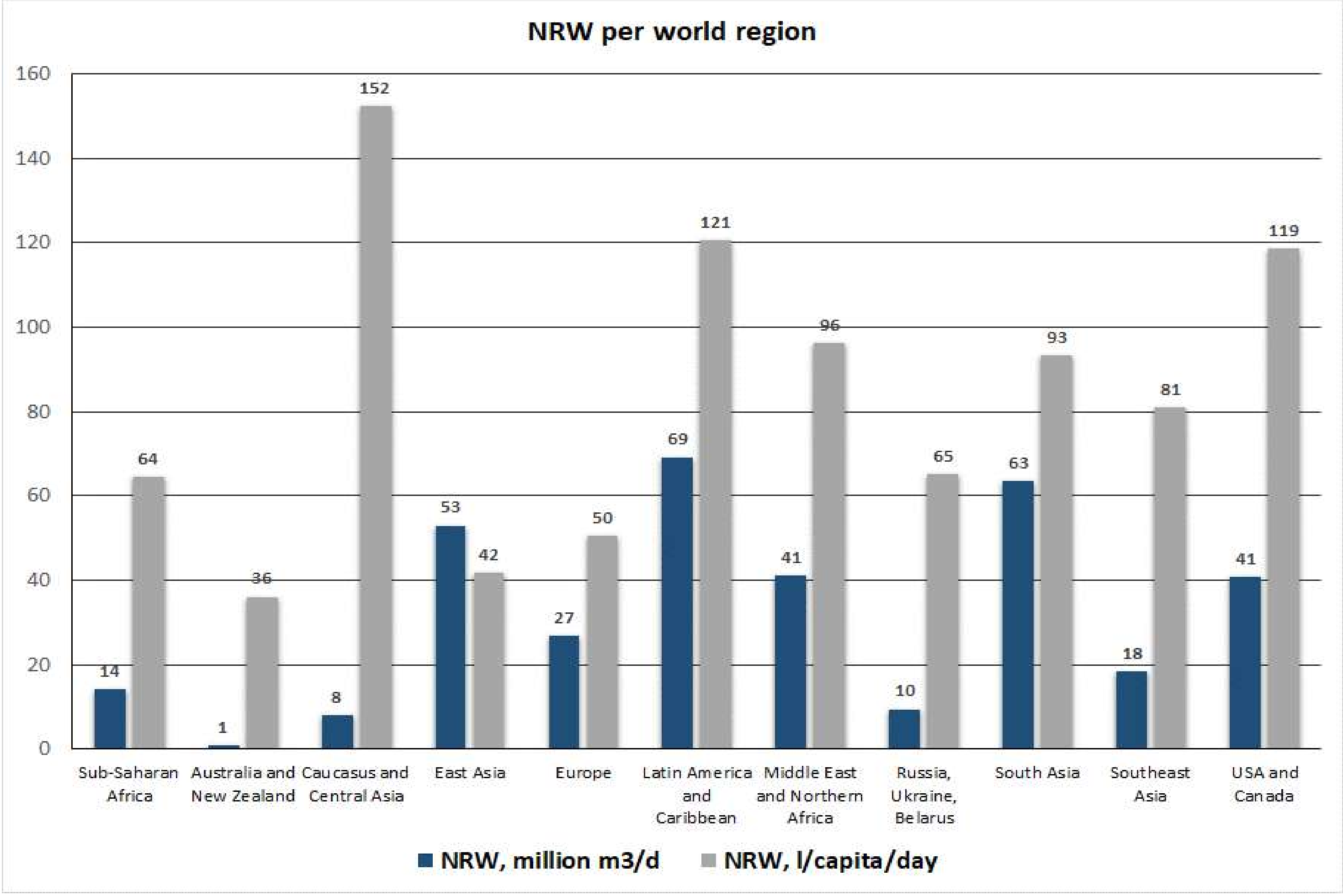
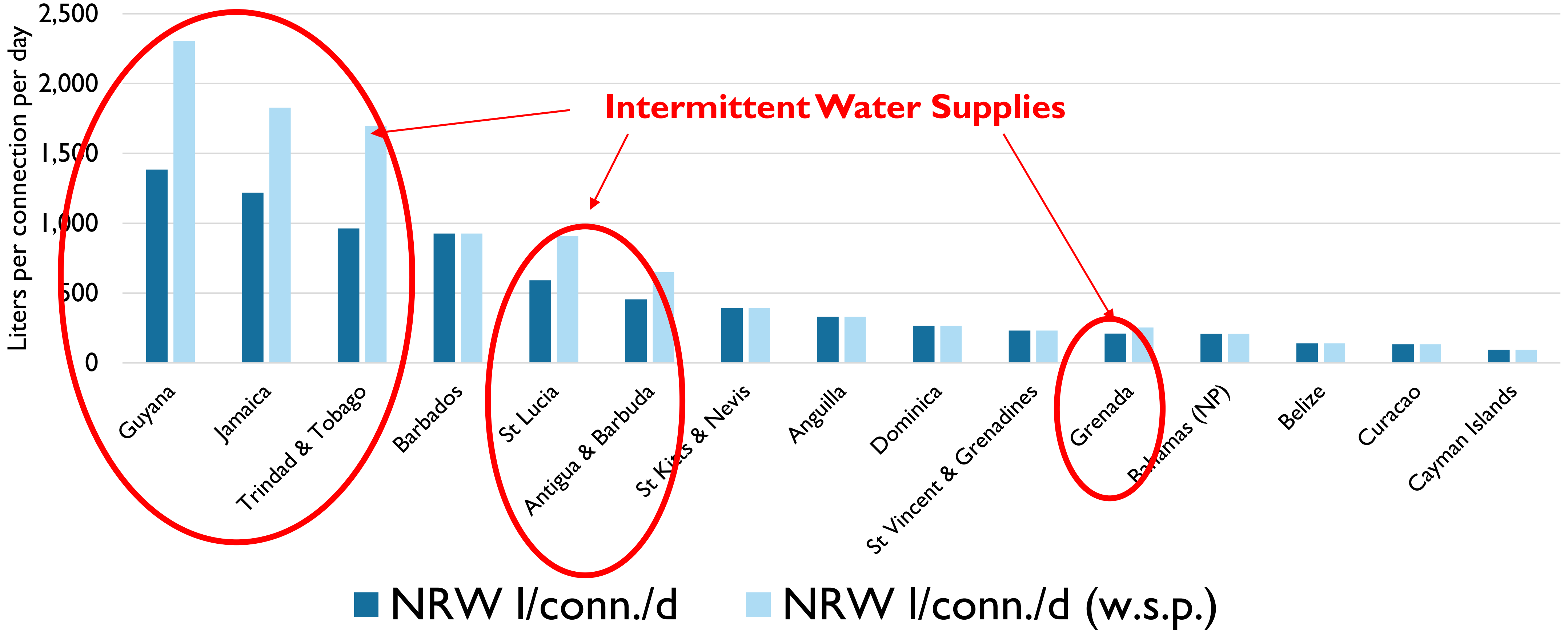
Average Caribbean NRW Levels High



Source: Wyatt, Liemberger, 2019

NRW Varies – Highest Islands Also Have IWS



Source: Wyatt, Liemberger, 2019

Impacts of Climate Change in the Caribbean

- 7 Caribbean countries already identify by UN as having extremely high levels of water stress
- Caribbean water resources suffering severely from climate changes
  - Hotter, drier
  - Extreme variability in rainfall
    - Reduced rainfall
    - Droughts more intense and more frequent
    - More intense storms / hurricanes
      - Heavy rains, Flash flooding
    - Increased saline intrusion – rising sea levels
    - Reduced raw water quality
  - Reduced capacity of existing water resources

- Increased intermittent water supplies (IWS)
- Limited traditional new water resource availability - costly if available
- RO water resources becoming the only solution for new water resources
  - Much higher marginal costs of production

Impacts of High NRW for Water Utilities

- High operating costs
- Poor customer service
- Loss of revenues
- IWS
  - Spiral of decline
  - Increases in breaks / leaks
  - ALC very difficult
  - Increasing NRW

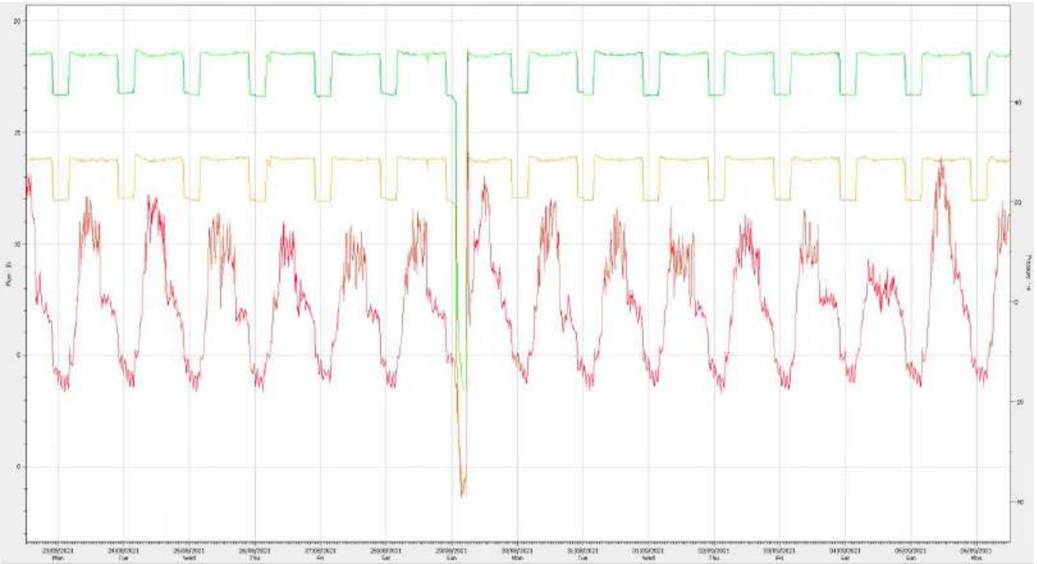
Solution?

- Caribbean water utilities must take effective action to reduce NRW
  - Stop the cycle of decline
  - Improve utility finances and customer service
- Sustainable NRW reduction is extremely cost effective
  - Use existing water resources efficiently
    - Eliminate IWS, improve customer service, meet new demands
  - Defer new water resource development
- The majority of NRW is always due to physical losses
  - NRW reduction strategy must effectively reduce physical losses

Data Requirements

If You Can't Measure It, You Can't Manage It!

- Effective physical loss reduction needs a lot of time series data:
  - System input volumes
  - Flows into / out of pressure zones and DMAs
  - PRV inlet / outlet pressures
  - PRV controllers
  - Critical point pressures
  - Average zone pressures
  - Storage tank levels / inlet outlet flows
  - Large customer consumptions
  - Leak noise loggers / leak noise correlators
  - Etc.



Caribbean Distribution Networks

- High break rates
- High rate of reoccurrence of leakage
- Need small DMAs to focus leak detection and keep losses low
- Many data collection points!
  - Typically hundreds..
  - Distributed throughout the distribution network
  - Mostly in locations with no power supply

Data Communication Requirements

- Real time data not required for physical loss reduction
- Data received once a day, ideally early in morning, is sufficient
  - Enables daily assessment of NRW in each DMA
- Reliable data communications important
- Data resolution
  - Minimum 15 minute average data
  - But higher resolution data (eg 1 minute average data) gives better insight of the reasons for variations in trends.
  - For pressure loggers, ability to switch into very high frequency logging to record damaging pressure transients is very useful

Telemetry Options

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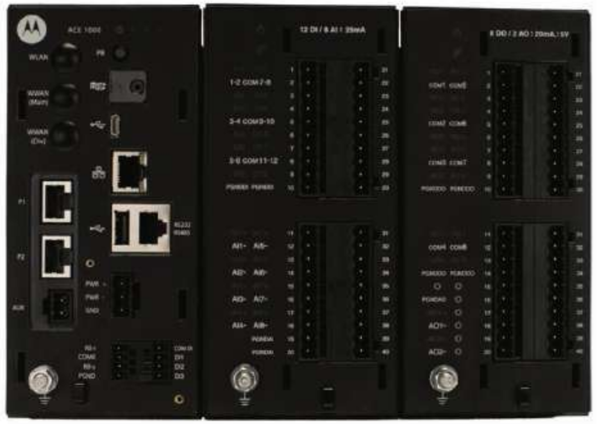
SCADA

- Possible solution if money is no object!
  - Not necessary – real time data not required
  - Can be useful for system input meters, in order to immediately identify any failure of the system input flow data recording, however alarms can be configured on any telemetry logger to provide this information.
  - Most expensive solution
  - Need to include budget for:
    - Environmental protection of SCADA RTUs (IP 68)
    - Provision of power to each RTU eg solar power / supply from street lighting etc.



Conventional Cellular Data Loggers

- Using 2G / 3G or 4G cellular modems
- Much cheaper solution than SCADA RTUs
- Stand-alone battery powered (lithium batteries)
- Environmental protection to IP 68
- Have been the main technology chosen to support NRW reduction projects for many years
- But these data loggers suffer from several problems..

Problems with Cellular Data Loggers

- Network not owned by utility – no control over network operators
- Cellular network operators continually upgrading technology to satisfy demands of mobile phone customers
  - Data loggers using older technologies rendered obsolete as old technologies are phased out by the operator – unless modem card can be replaced.
  - Logger manufacturers are reluctant to support latest technology because each new cellular technology requires more battery power.
- Communication from chambers is poor
  - Telemetry pillars and / or external antennas often required

- Poor data connections cause high battery drain
  - Battery replacements quickly required. But shipping lithium batteries is a problem!
- High data communication costs

NarrowBand-Internet of Things (NB-IoT)

- A new communication standard that was agreed in 2016
- A standards-based low power wide area (LPWA) technology
- Developed to enable a wide range of new IoT devices and services
  - To support the development of Smart Cities
- Rapid adoption across the world. NB-IoT now operational with 158 network operators in 83 countries, but as yet no operational NB-IoT networks in the Caribbean
- Several of the data logger manufacturers now offer NB-IoT versions of their data loggers
  - Provide considerable benefits over 2G, 3G or 4G technologies

Benefits of NB-IoT Data Loggers

- Considerably lower power consumption
  - 5-10 x less than 3G / 4G
  - Much longer battery life
- Significantly improved underground coverage
  - No need for telemetry pillars / external antennas
- Much lower communication costs
- Separate from mobile phone communication technologies
  - Will not become obsolete
- Overall lower costs of ownership and operation
- A much better technology to support NRW reduction projects

Conclusions

Conclusions

- Caribbean water utilities must take effective action to reduce NRW
- Sustainable NRW reduction is extremely cost effective
- NB-IoT Data Loggers / PRV controllers / Leak noise loggers
  - Much better communication technology to support NRW reduction projects
  - Will reduce the technology costs of implementing NRW reduction projects
- Caribbean water utilities should lobby cellular operators / governments for the introduction of operational NB-IoT networks in the Caribbean

Any Questions?

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Drafting Project Specifications for SWRO Facilities: Best Practices and Lessons Learned

Ahmed Elsheshtawy, PE
Engineer – Water Production
Water Authority - Cayman

Agenda

Water Authority - Cayman

1. Importance of Effective Specifications
2. Project Scope
3. Project Information and Studies
4. Process and Technology
5. Standards and Materials
6. Instrumentation and Control Systems
7. Project Documentation
8. Energy Consumption
9. Operation and Handover

1. Importance of Effective Specifications

Water Authority - Cayman

- *98% of infrastructure projects suffer cost overruns of more than 30%; 77% are at least 40% late**

- Ensure better value for money
- Ensure low O&M costs
- Ensure a smooth transfer of plant operations

- Avoid cost and schedule overruns
- Manage/mitigate project risks
- Avoid disputes

**McKinsey (2017)*

2. Project Scope

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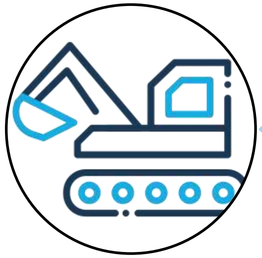
Product Standards

- Application
- Quality
- Quantity



Construction Outcomes

- Buildings, civil works, electrical works
- Intake and Outfall
- Pre- and post-treatment
- Salt removal
- Storage and Distribution

Parts and Equipment - Pumps, motors, membranes, filters, auxiliary systems, instrumentation, etc.

3. Project Information and Studies

Water Authority - Cayman

- Feasibility study/ business case
- Pilot testing
- Bathymetric
- Hydrogeological
- Source water quality
- EIA
- Common issues specific to region (e.g., red tide)

Project Studies

- Trade and Business
- Procurement
- Planning
- Environmental
- Employment/ Immigration

Local Laws and Regulations

4. Process and Technology

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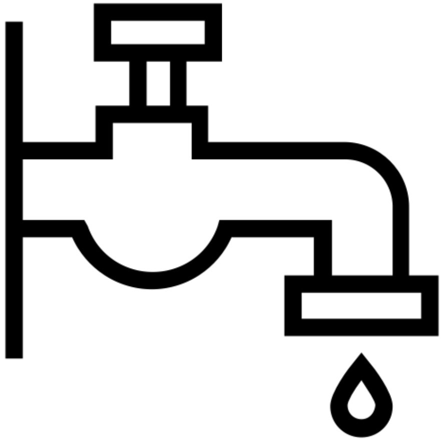
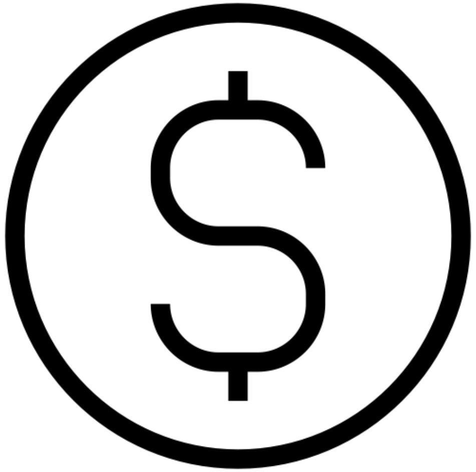


- Depends on the project
- Leverage your experience
- Leverage market expertise
- Technology – rewards vs. risks
- Design for low O&M



5. Standards and Materials

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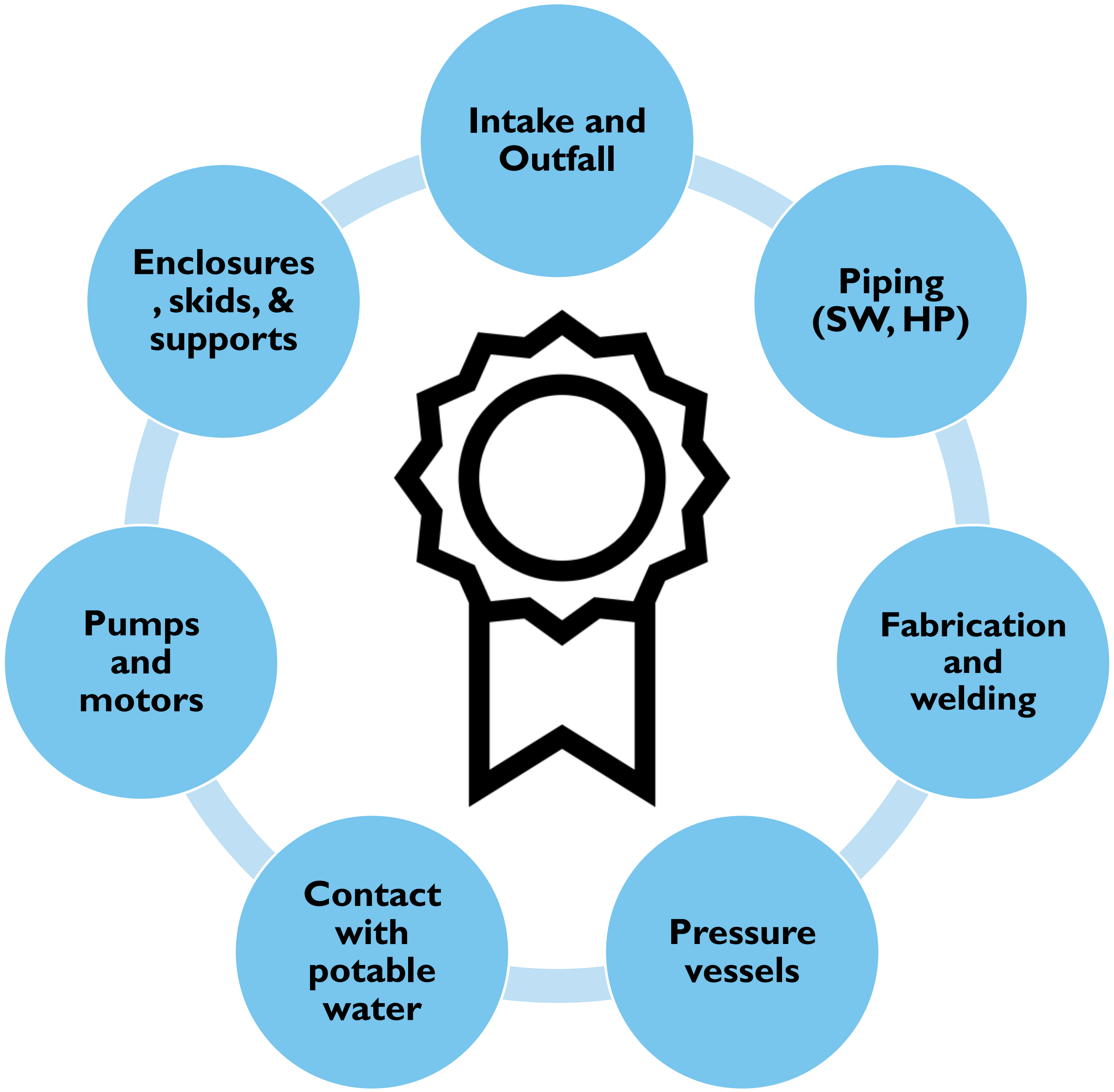


6. Instrumentation and Control Systems

Water Authority - Cayman

Data acquisition method and frequency

Notifications and alarms

8-hr vs. 24-hr staff operation

What data to collect

Accessibility, integration, and security

7. Project Documentation

Water Authority - Cayman

Design Documents

Software – PLC, HMI, SCADA

Spare part lists/inventory

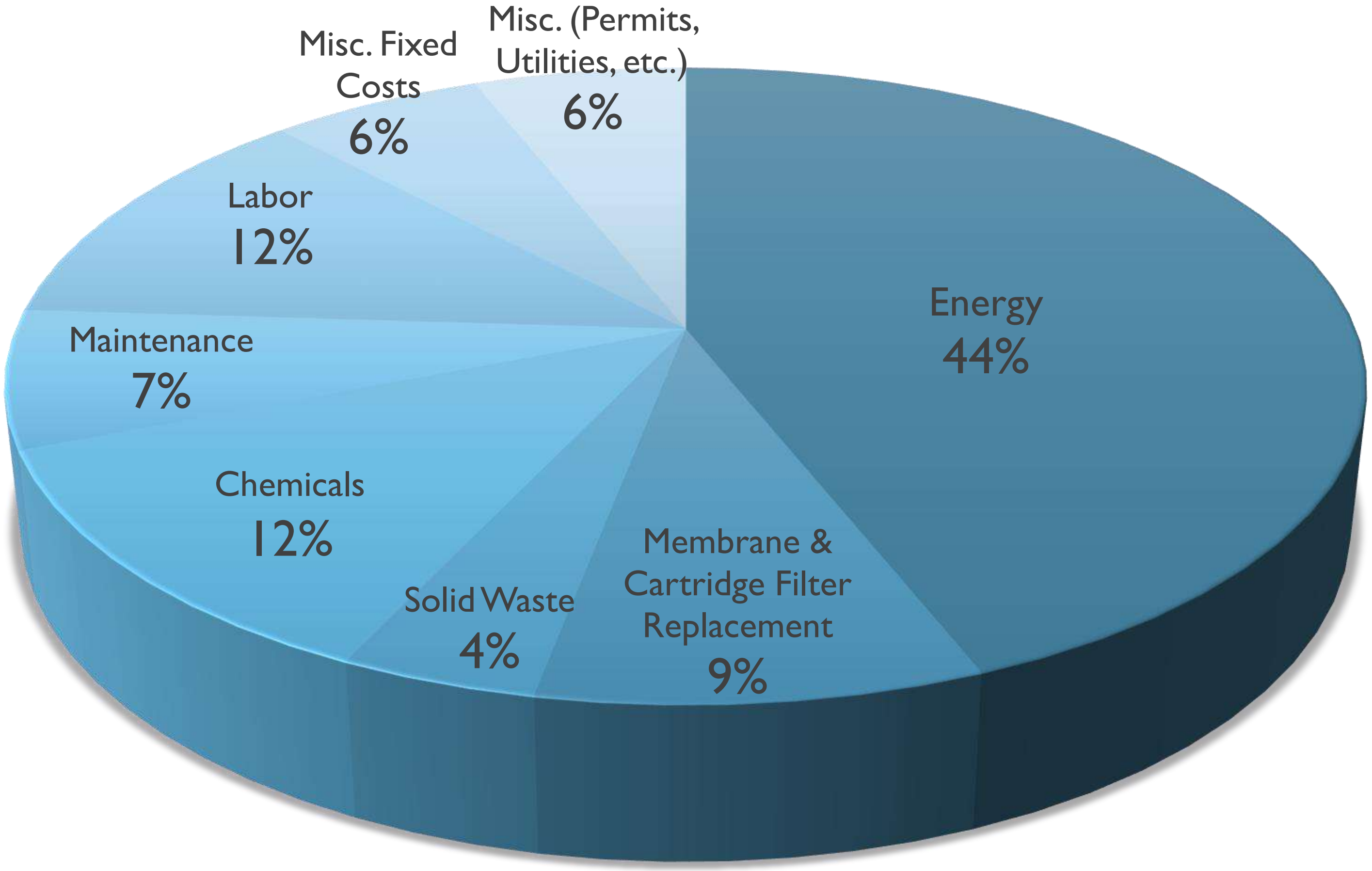
Drawings – PFDs, P&IDs, design, shop, as-built

Equipment vendors/IOM manuals

Maintenance Plans and SOPs

8. Energy Consumption

Specific Energy Consumption (kWh/m3 or kWh/kgal)



Typical SWRO OPEX Breakdown

9. Operation and Handover

Water Authority - Cayman

Cleaning/Backwash Systems

Inspections and Performance Tests

Chemicals Storage, Handling, and Disposal

Disaster Preparedness

Reporting – info, frequency

Training Expectations

In Summary

- The more *information* you collect and provide, the better
- Ask questions and seek *feedback*
- Make sure the specifications utilize the *expertise of the market*
- Make sure the bidding team has the *right mix* of skills and experience
- A relationship based on *collaboration and communication* is the best way to go

Water Authority - Cayman

*“The **Bitterness of Poor Quality** remains long after the Sweetness of Low Price is Forgotten.”* - Benjamin Franklin.

Thank you!

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Water Reuse and Resiliency: From Florida to the Caribbean?

30th Annual Caribbean Water and Wastewater Association (CWWA) Conference and Exhibition: Cayman Islands

October 5, 2021

Kevin Carter,

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Paper and Presentation Main Themes

- Water reuse is a global resilience tool for drought and other water supply pressures (e.g., population growth):
  - Florida is a national leader in the USA for water reuse.
- Many Caribbean nations are water scarce or have drought prone regions:
  - Climate change expected to worsen Caribbean water scarcity and drought conditions.
- Initiatives to improve Caribbean wastewater management and infrastructure include water reuse concept.
- Collaboration with Florida Water Sector can facilitate water reuse development to improve Caribbean drought resilience while improving wastewater management.

What is Water Reuse?

- Water reuse is treating wastewater, stormwater, saltwater or graywater as needed for a beneficial use (One Water Concept* and Integrated Water Resources Management**).
- Reclaimed water and recycled water are often used interchangeably with term water reuse.
- For this presentation and paper, focus is on water reuse from municipal wastewater effluent treated for uses shown on figure.

* For example see One Water Los Angeles, **Guiding Principles (lacitysan.org)**

** See United States Environmental Protection Agency. 2020. National Water Reuse Action Plan. https://www.epa.gov/sites/default/files/2020-02/documents/national-water-reuse-action-plan-collaborative-implementation-version-1.pdf.

Figure from Rodriguez, D. J.; Serrano, H. A.; Delgado A.; Nolasco, D.; Saltiel, G. for World Bank 2020. https://openknowledge.worldbank.org/handle/10986/33436

Water Reuse is a Global Resource

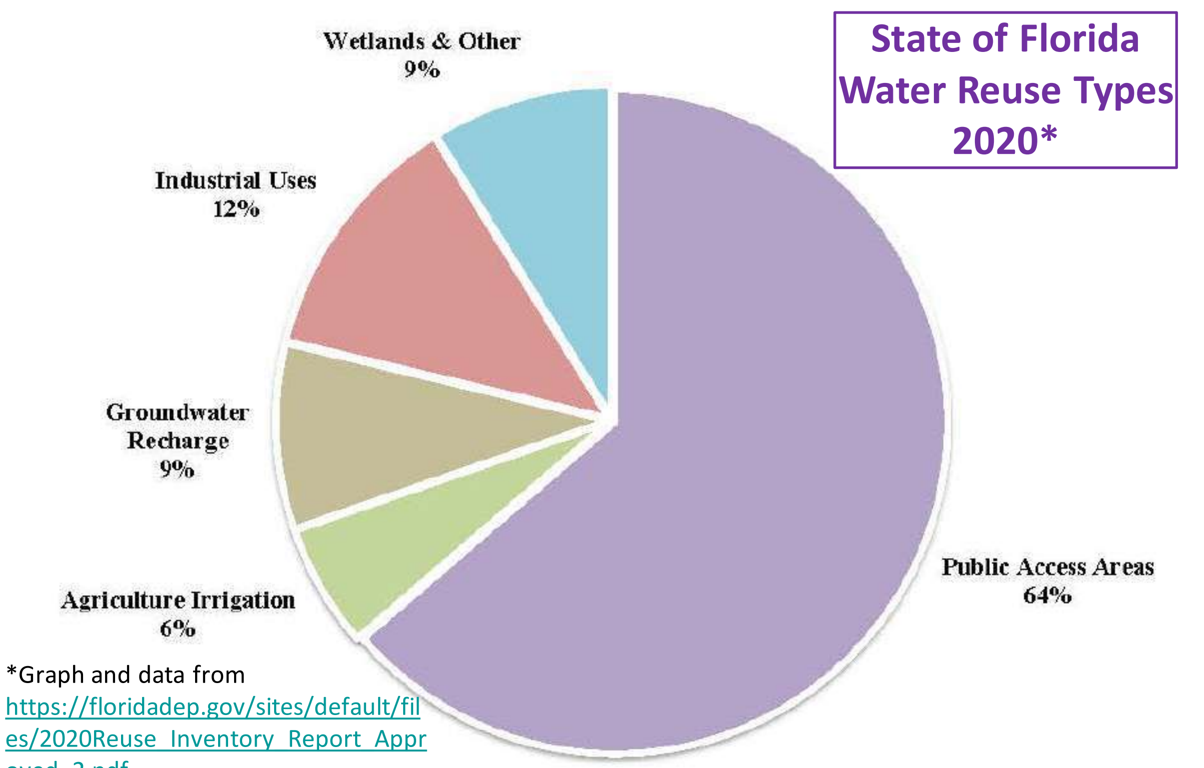
Photo from https://www.kkl-jnf.org/water-for-israel/water-reservoirs

Photo from https://www.pub.gov.sg/watersupply/fournationaltaps/newater

- Israel reuses 90% of its municipal wastewater*, primarily for agriculture.
- Singapore produces 40% of its public drinking water needs from potable reuse and plans to expand to 55% by 2060.**
- In 2015, State of California produced 82 billion gallons for agriculture use, 31% of total state water reuse production.***

* https://www.waterworld.com/international/wastewater/article/16202781/israel-reuses-nearly-90-of-its-water
** https://www.pub.gov.sg/watersupply/fournationaltaps/newater
*** https://watereuse.org/wp-content/uploads/2019/05/California-Recycled-Water-Milestones-Poster-2-20-2019.pdf

The Florida Water Reuse Story



*Graph and data from https://floridadep.gov/sites/default/files/2020Reuse_Inventory_Report_Approved_2.pdf

Photo from https://www.sfwmd.gov/our-work/alternative-water-supply/reuse

- Florida a national leader with 884* million gallons (mgd) produced per day in 2020 (> 320 billion gallons per year).
- Public Access Areas # 1 = residential lawn, golf course, + parks irrigation.
- Smaller percentages are still relatively large volume:
  - For example, agriculture irrigation* = ~ 19 billion gallons per year.

The Florida Water Reuse Story: Historic Milestones

1967 – City of Tallahassee agricultural water reuse pilot project

1977 – City of St. Petersburg urban water reuse project

1986 – In Central Florida, Water Conserv II became "the largest reuse project of its kind in the world"

1989 – State of Florida* declares water reuse a state policy objective and creates first rules

1993 – Florida's water reuse Production tops 300 MGD**

1993 – State of Florida* initiates 2-phased rulemaking to redefine and expand reuse rules

* State of Florida refers to Governor and State Legislature if referenced to policy or law; Environmental agency, currently Department of Environmental Protection, for rules

** MGD = Million of Gallons per Day; source York and Wadsworth 1998, https://fwrj.com/articles/9811.pdf
~ = 1.36 billion liters per day

The Florida Water Reuse Story: Historic Milestones (cont.)

1994

State of Florida* enacts the APRICOT Act; 1 of 4 state laws created in 1990s to promote water reuse

1999

State of Florida* expands ground water recharge and indirect potable reuse rules; new pathogen monitoring required

2003

Florida's water reuse Production tops 600 MGD**

DEP** publishes water reuse strategy document to plan next 20 years

2005

State of Florida* passes law to greatly increase state funding for water reuse projects

* State of Florida refers to Governor and State Legislature if referenced to policy or law; Environmental agency, currently Department of Environmental Protection (DEP)**, for rules

** MGD = Million of Gallons per Day; source DEP's 2020 Reuse Inventory, https://floridadep.gov/sites/default/files/2020Reuse_Inventory_Report_Approved_2.pdf
~ = 2.72 billion liters per day

The Florida Water Reuse Story: Historic Milestones (cont.)

2008

State of Florida* enacts Ocean Outfall Law mandating five large SE Florida utilities change to 60% water reuse by 2025

2009-2013

DEP** and utilities meet for 4 years leading to State of Florida passing law clarifying water reuse ownership

2017

Florida's water reuse Production tops 800 MGD***

2019-2020

A Potable Reuse Commission releases report used by State of Florida* to enact law requiring potable reuse rulemaking

2021

State of Florida passes law effectively ending most surface water discharges by 2032 to increase water reuse

* State of Florida refers to Governor and State Legislature if referenced to policy or law; Environmental agency, currently Department of Environmental Protection (DEP)**, for rules

***MGD = Million of Gallons per Day; source DEP's 2020 Reuse Inventory, https://floridadep.gov/sites/default/files/2020Reuse_Inventory_Report_Approved_2.pdf
~ = 3.64 billion liters per day

The Florida Water Reuse Story: Key Takeaways

- Florida Legislature and Governor active interaction on water reuse:
  - Important for agency action, funding, and public support.
  - Many laws promoting water reuse also banned or limited surface water discharges.
- Proactive government agency who not only regulates, but promotes scientific and engineering development to enhance water reuse rules:
  - For example, Florida utilities' top annual water reuse award named after Dr. David York* who led the FDEP's efforts to grow water reuse in 1990s through 2010s.
- A proven need for the tool leads to its development:
  - For Florida, its driven by population growth and drought resilience.

* https://watereuse.org/about-watereuse/honorary-members/

Caribbean Drought Resiliency Needs

- United Nations' Food and Agriculture Organization (FAO, 2016*) listed seven Caribbean countries in the world's top 36 water-stressed countries:
  - Barbados listed in the top ten.
  - Agriculture sector listed as especially vulnerable to seasonal droughts.
- FAO (2016*), CWWA *Regional Strategic Action Plan for Building Governance and Resilience in the Water Sector* (RSAP) and numerous other sources state Caribbean must prepare for more climate change induced drought.
- Drought resiliency particularly important by itself but also due to several other water security driving forces described by Cashman's (2013**) four 'As':
  - Adequacy, Accessibility, Assurance, and Affordability.

*http://www.fao.org/americas/noticias/ver/en/c/419202/
** https://publications.iadb.org/publications/english/document/Water-Security-and-Services-in-The-Caribbean.pdf
Photo from http://rcc.cimh.edu.bb/drought-bulletin-caribbean/

Caribbean Wastewater Management Solutions

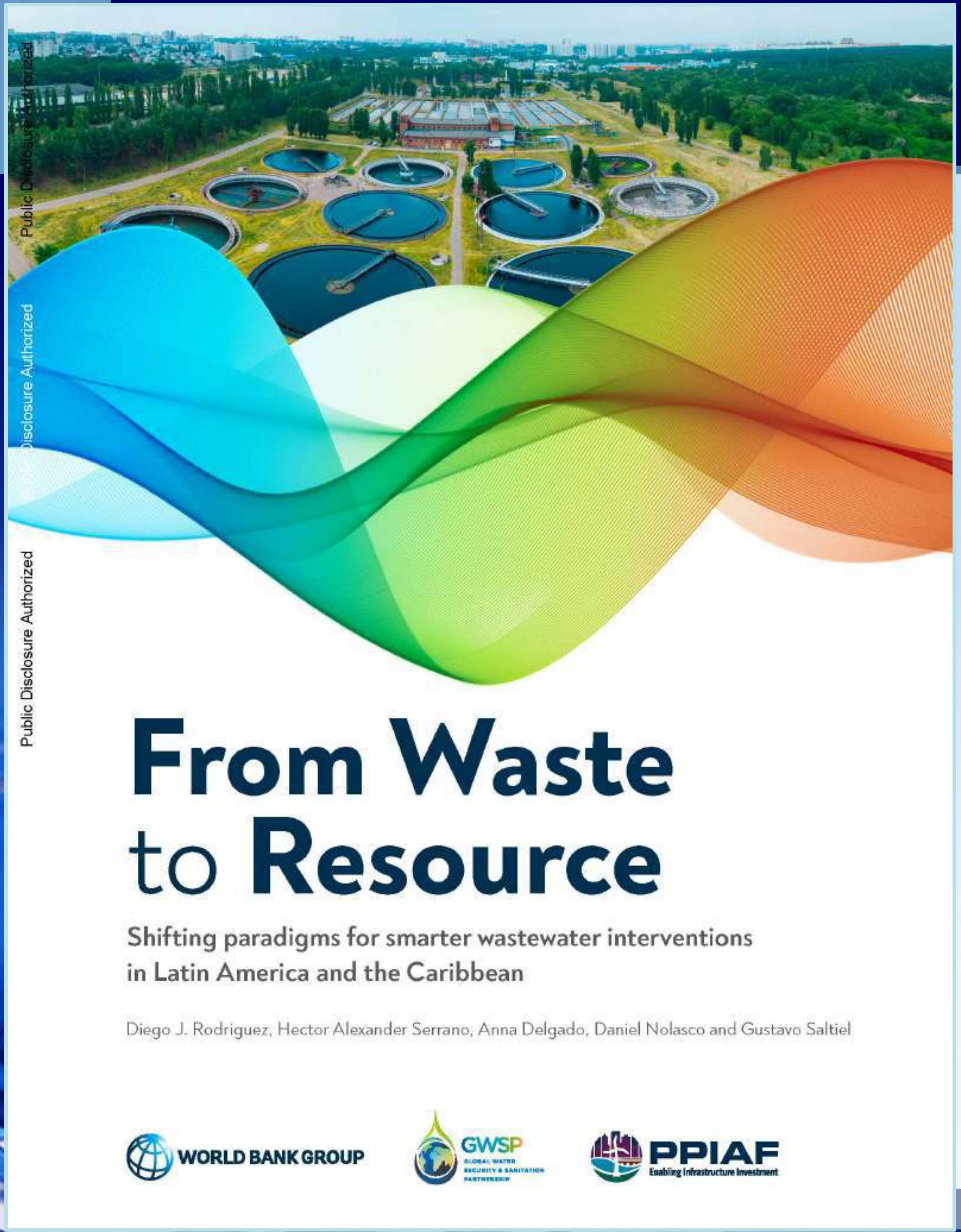
Countries Working with the Caribbean Regional Fund for Wastewater Management (GEF CReW+)**

**https://academy.gefcrew.org/en/gefcrew

- Approximately 80% of wastewater in Caribbean is discharged to the environment with no treatment.*
- Global Environmental Facility (GEF) financing and the Inter-American Development Bank (IDB) and UNEP co-implementing solutions via GEF CReW+.
- Among many goals, GEF CReW+ program seeks to*:
    - "Promote development of norms, strategies and policies."
    - "Identify sustainable finance mechanisms."
    - "Design and construct climate resilient wastewater treatment plants and sanitary facilities."
    - "Treat wastewater not as waste but as a valuable resource **with reuse potential**."

*https://academy.gefcrew.org/images/academy/GEFCReW-FactSheet_EN.pdf

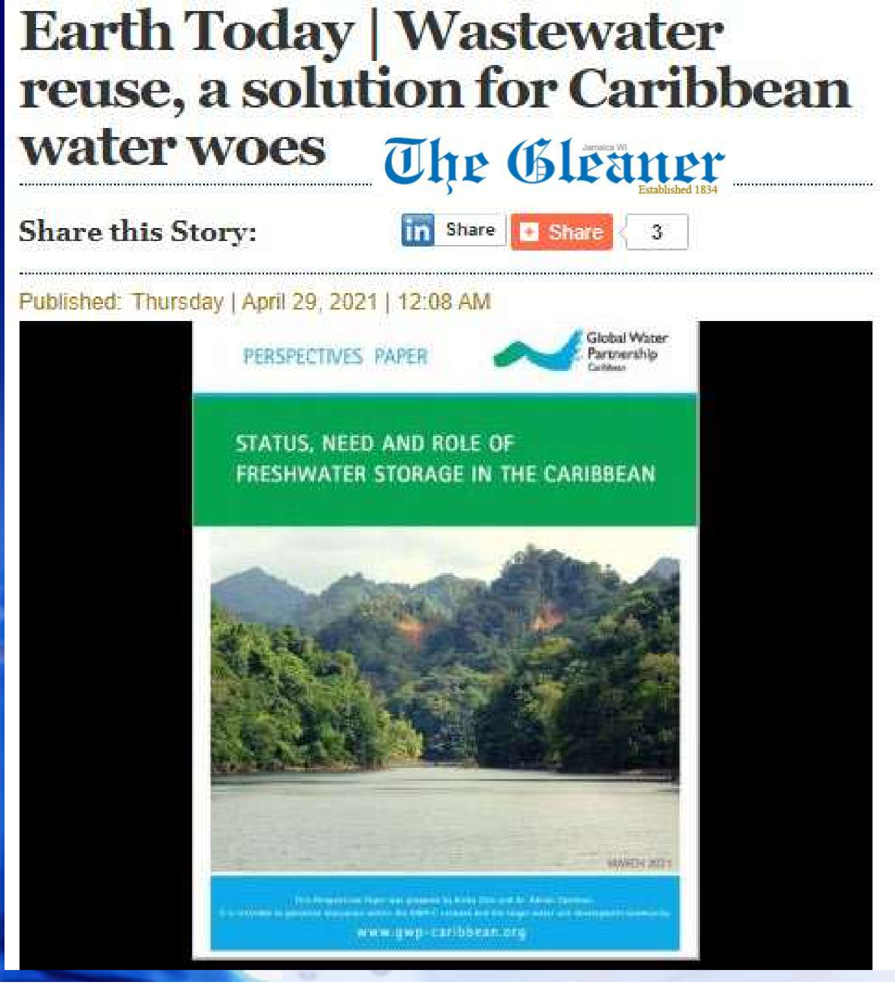
Caribbean Wastewater Management Solutions (cont.)



- World Bank's 2020 *Wastewater: From Waste to Resource** states: "Wastewater treatment is one solution to the water scarcity issue, and also to the problem of water security..."
- World Bank 2020's* 4 Action Steps:
  - "Plan wastewater within the river basin (watershed)."
  - "Move from wastewater treatment plant to water resource recovery facilities."
  - "Implement innovative financing and business models."
  - "Work on policies, institutions, and regulations."

*https://openknowledge.worldbank.org/handle/10986/33436

Combining Caribbean Drought Resiliency and Wastewater Management Solutions



https://jamaica-gleaner.com/article/news/20210429/earth-today-wastewater-reuse-solution-caribbean-water-woes
gwp-c-perspectives-paper---status-need--role-of-freshwater-storage-in-the-caribbean.pdf*

- Water reuse is one tool for Drought Resiliency:
  - Stormwater harvesting/storage; capturing freshwater lost to sea during heavy rainfall (see Global Water Partnership 2021*).
  - Water loss and non-revenue water solutions (note CWWA’s Water Loss Specialist Group recently formed).
  - Personal rainwater harvesting** and conservation techniques.
  - Peters*** (2015) in an Eastern Caribbean water reuse analysis emphasized a water reuse-desalination nexus.
- Water reuse from irrigation to potable reuse would be site dependent: “Right Reuse, Right Time, Right Place.”****

** http://www.caribbeanrainwaterharvestingtoolbox.com/index2.htm

***https://www.researchgate.net/publication/307824023_Wastewater_reuse_in_the_Eastern_Caribbean_a_case_study

**** http://prc.watereuseflorida.com/wp-content/uploads/Framework-for-Potable-Reuse-in-Florida-FINAL-January-2020-web10495.pdf

Positive News Headlines
Assist Policy Makers' and Public's Education

The Gleaner
Jamaica WI
Established 1834

Earth Today | 'Wastewater too valuable to overlook'

Published: Thursday | July 18, 2019 | 12:00 AM

https://jamaica-gleaner.com/article/news/20190718/earth-today-wastewater-too-valuable-overlook

The Barbados Advocate
Established October 1895

EDITORIAL - REDUCE AND REUSE WASTEWATER Wed, 03/22/2017 - 12:00am

https://www.barbadosadvocate.com/columns/editorial-reduce-and-reuse-wastewater

Jamaica Observer

Reclaiming water: A solution to one of Jamaica's problems

BY SANNETTE GRANT

https://www.jamaicaobserver.com/columns/reclaiming-water--a-solution-to-one-of-jamaica-s-problems_14126106

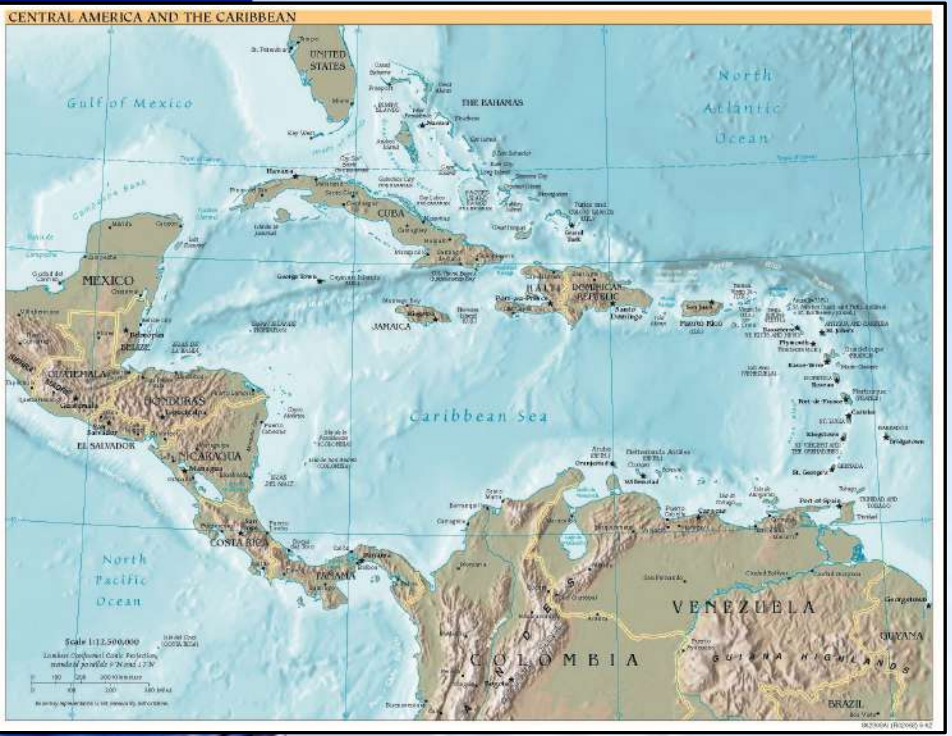
Trinidad & Tobago Guardian

Sat Jun 01 2019

Taking the yuck factor out of recycled water

https://www.guardian.co.tt/article/taking-the-yuck-factor-out-of-recycled-water-6.2.858141.9c295029dd

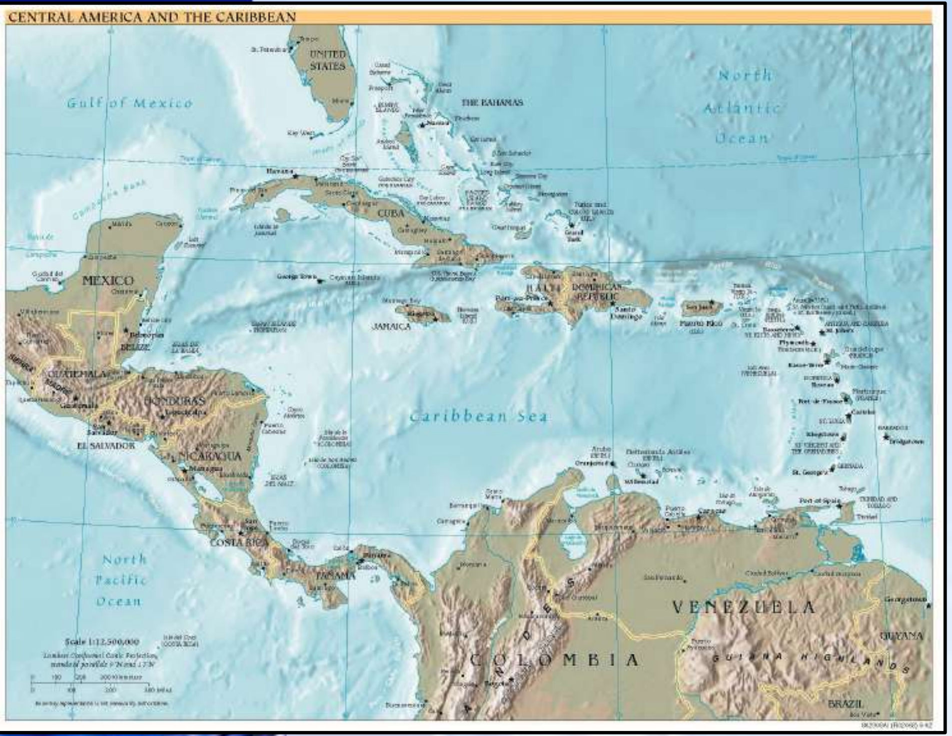
Recommendations for Florida and Caribbean
Water Reuse Collaboration



- Develop specialist work group(s) to focus on water reuse challenges and opportunities:
  - Regional feasibility assessment to identify gaps and opportunities.
  - Determine which nations/utilities ready to explore water reuse as resiliency tool and develop pilot projects.
  - Building political support and funding mechanisms.
  - Public education and acceptance.
  - Laws and regulation development.
  - Engineering and technical considerations.

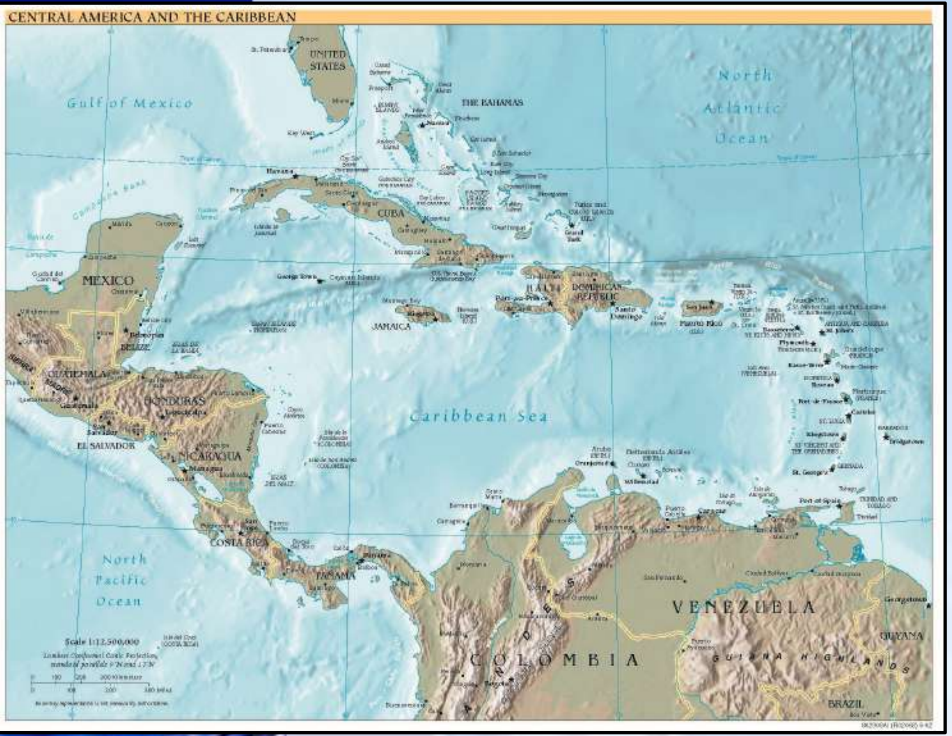
* Especially as identified by GEF CReW+ (2021), World Bank (2020) and Peters (2015) among others.

Recommendations for Florida and Caribbean Water Reuse Collaboration (cont.)



- Continue to build the Caribbean water reuse dialogue by hosting virtual seminars, in-person workshops, and field demonstrations.
- Develop a global catalog of water reuse projects, programs, and professionals to learn from and use to develop Caribbean water reuse.
- Develop water reuse twinning programs between the Caribbean and Florida.

Recommendations for Florida and Caribbean Water Reuse Collaboration (cont.)



- Work with CWWA, Caribbean Water & Sewerage Association (CAWASA) and partners to determine:
  - Appropriate timing and methods to promote water reuse with policy makers such as the High Level Forum of Caribbean Ministers Responsible for Water.
  - Feasibility to expand water reuse in the *Regional Strategic Action Plan for Building Governance and Resilience in the Water Sector* (RSAP).
  - Water reuse capacity building strategies including training needs and platforms.

Conversations Lead to Solutions – Let's Talk!
Time For Questions and Discussion

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CARIBBEAN WATER AND WASTEWATER ASSOCIATION THE CAYMAN ISLANDS | 2021

30 CWWA CARIBBEAN WATER AND WASTEWATER ASSOCIATION
ANNIVERSARY
1991-2021

Thank you CWWA and Cayman Islands for going Virtual Again in 2021!

Happy 30th Anniversary CWWA!

Great CWWA 2019 Memories from St. Kitts and N

Please join Special 30th Anniversary Session Tuesday Oct. 5th 3:00 - 4:00 p.m.

Kevin Carter

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An Integrated Water Resource Management Framework to Support Implementation of the Cartagena Convention

J. Eugenio Barrios O. International Consultant, eugenio.barrios.mx@outlook.com

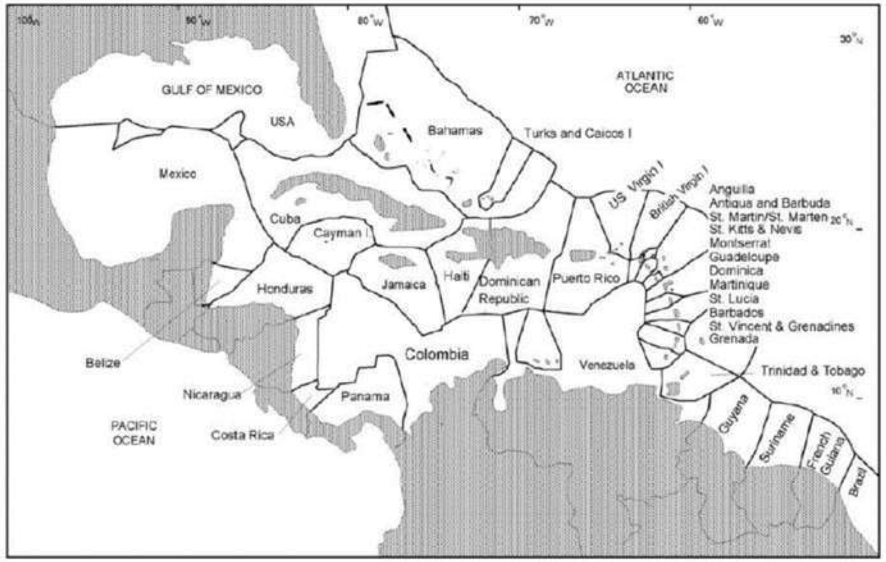
Christopher Corbin, Programme Officer, Cartagena Convention Secretariat, Ecosystems Division, United Nations Environment Programme (UNEP), Christopher.Corbin@un.org Christopher.Corbin@un.org

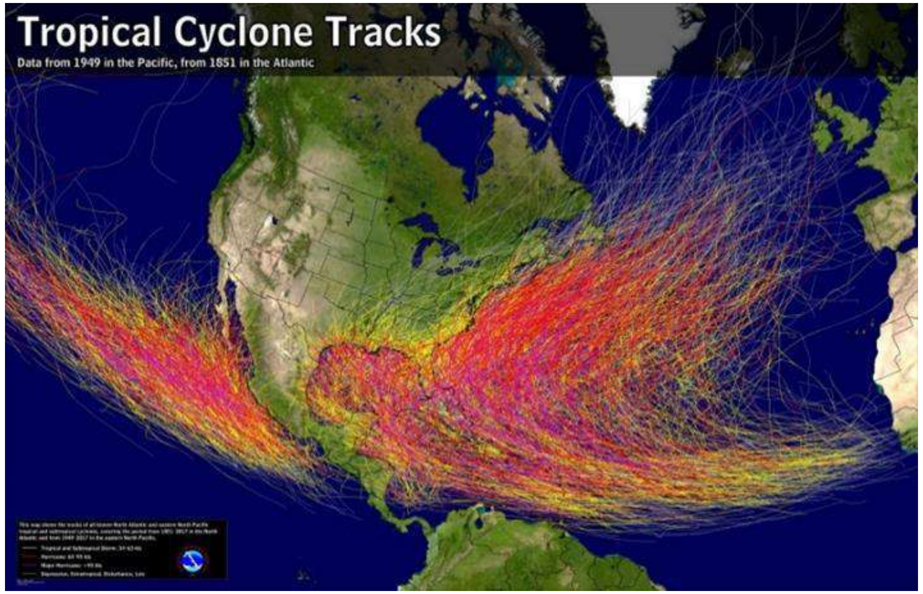
Cartagena Convention

- Regional legal framework for the protection and development of the Wider Caribbean Region (WCR)
- 3 protocols: land-based sources of pollution (LBS), oil spills and specially protected areas and wildlife (SPAW)
- After almost 20 years pollution prevention and control from wastewater and agricultural runoff is still a challenge for the region.

Challenges:

- Pollution
- Tropical cyclones (250K deaths, 2.4% GDP)
- Ocean Economy (USD 407 billion in 2012)





IWRM

A process *which promotes the coordinated development and management of water, land, and related resources to maximize the resultant economic and social welfare in an equitable and sustainable manner (UN Environment, 2018).*

Water Security: *The capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UN Water, 2013).*

The Water-Food-Energy Nexus. *It refers to the relationships among water, food, and energy security and the need for integrated planning.*

WATER IN THE SUSTAINABLE DEVELOPMENT GOALS

IWRM AND CLIMATE CHANGE, BIODIVERSITY, RESILIENCE

- Water is the number one priority for adaptation actions in most of the INDCs and is directly or indirectly related to all other priority areas (UNESCO, UN Water 2020)

- IWRM could become a powerful tool for biodiversity conservation if the ecological role of hydrological regimes is understood

- IWRM is a powerful approach that needs to be reinforced with other approaches to have a unified resilient response to future risks

A new IWRM approach

- Water resource management must be an independent process, out of the control of any sector

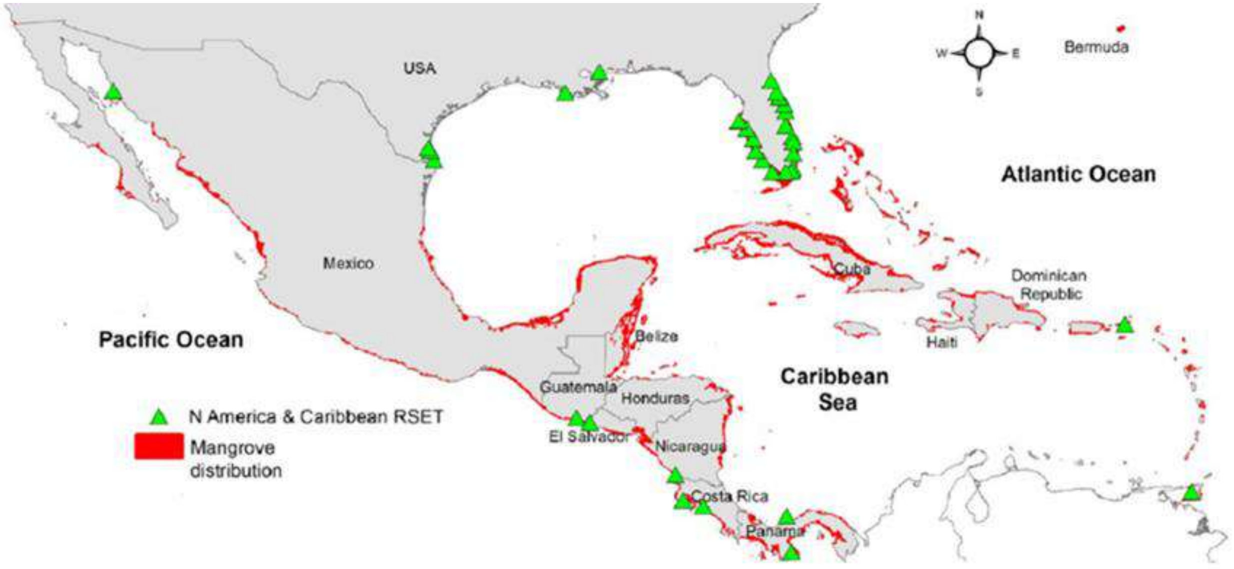
- There is a strategic and a unique opportunity to develop an IWRM process in those places where there´s no conflict yet.

- Integrate climate change, health and development solutions under a resilient goal and common principles

AN IWRM FRAMEWORK TO SUPPORT IMPLEMENTATION OF THE CARTAGENA CONVENTION AND ITS PROTOCOLS

COMMON PRINCIPLES

- Ecosystem-based management
- Source-to-sea (S2S)
- Sustainable consumption/production
- Natural capital approach
- Science-policy interface
- Resilience Building
- One-Health for All
- Public participation (Escazu Agreement)



KEY IWRM ACTIONS

A water governance model must be in place to support authority on each country.

Any solution must be part of a IWRM Plan to ensure: governance, goals, feasibility, accountability, efficiency.

Water Governance

Water for the environment (Eflows/ S2S)

Water Budget and Allocation

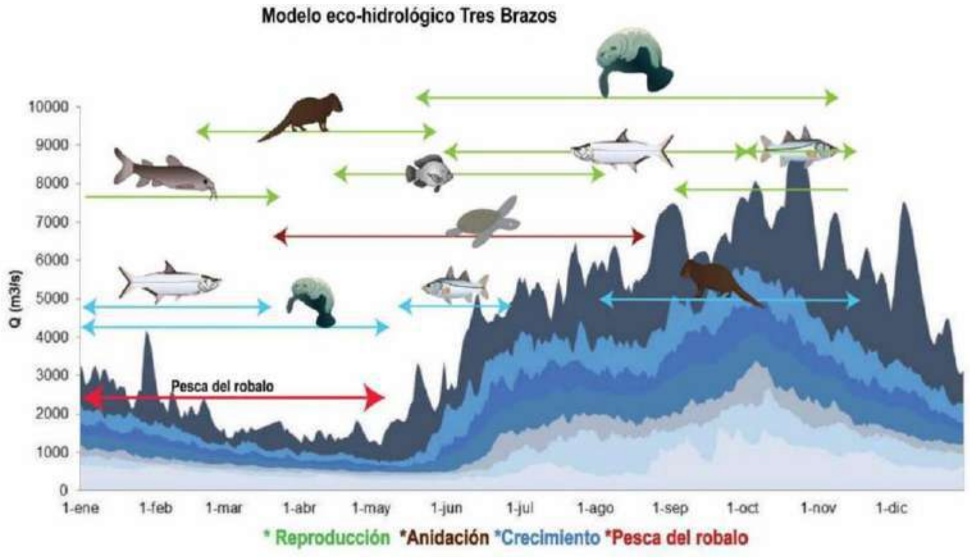
Disaster Risk Reduction/Management

Planning (Integral Solutions)

Financial mechanims

Information and knowledge management

I & KM must be part of the management process to support participation

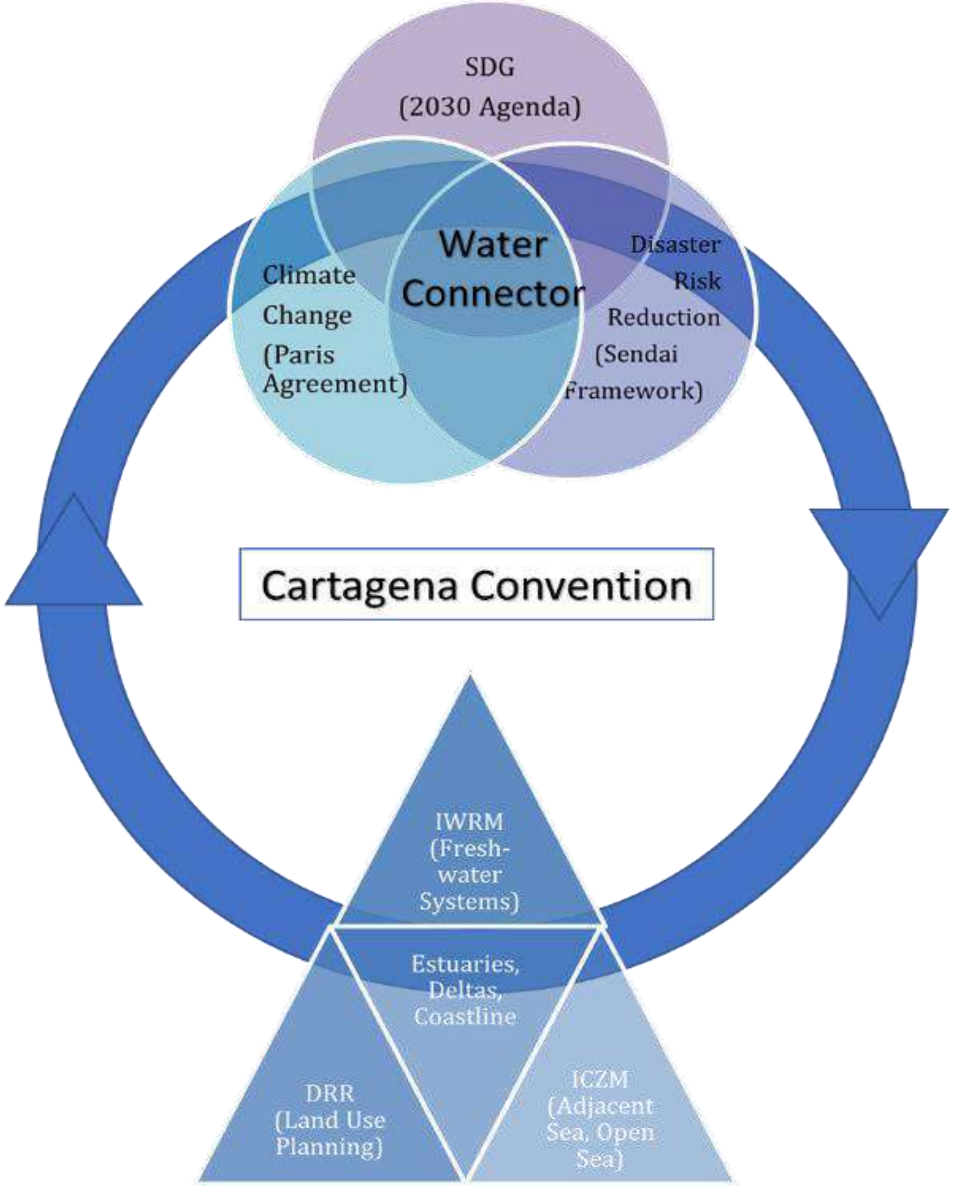


Integration of ecosystem services and resource recovery practices is an opportunity to propose other financial sources

- Water budget and allocation could be considered the core activity of water resource management.

The Sendai Framework for Disaster Risk Reduction 2015-2030

Conceptual framework



Principle	IWRM	ICZM	DRM
Ecosystem-based management	*Ecological flows based on hydrological regime/hydroperiod of coastal ecosystem including water quality (pollution, sediments, nutrients)* *Land use plans for coastal ecosystems risk reduction* *River basin green infrastructure for DRM*		
S2S	*Protect water catchment, storage and distribution* *Regulate water uses* *Ensure connectivity*	*Set limits to sediment and nutrient loads* *Define ecological process for migratory species*	*Define river hydraulic capacity for protection (floodplains, riparian corridors)* *Avoid invasion of flood prone areas*
Sustainable consumption	*Water use efficiency* *Wastewater resource recovery*	*Fisheries* *Deltas and estuaries protection*	*Specific risk reduction plans for economic sectors*
Natural Capital	*Integrated value of coastal ecosystem services (e.g., Mangrove Management)*		
Resilience building	*River basin resilience (water resilience + coastal resilience)*		
Science-Policy	*Integrative knowledge socio-ecological systems*		
One health	*Safe drinking water and sanitation* *Aquifer pollution control*	*Healthy coastal ecosystems*	*Ensure resilient infrastructure*
Social participation	*River basin councils*	*Coastal communities, port authorities and tourism sector*	*Disaster Risk Governance*

IWRM-CF a different approach

- It opens the process to **other sectors** such as environment and health, and **other processes** such as DRM and the ICZM.
- It is based on **common principles**, particularly an ecosystem-based management principle to promote integration and to build long-term solutions.
- It is geographically **focused on the coastal zone** and oriented to the climate adaptive restoration/conservation of the marine ecosystem as a common goal.
- It clarifies that although full water and sanitation coverage is urgently needed, it cannot be the only goal for the water sector in the region. **IWRM must guide a broader process to build water security for all**.
- It observes the importance of having a **water governance** structure in place, supported by the **Escazu Agreement**, as a unique binding agreement for Latin America and the Caribbean.

Thank you!

Eugenio Barrios and Christopher Corbin

INNOVATION & SMART TECHNOLOGIES
BUILDING RESILIENCE IN THE WATER & WASTE INDUSTRIES
CWWA 30th Annual Conference and Exhibition
CARIBBEAN WATER AND WASTEWATER ASSOCIATION
THE CAYMAN ISLANDS
3-8 OCTOBER 2021

Sea Level Rise Wellfield Protection Procedures

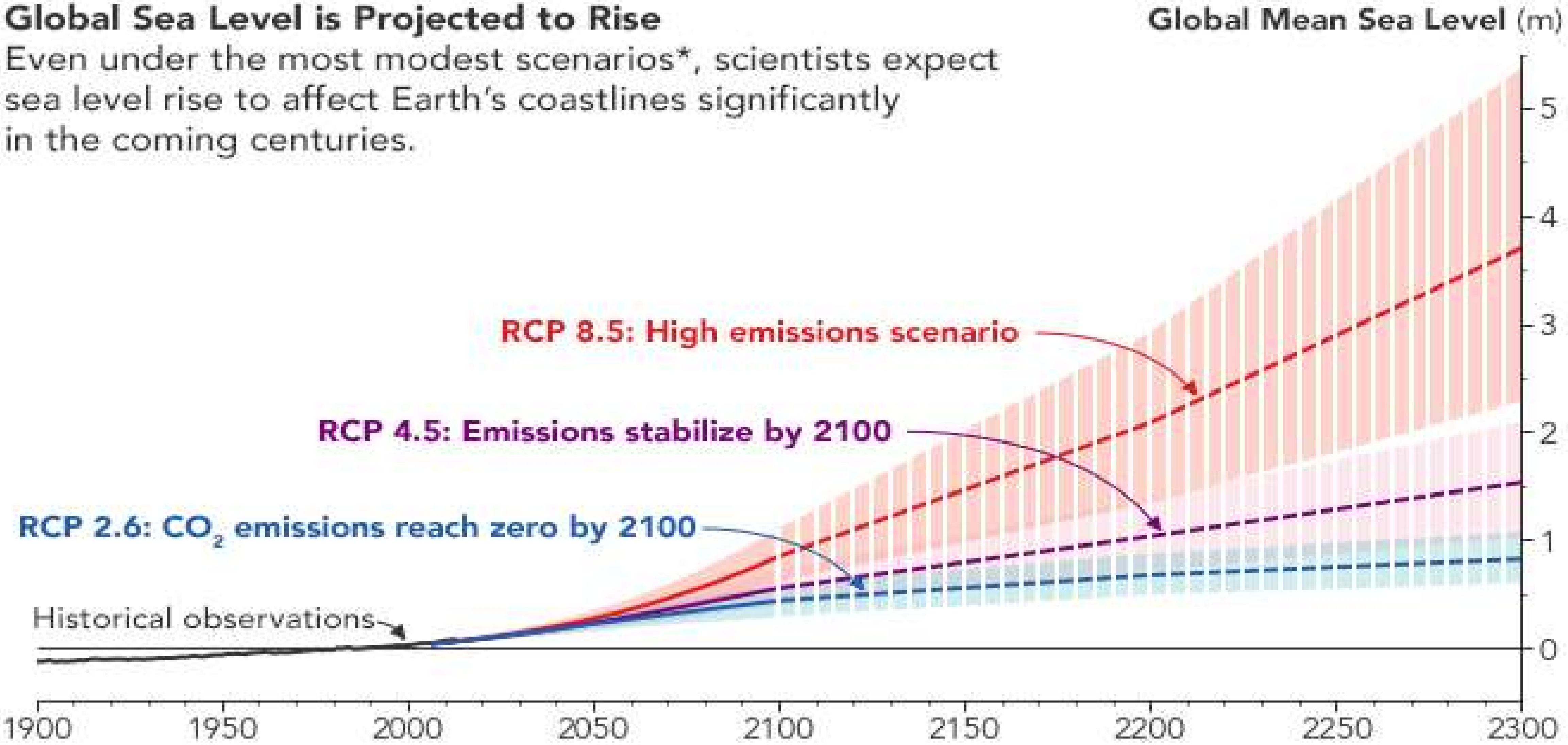
Sandy Nettles, P.G.
N.S. Nettles & Associates, Inc./Ocean Earth Technologies

Agenda

- Sea Level Rise (SLR) is a major concern for Caribbean Islands as it will impact their groundwater resources, increase coastal storm surge, and reduce their overall land mass.
- The coastal areas of the islands generally exhibit the major population centers, recreational areas, tourist (economic) centers, ports and coastal highways.
- Encroaching sea level will clearly adversely impact each of these venues. Of primary importance for island communities are the freshwater aquifers that supply the population and commerce water for drinking and product manufacture.
- Groundwater is often the primary source of most freshwater development on Caribbean islands. Those islands that do not have freshwater aquifers or springs, typically have to develop rainfall capture facilities, desalination methods or import water via ships.
- As sea level rises, the groundwater reservoirs will be compressed, reducing the volume of the islands naturally stored groundwater.

Global Sea Level is Projected to Rise

Even under the most modest scenarios*, scientists expect sea level rise to affect Earth's coastlines significantly in the coming centuries.



*Scientists use **Representative Concentration Pathways (RCPs)** to calculate future projections based on near-term emissions strategies and their expected outcomes in the future.
The RCP values refer to the amount of radiative forcing (in W/m^2) in the year 2100.

- The IPCC SROCC found that global sea level could rise by 30 to 60cm (1 to 2ft) by 2100, and a rise of 110cm (over 3.5ft), was possible but unlikely (Figure 1).
- The IPCC stated “Even if huge cuts in emissions begin immediately, between 29cm and 59cm of SLR is inevitable because ice caps and glaciers melt slowly.”
- Research by the University of Copenhagen’s Niels Bohr Institute recently found that under worst case scenario using their method that involves including historical (back to 1850’s) temperature and sea level data, the world could see a rise of 135cm (4.4ft) by end of this century.
- Ice sheets and ocean heat content have multi-century response times and this can lead to model drift if the model (Figure 2) is not perfectly initialized

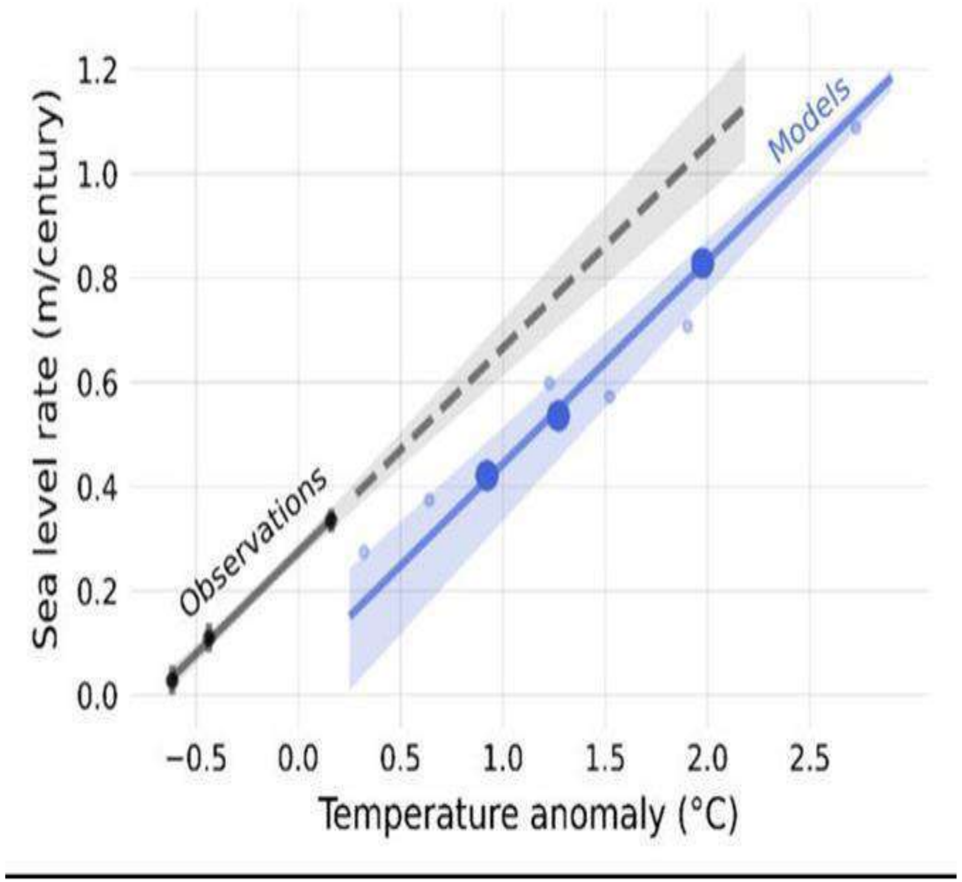


Figure 2- Comparison of measured SLR data to model results

- **Groundwater**
- Most Caribbean islands are volcanic, with a central core of volcanoes surrounded by carbonate reef and sand shorelines.
- Historic lava flows flowing down the sides of the volcanoes create dense rock ridges separated by valleys that occur as spokes around a wheel. Between these ridges accumulation of volcanic ejecta and ash fill the valleys.
- The valley fill is typically comprised of fine sand to boulders and are very permeable. Rainwater percolates rapidly into the valley sediments creating freshwater aquifers in each valley.
- All of these valleys have a freshwater storage capacity based on the aerial extent of the valley, the thickness of the coastal aquifer, rainfall recharge, aquifer Storage and Transmissivity (measured by an Aquifer Performance Test).
- Many of these valleys drain directly to the shoreline and are unconfined aquifers.
- **It is rare that these groundwater basins have been adequately defined to determine the Valleys Safe Sustained Yield**.

- Additionally, it is extremely rare to find a Caribbean Island wellfield that has a salt water intrusion monitoring network installed to control the wellfield pumping schedule or to aid in predicting salt water intrusion locations and rates.
- Without such a network of monitoring wells and a wellfield operating program for an unconfined aquifer, these wellfields are highly susceptible to salt water intrusion such as occurred in the St. Kitts Basseterre Valley Aquifer Wellfield in 2015.
- Most island coastal aquifers are water table, unconfined aquifers that are recharged by rainfall. Unconfined aquifer wellfields should not be designed or operated in the same fashion as artesian aquifers.
- The smaller storage capacity of unconfined aquifers can be easily dewatered (pumping exceeding rainfall recharge), resulting in mining of the water source.
- Over pumping coastal aquifers will result in salt water intrusion into the wellfield.

Controlling salt water intrusion advancement into a wellfield requires an understanding of:

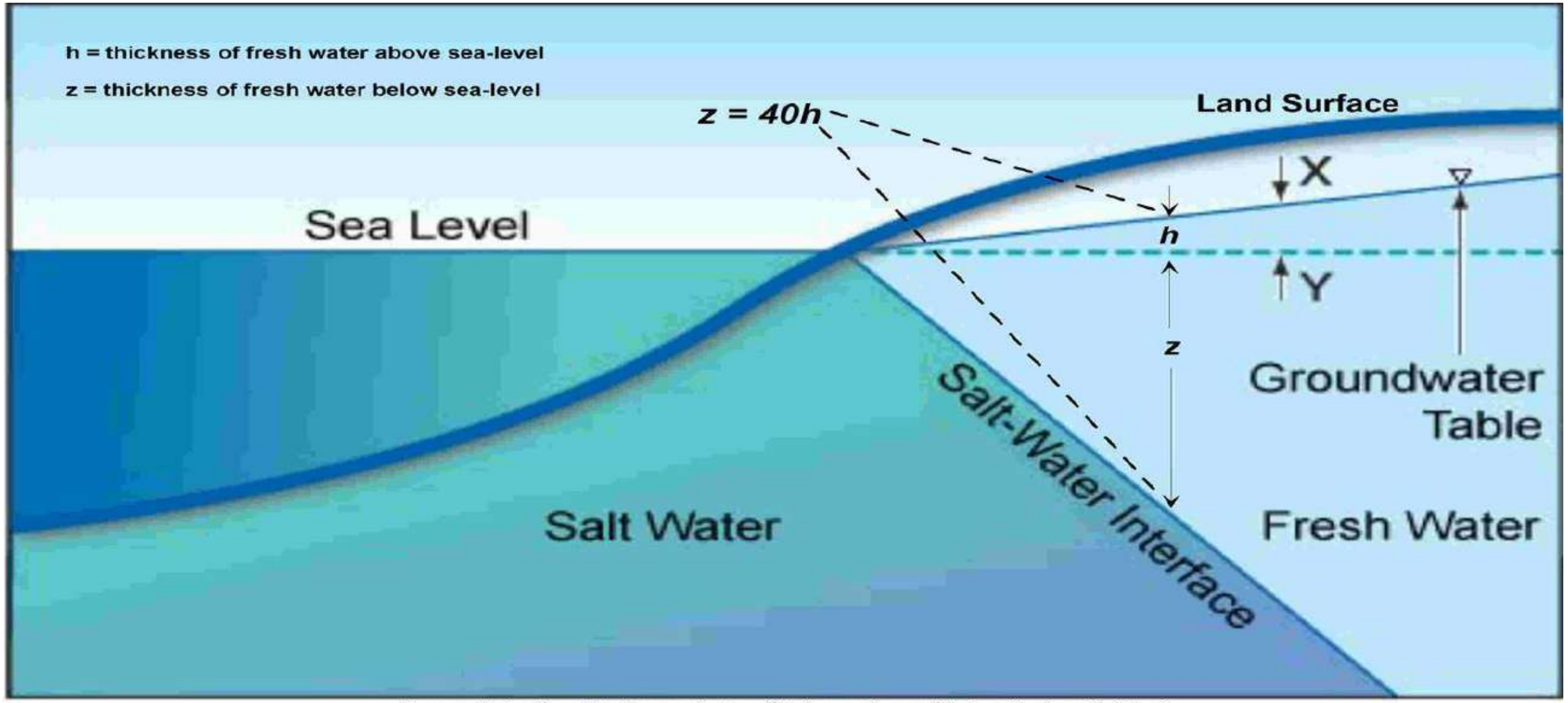
- 3 dimensional hydrogeology of the groundwater basin
- Well construction technology
- Unconfined aquifer performance testing (72hour pumping test) and determination of the Delayed Yield Effect
- Salt water interface monitor well construction technology
- Wellfield design and operation for coastal unconfined aquifers
- Fresh/salt water interface monitoring methods
- Groundwater level elevations
- Depth and location of the fresh/salt water interface

The quantity of groundwater that can be sustainably withdrawn is the Safe Sustainable Yield (SSY) and is dependent on several additional factors:

- Delineation of the basin’s hydrologic boundary (Areal extent of its water (recharge) basin
- Definition of the underlying geology and aquifer units (Aquifer depth and thickness, presence of dikes or sills, aquitards, stratigraphic lithologies)
- Determination of the groundwater gradient and range of water level fluctuation seasonally and with pumping schedules
- Soils type, distribution and hydrologic characteristics
- Rainfall rate and distribution within the watershed
- Topography and geomorphology
- Evapotranspiration rates and distribution (for water tables less than 5ft below land surface datum (lsd)
- Surface water runoff
- Groundwater recharge rate
- Groundwater withdrawal locations, rates and periodicity.
- Depth to the fresh/salt water interface below the water table
- Slope of the aquifer and water table
- Structural geologic controls affecting groundwater storage and transmission (intrusive dikes, faults)

Figure 3 Ghyben-Herzberg Principle

- The Ghyben Herzberg Principle controls the depth of the fresh/salt water interface beneath an island or peninsulas such as the State of Florida.



* Image obtained from http://www.solinst.com/Res/papers/images/Ghyben-Herzberg-Relation.jpg

- The presence of any fresh water lens stored within an island's sediments or rock is due to the density differential of the fresh water compared to the underlying salt water.
- Fresh water has a density of 1.00g/cm3 and seawater has a density of 1.035g/cm3.
- The Ghyben-Herzberg principle, based on this density differential states: For every foot of fresh water (h) present above sea level, there will be 40 feet of fresh water (H) below sea level (Herzberg, 1901).
- The equation (Figure 3) has proved accurate and reliable in Island situations.

Coastal Aquifer wellfield examples of salt water intrusion impacts

St. Kitts Basseterre Aquifer Wellfield

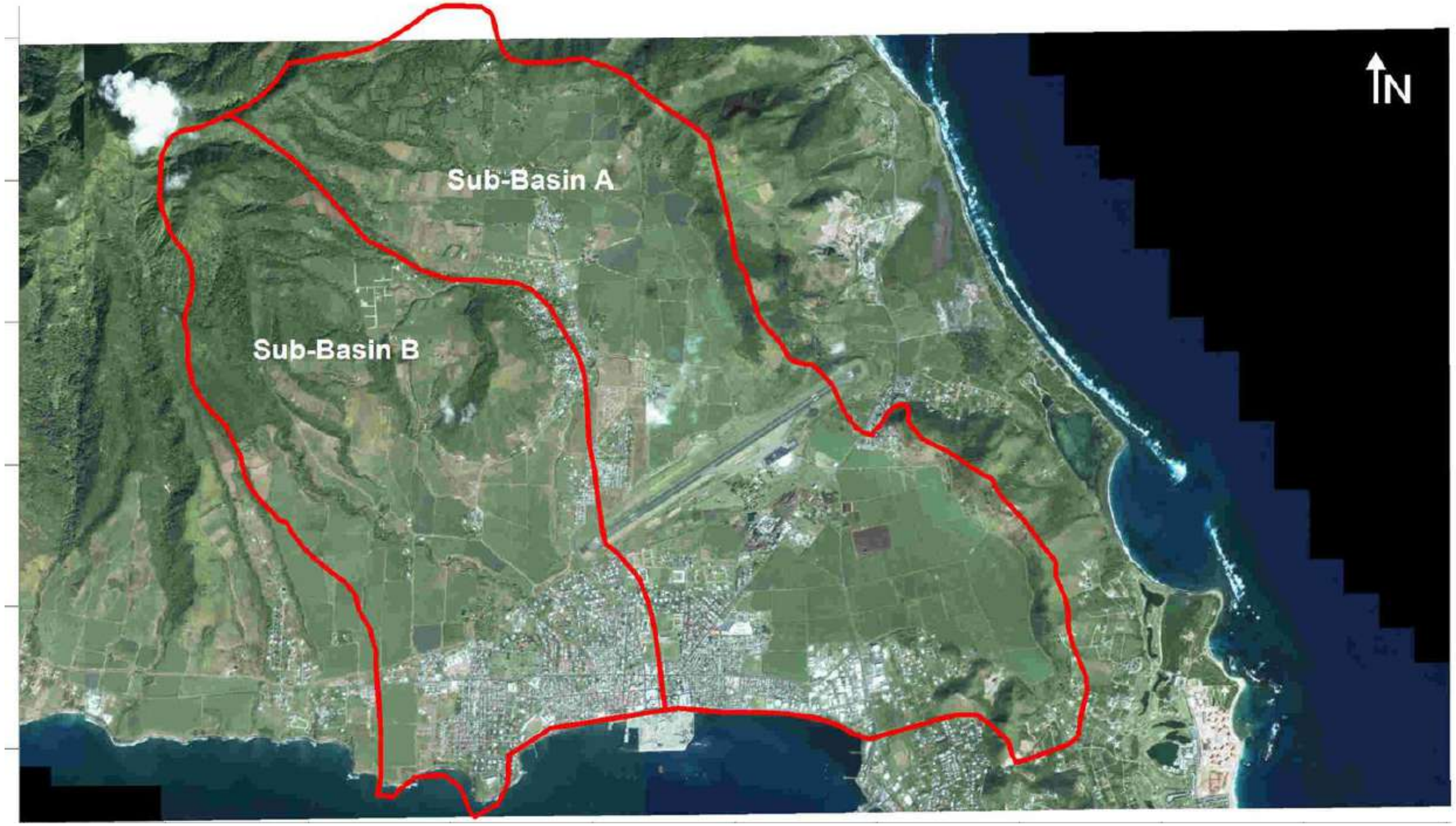
- In 2009 Ocean/Earth Technologies (OET) was contracted to perform a Hydrogeologic Evaluation of the St. Kitts Basseterre Valley Aquifer Wellfield.
- The wellfield had been investigated and designed by Dr. Christmas in the 1970's with production wells being drilled in 1988 by Kerr, Priestman & Associates.
- Williams updated and reworked the Christmas data and confirmed Dr. Christmas's safe sustained yield estimates.
- OET geophysically mapped the wellfield property using Multi-channel Electrical Resistivity (MER) to provide a more complete and detailed hydrogeologic assessment of the wellfield hydrology and to locate the fresh/salt water interface.
- OET also investigated the integrity of many of the wellfield production wells and monitor wells.

St. Kitts and Nevis, BWI

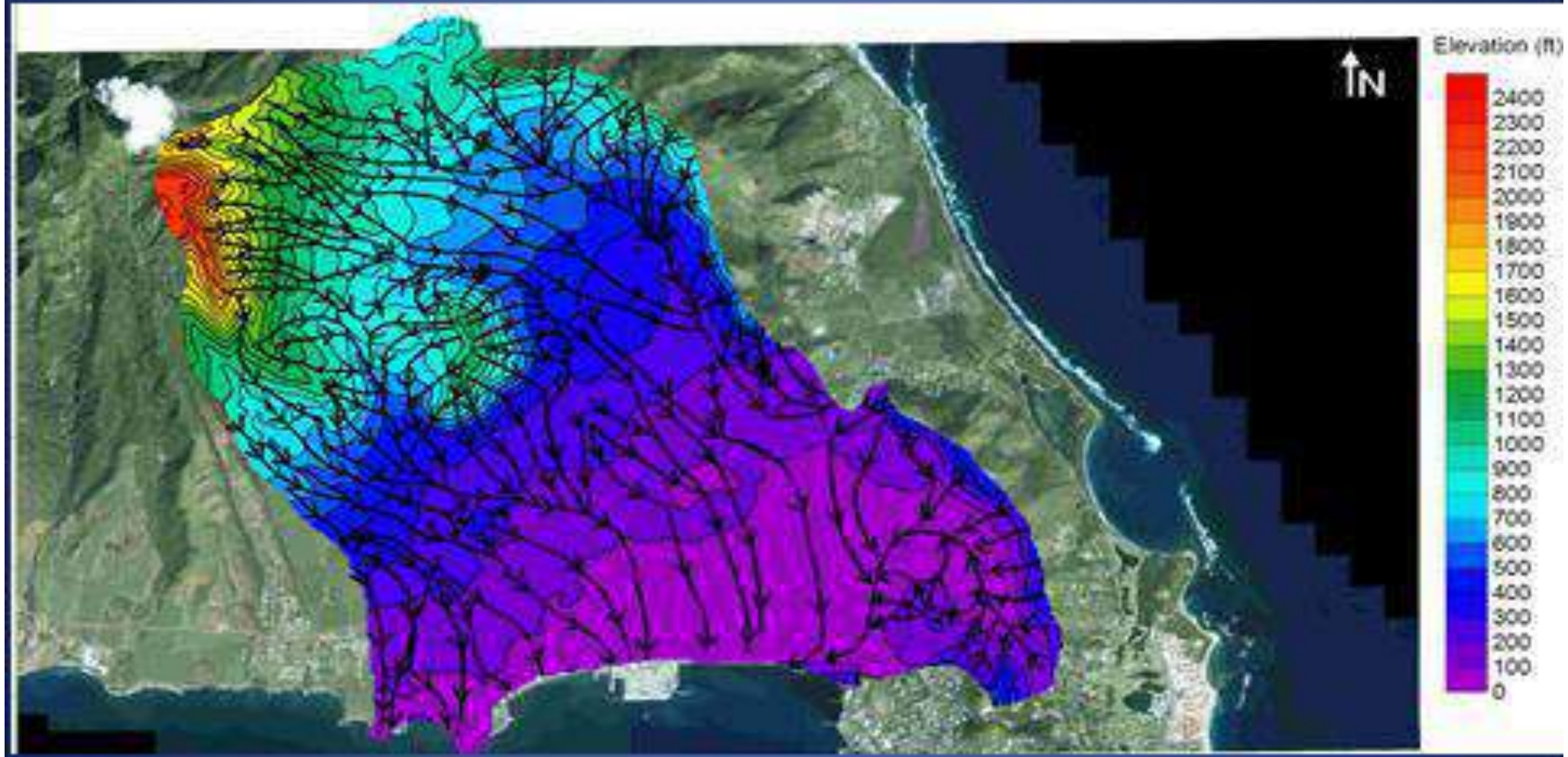
The most critical data recorded by this 2009 investigation were:

- The presence of the fresh/salt water interface was recorded to be just below the supply well intake screens across the entire wellfield area (Figure 4).
- Salt water intrusion was already encroaching on the wellfield from the SW, SE and NE (Figures 5 and 6).
- Only five of the SSY parameters are well documented for the entire Basseterre Valley Watershed (boundary, topography/geomorphology, rainfall, soil type/distribution and groundwater withdrawal locations, rates and periodicity).
- Of the five remaining parameters, the geology and aquifer units were defined only within the wellfield area (10 percent of the watershed area) with the 2009 OET MER mapping.
- Ninety percent of the remaining watershed is not accurately defined in terms of the hydrology, geology, and aquifer characteristics.
- The geophysical mapping across the Basseterre Valley Aquifer Wellfield site (the southeastern terminus of the Basseterre Valley) revealed the presence of three distinct resistivity stratigraphic units across the site (from the 2009 OET report):
- The results of the initial mapping emphasize the importance of accurately delineating the fresh-salt water interface across the watershed, and monitoring its location during pumping.
- An extensive monitor well network should be developed to deal with this sensitive interface issue.
- Additional water supplies needed to be developed immediately. Construction of new wells should be placed to the north of the airport and in the higher elevations of Sub-basins A and B of the Basseterre Valley Aquifer Watershed.
- Salt water intrusion into the Basseterre Valley Aquifer water supply wells was predicted by OET to occur in 2014 or 2015 if pumping from the wellfield continued at its 2009 withdrawal rates.
- In 2015, the wellfield exhibited a spike in saltwater intrusion and wells had to be shut down and water rationing instituted.

Hydrologic Basins of the Basseterre Valley Aquifer



Topography and Drainage Flow Paths Within Watershed

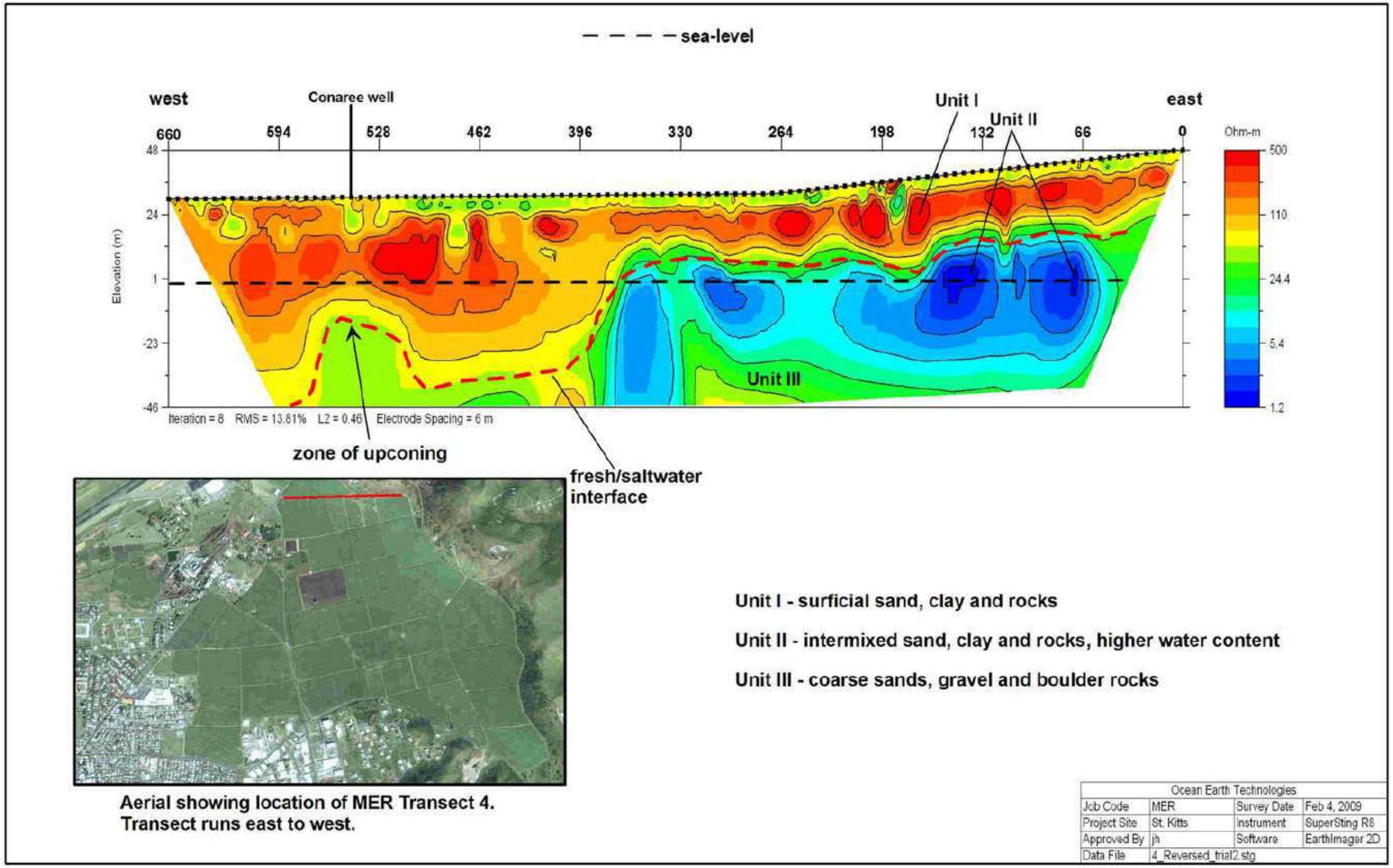


Basseterre Valley Aquifer Wellfield

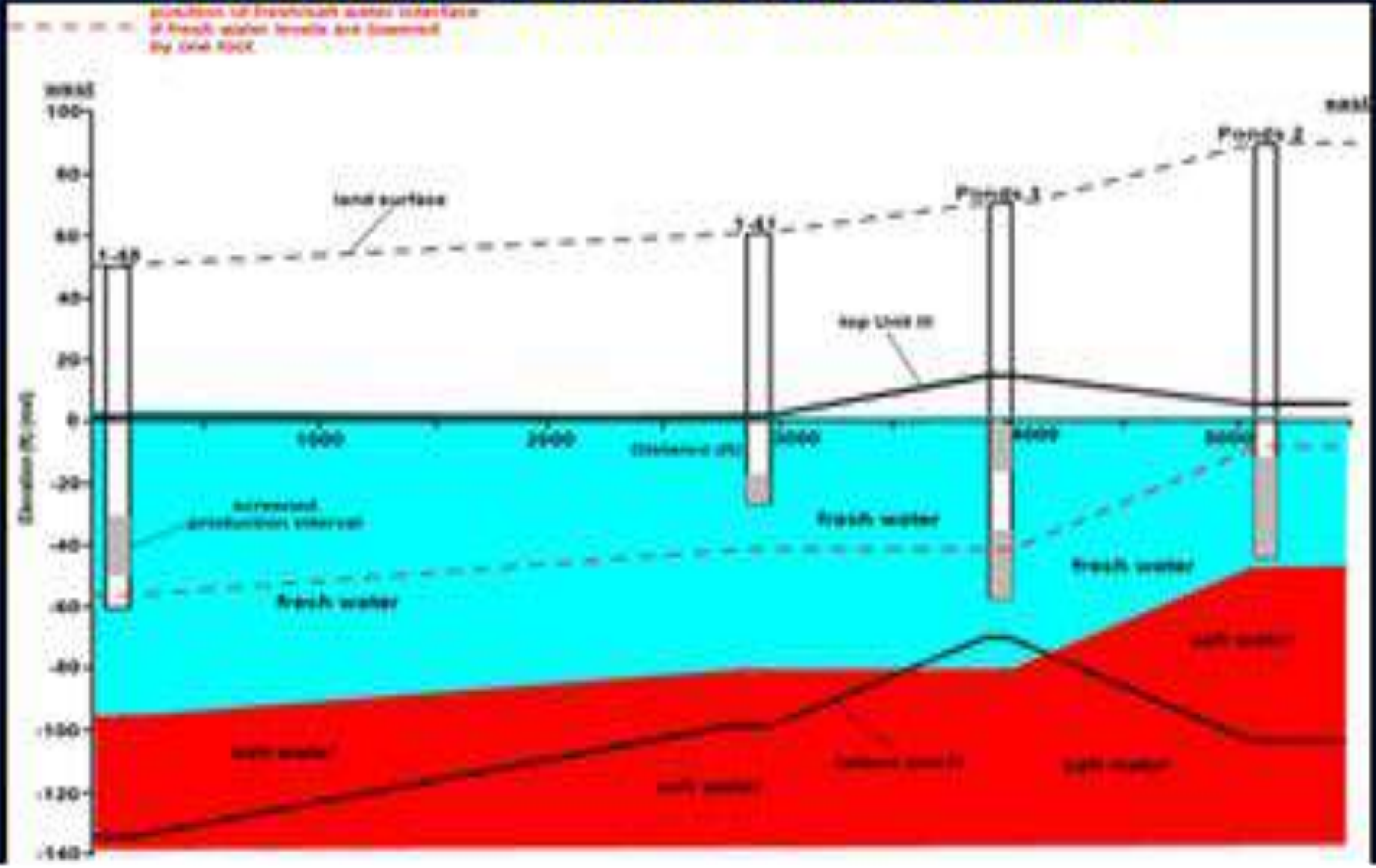
Aquifer and Well Field

- Unconfined coastal aquifer (subject to salt water intrusion)
- Recharged directly by rainfall
- In 2009 there were 10 supply wells along with several monitor wells in the watershed area
- Pumping rates range from 36-390 gallons per minute (gpm)

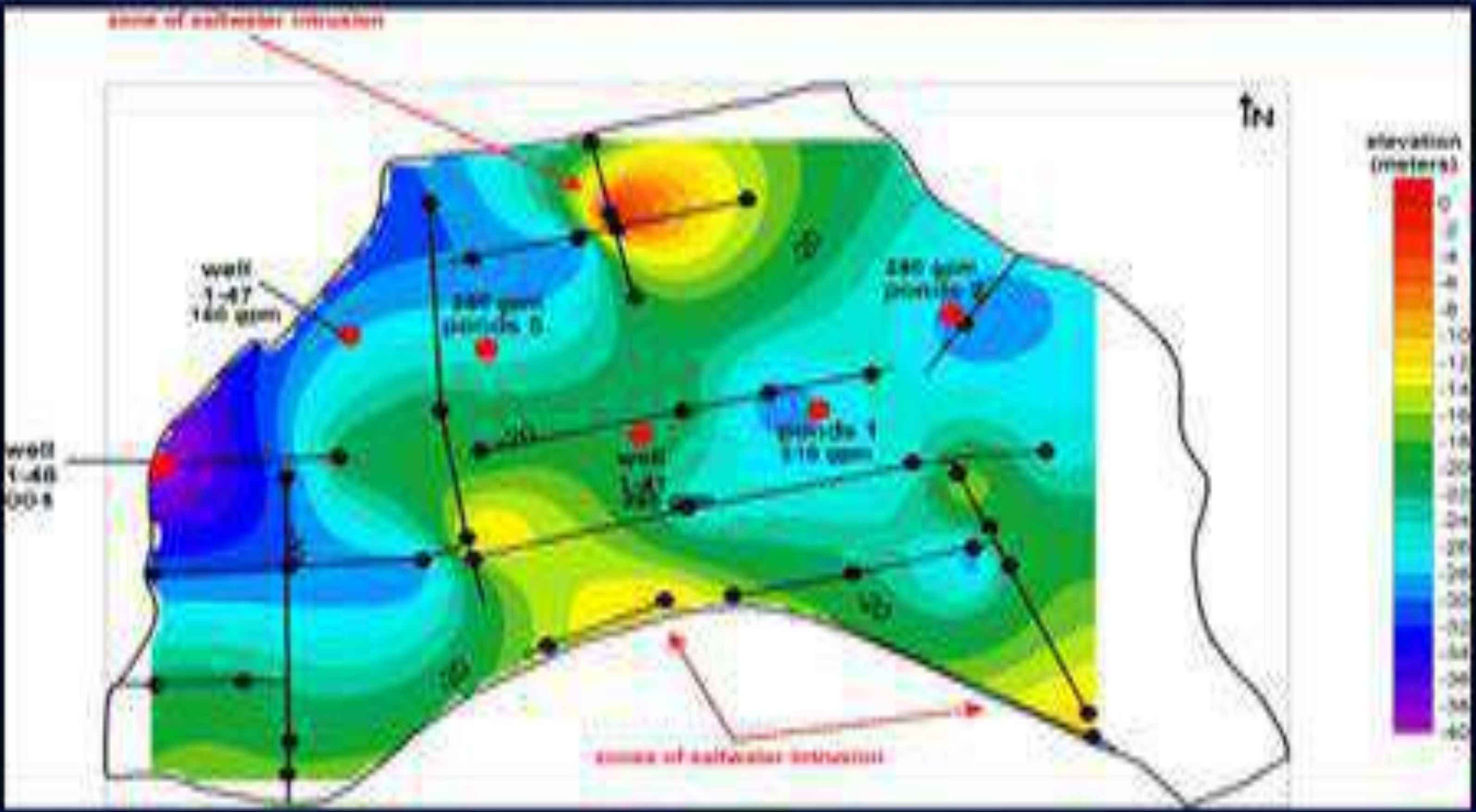
Pumping Wells Can Affect the Fresh/Salt Water Interface (Upconing)



Cross Section of Fresh/Salt Water Interface Across the Valley



Elevation of the Fresh/Salt Water Interface Derived from MER Data



- Since our 2009 report, the Government of St. Kitts had entered into a contract with another consultant (2009) to develop deep (greater than 400 feet of elevation) groundwater supplies in the upper Basseterre Valley Watershed.
- After 2 years of geophysical mapping the consultant determined that developing groundwater at elevations greater than 400 feet msl was not economically feasible because the valleys aquifers at those elevations were too narrow to store sufficient quantities of fresh water.
- As such, OET focused our investigation on locating and developing additional groundwater supplies from less than 400 feet of elevation.

In 2016 OET was contracted to perform an Emergency Water Resource Investigation. MER was recorded in the Upper Basin A watershed of Basseterre Valley as well as in Basin B in the Shadwell and Beacon Heights valleys as shown in Figure 7 below.

MER Transect Location Map

Ocean Earth Technologies
Figure 7

- These data support OET’s conclusions from 2009 that the highly permeable sediments (units 3 and 5) comprising the Basseterre Valley Aquifer prevent significant mounding of groundwater up-gradient.
- This results in a limited potential groundwater supply, and this limitation must be built into future hydrologic simulations of the Basseterre Valley Aquifer for Sub-basin A.
- A relatively flat water table (<5ft msl), as documented within the Basseterre Aquifer Wellfield, appears to extend well north of the airport as shown in MER Transects T-1, T-5 and T-6 recorded in 2016.
- This flat water table greatly increases the risk of saltwater intrusion into the existing wellfield from groundwater withdrawals even if new wells are located north of the airport.
- By shutting down production of some or all of the existing wells and developing the new wells to the north, moving the water withdrawal points further inland and further from the salt water interface will reduce the rate of seawater encroachment to the new wellfield.
- The existing supply wells should then be converted to salt water intrusion monitoring wells to track the movement of the saltwater interface and permit the Water Department the ability to more effectively operate and manage water production from the new water supply wells located to the north of the airport.
- However, the geophysical data presented in this report indicates that there are geologic features (impermeable intrusive dikes) that may limit groundwater storage volume within Sub-basin A.

Sub-basin B water supply development potential

- Sub-basin B includes narrow valley formations that are similar to Sub-basin A but indicate they store groundwater at higher elevations than those in Sub-basin A.
- As the Sub-basin B exhibits the same geologic stratigraphy as Sub-basin A the water production potential for Sub-basin B should be equivalent.
- However, the igneous dikes that hold the groundwater at higher elevation (+19ft msl) and creates a thicker fresh water lens (700ft) in Sub-basin B also limit the aerial distribution of the Sub-basin B aquifers and therefore their Safe Sustained Yield.
- The higher elevation of the aquifer in Sub-basin B also reduces the potential for saltwater intrusion into wells in this basin.

Results of the Emergency Water Resource Investigation
Site 1- north of the RLB Airport in Sub-basin A

- These data support OET’s conclusions from 2009 that the highly permeable sediments (units 3 and 5) comprising the Basseterre Valley Aquifer prevent significant mounding of groundwater up-gradient.
- A relatively flat water table (<5FT msl), as documented within the Basseterre Aquifer Wellfield, appears to extend well north of the airport as shown in MER Transects T-1, T-5 and T-6 recorded in 2016.
- This flat water table (greatly increases the risk of saltwater intrusion into the existing wellfield from groundwater withdrawals even if new wells are located north of the airport.
- Some of the existing supply wells should then be converted to salt water intrusion monitoring wells to track the movement of the saltwater interface and permit the Water Department the ability to more effectively operate and manage water production from the new water supply wells located to the north of the airport.
- Vertically oriented, mid-range resistivity features indicate the porous zones of the Basseterre Aquifer in the central region of Sub-basin A may be separated by impermeable intrusive dikes (Unit 6 of Christmas, 1977) or have low permeability zones that may significantly reduce water production capability in these features.

- This suggests that increasing elevation in the Sub-basin A valley does not necessarily increase the water storage capacity of the Basseterre Valley Aquifer or production capacity of this aquifer.
- These vertically oriented features will also have significant impacts on groundwater withdrawals, as they may form lateral no-flow boundaries that will adversely impact long-term groundwater withdrawals and model results in these areas by reducing aquifer groundwater storage volume.
- Very low resistivity values are recorded in the sediments below sea level of the central and eastern parts of T5. The very low resistivity values (<10 Ohm.m) may indicate the presence of slightly elevated chlorides in the groundwater.
- Note that the airport runway was constructed through the topographic break between the Canada and Conaree Hills where resistivity data presented in the OET 2009 report indicated saltwater was intruding from the east into the wellfield.

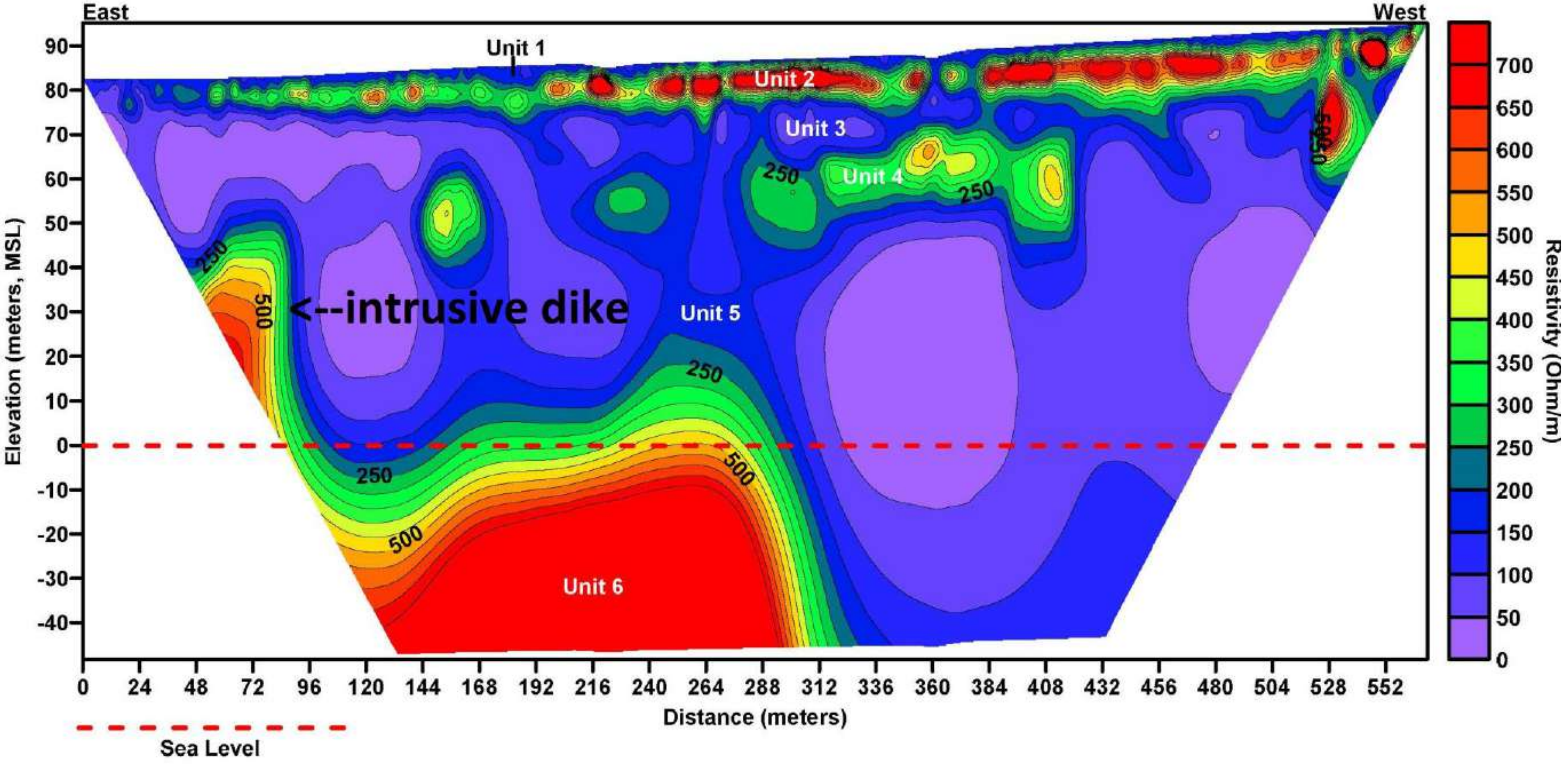
Site 2 - Beacon Heights – West of Sub-basin B

- A low resistance, potentially water-saturated Unit 5 epiclastic volcanics (light blue to purple hues) stratum extends below the Unit 4 lava rock stratum to the base of the profile at 71 meters (234ft) depth. Elevation range for this potentially water productive Unit 5 is below 50m (164ft) MSL.
- No indicators of saline groundwater were recorded in T1, 2, or 3 within the depths mapped.

Site 3 –Sub-basin B, Shadwell

- Sub-basin B includes narrow valley formations that are similar to Sub-basin A but indicate they store groundwater at higher elevations than those in Sub-basin A.
- The igneous dikes that hold the groundwater at higher elevation (19ftmsl) in Sub-basin B also limit the aerial distribution of the Sub-basin B aquifer and therefore its Safe Sustained Yield.
- The higher elevation of the aquifer in Sub-basin B also reduces the potential for saltwater intrusion into wells in this basin as the freshwater lens is 760ft thick and produces 700gpm.

MER Transect 9- Shadwell Area, Sub-basin B showing intrusive dike trapping groundwater

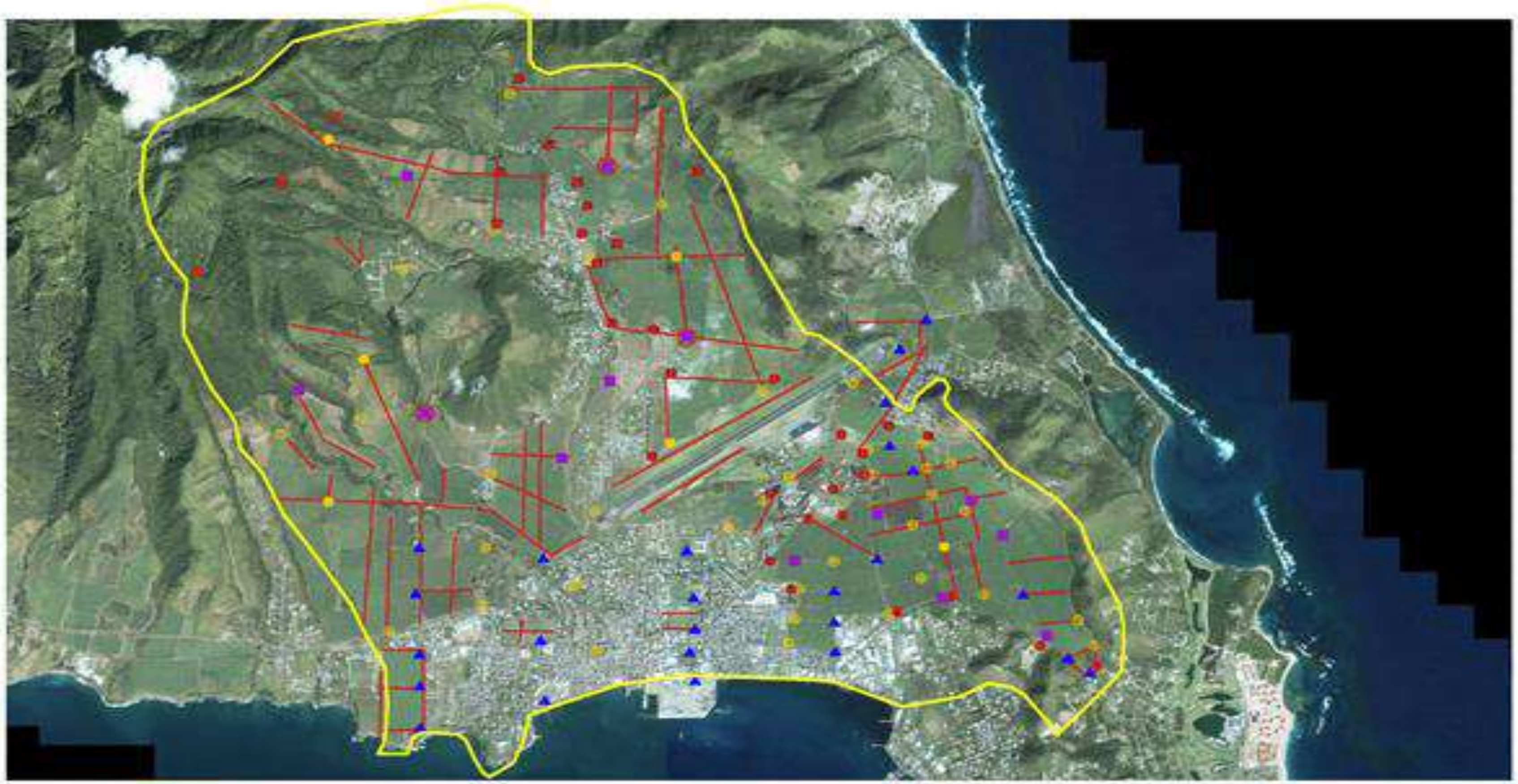


Recommendations for Monitoring the Fresh/Salt Water Interface to Protect Your Coastal Aquifer Wellfields.

- Monitoring the fresh/salt water interface is a 3 dimensional program. The interface can move both vertically and horizontally through the aquifer depending on recharge activity, pumping and tidal flux.
- Interface monitor well distribution should consist of transects oriented perpendicular to the shoreline with each transect having 3 to 4monitor wells set at 100 to 200ft spacing from the shoreline to the wellfield boundary or nearest supply well. Narrower spacing may be warranted.
- An additional deep interface well should be constructed 20ft from each water supply well to monitor for vertical up-coning of saline groundwater.
- All interface monitoring wells should be fully screened from 5ft below land surface to 30ft below the initially recorded interface depth as determined by Resistivity mapping.

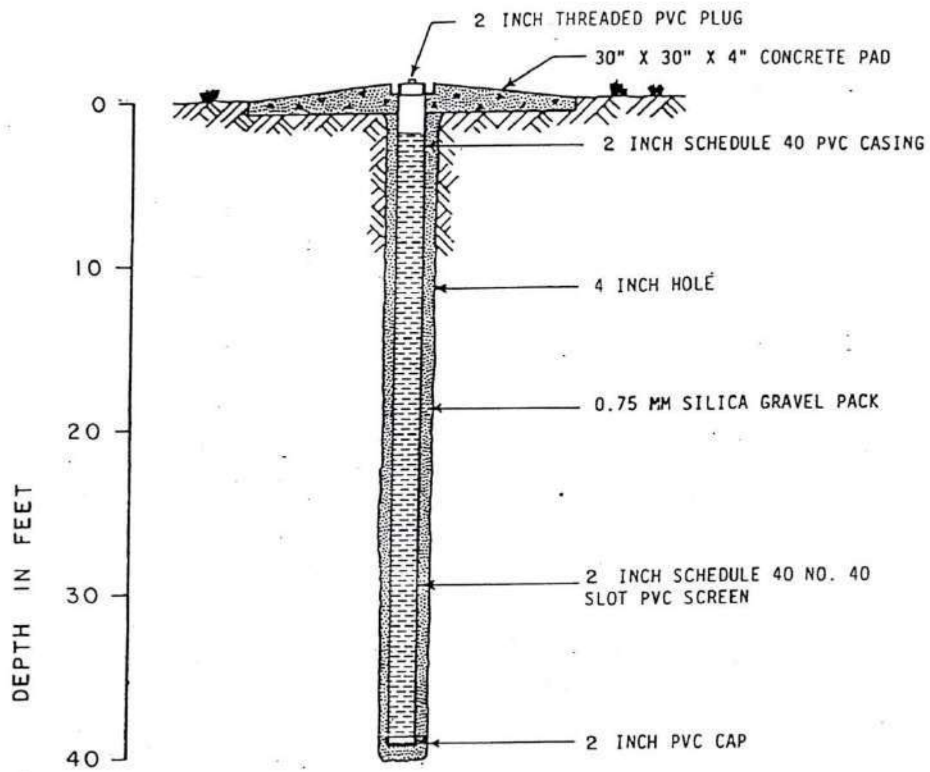
- Production wells should be run for no more than 24 hours at a time with a 24 hour recovery time to permit recovery of the local water table elevation.
- Continuous pumping (24/7) of unconfined aquifers results in a Delayed Yield Effect (removes water from storage) and drastically increases drawdown at the well head. This increased drawdown of the water table elevation induces up-coning of salt water at the well.
- Salinity surveys should be recorded in all interface monitor wells on a weekly basis during dry seasons and monthly during wet seasons.
- Interface vertical and horizontal fluctuation should be mapped with each monitoring episode and compared to previous data to track encroachment so that modifications to the supply well pumping regime can be made to stop the saline encroachment from entering the wellfield.
- Supply well distribution should never be established as 2 parallel lines of wells oriented perpendicular to the shoreline

Figure 56
Proposed Monitoring Program



MER Transects
Recording monitor well-water level with salinity
Monitor well- recording water level and recording rain gauge
Proposed Petroleum contamination monitoring wells (31 wells)
Monitor wells
Gauging station
Recording monitor well
Recording monitor well with aquifer performance test site
N

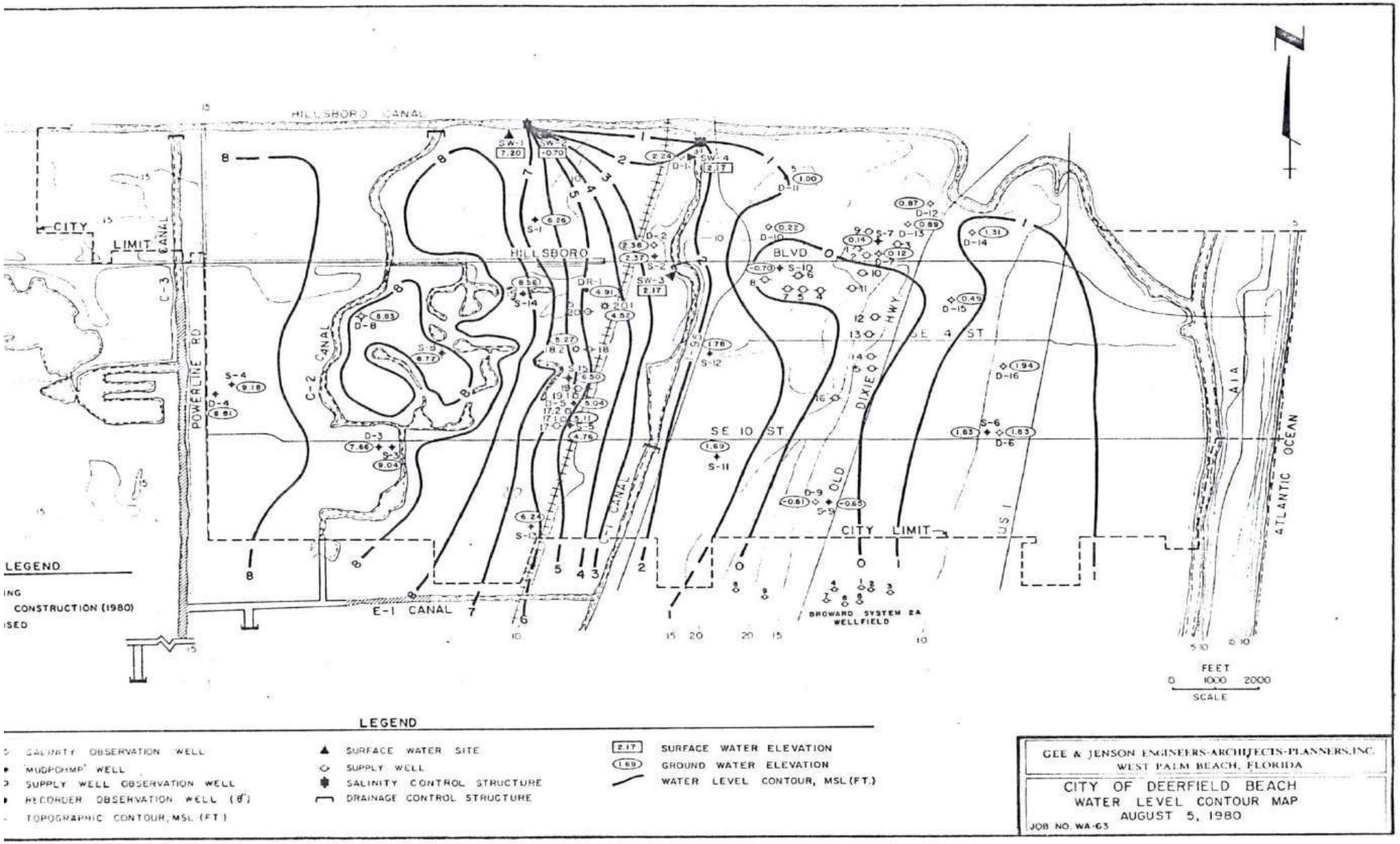
Ocean Earth Technologies



DESCRIPTION OF WORK

1. DRILL 4 INCH HOLE TO 40 FEET
2. FURNISH AND INSTALL 2 INCH SLOTTED PVC SCREEN FROM 5 TO 40 FEET AND 2 INCH PVC CASING FROM 0 TO 5 FEET
3. GRAVEL PACK ANNULUS WITH 0.75 MM SILICA SAND
4. DEVELOP WELL BY AIR LIFTING
5. CONSTRUCT 30 INCH X 30 INCH X 4 INCH CONCRETE PAD

FIGURE 2


HILLSBORO CANAL
CITY LIMIT
C-3 CANAL
C-2 CANAL
POWERLINE RD
HILLSBORO BLVD
SE 4 ST
SE 10 ST
OLD DIXIE HWY
US 1
A1A
ATLANTIC OCEAN
E-1 CANAL
C-1 CANAL
BROWARD SYSTEM 2A WELLFIELD
FEET
0 1000 2000
SCALE
LEGEND
SALINITY OBSERVATION WELL
MUDPOHMP WELL
SUPPLY WELL OBSERVATION WELL
RECORDER OBSERVATION WELL (8")
TOPOGRAPHIC CONTOUR, MSL (FT.)
SURFACE WATER SITE
SUPPLY WELL
SALINITY CONTROL STRUCTURE
DRAINAGE CONTROL STRUCTURE
2.17 SURFACE WATER ELEVATION
1.69 GROUND WATER ELEVATION
WATER LEVEL CONTOUR, MSL (FT.)
GEE & JENSON ENGINEERS-ARCHITECTS-PLANNERS, INC.
WEST PALM BEACH, FLORIDA
CITY OF DEERFIELD BEACH
WATER LEVEL CONTOUR MAP
AUGUST 5, 1980
JOB NO. WA-63

Fresh/Salt water interface mapping at Temenos Estates on Anguilla

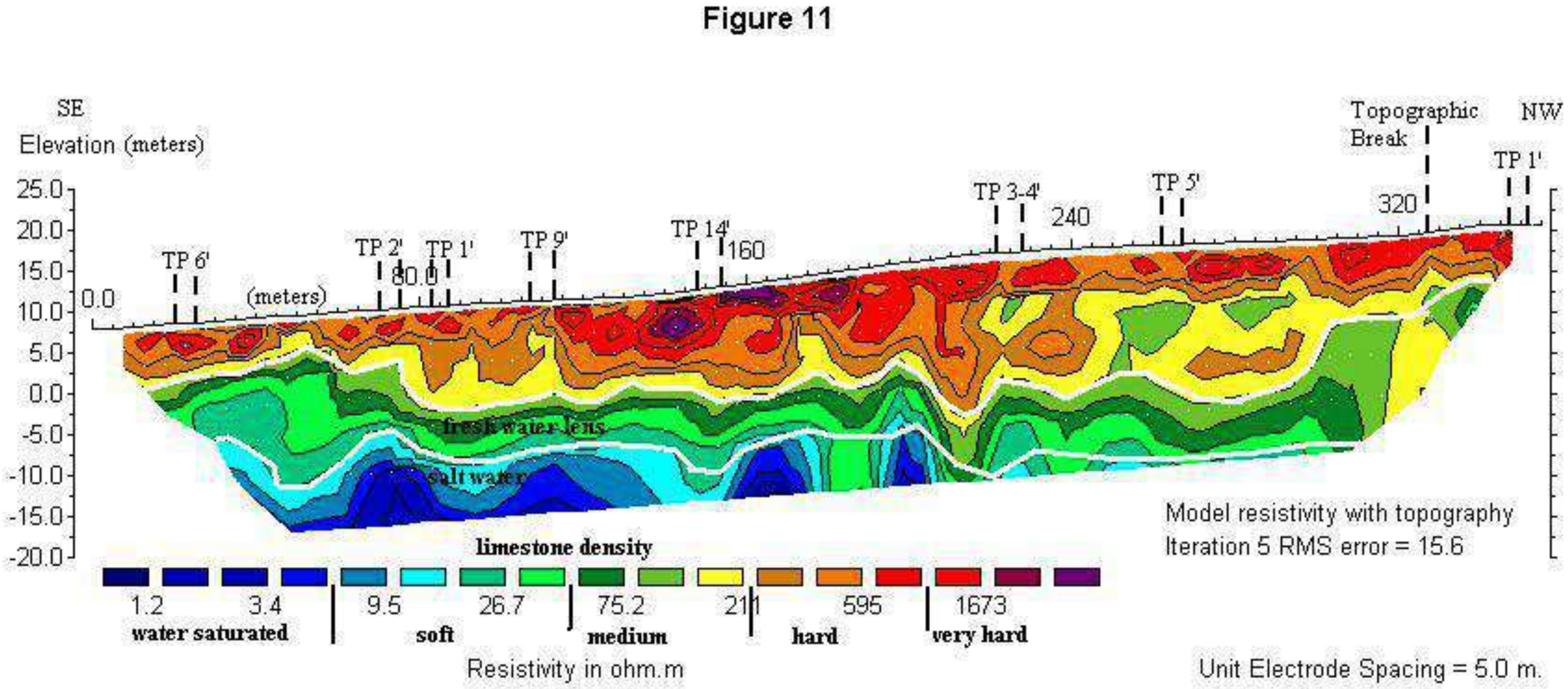
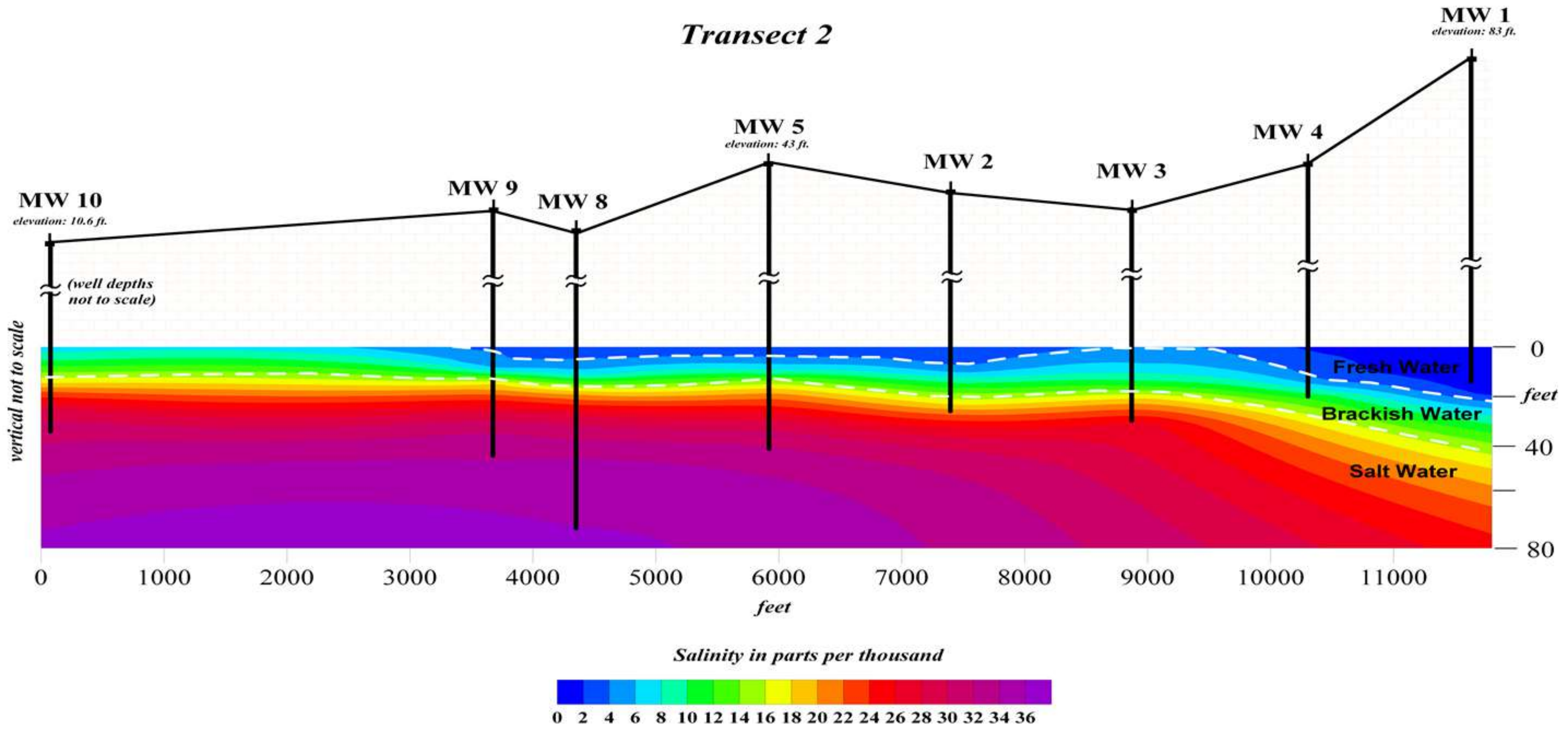


Figure 13
Temenos Estates Fresh Water Lens
Cross Section View



N.S. Nettles & Associates, Inc.

(jb)

Anguilla Golf Resort
Salinity Measurements

Location: Entrance to Cuisinart
Boring #: MW-1
Recorded by: TS
Total Depth: 144'
Depth to Water: 83'
Date: 6/2/2003 0640 hrs

Depth(ft)	Conductivity (ms)	Spec. Cond. (ms)	Salinity(ppt)	Temp(C)
85	4.6	4.86	2.7	28.6
86	7.9	7.6	4.3	28.6
87	11.5	10.8	6.1	28.6
88	17.4	17.5	10.2	28.6
89	36.9	34.5	21.6	28.6
90	38.3	35.9	22.5	28.6
91	38.6	36.1	22.7	28.6
92	38.6	36.2	22.8	28.6
93	38.7	36.2	22.8	28.6
94	38.8	36.3	22.8	28.6
95	38.9	36.4	22.9	28.6
96	38.9	36.4	22.9	28.6
97	38.9	36.4	22.9	28.6
98	38.9	36.4	22.9	28.6
99	38.9	36.5	22.9	28.5
100	38.9	36.5	22.9	28.5

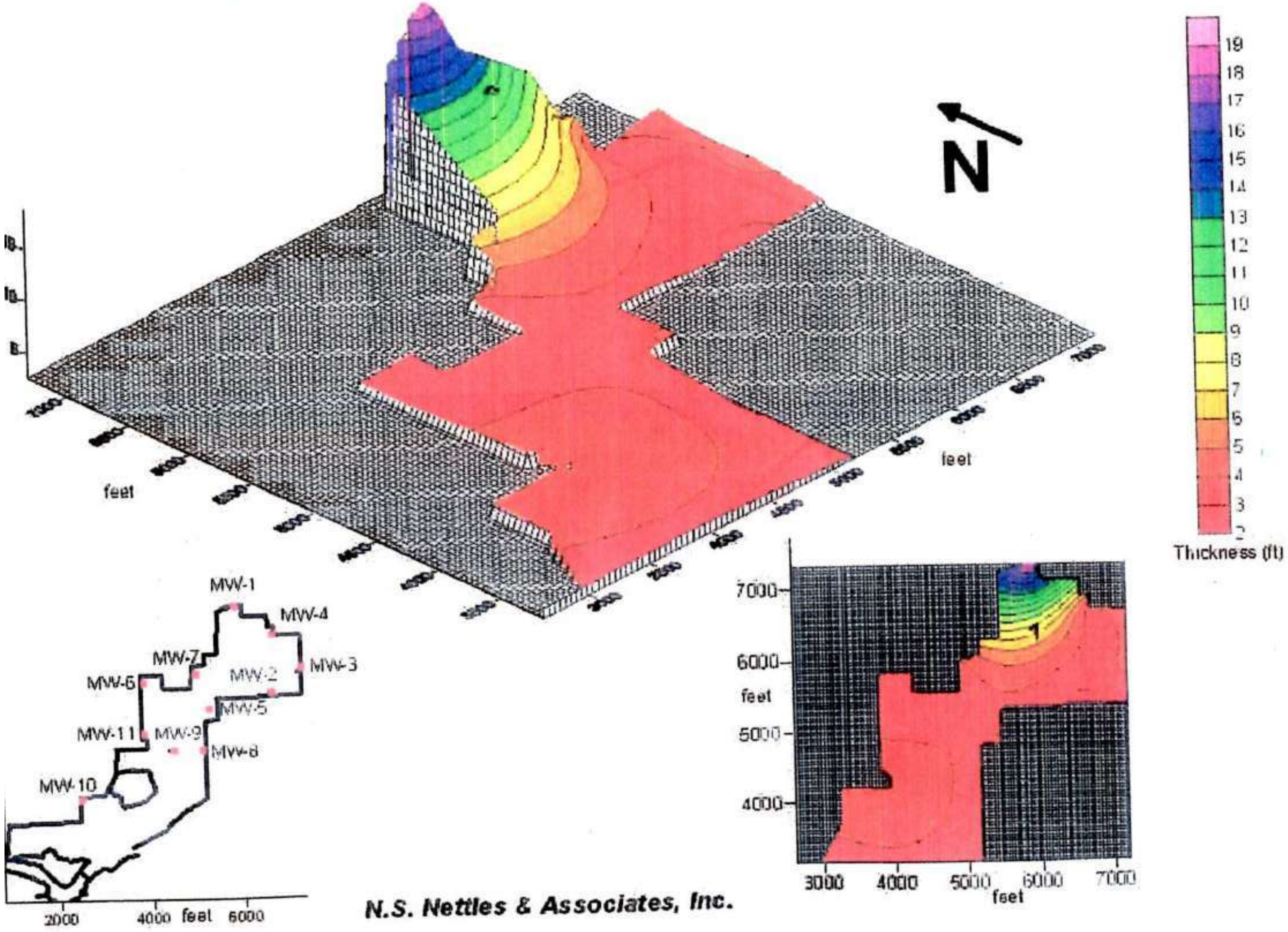
Date: 6/27/2003 0635 hrs
Recorded by: SN
Depth to water: 81.2 ft

Depth(ft)	Salinity(ppt)	
85	0.5	28.6
87.5	0.5	28.6
90	0.5	28.6
92.5	0.7	28.6
95	0.7	28.6
97.5	0.8	28.6
100	1.1	28.5

Figure 11

Anguilla Golf Resort

ndwater Contour Salinity 0-2 ppt



N.S. Nettles & Associates, Inc.

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Efficacy of the compost tumbler as a tool in organic waste management in households in Trinidad and Tobago

Presentation of paper by:
D. Indar, D. Ramlochan, R. Lewis & S. Mahabir

CPEF

Legally registered in 2015: Central Pathfinders Environmental Foundation

Mission: To promote ecological conservation through sustainable environmental and agricultural awareness and development.

Designation: Non partisan and volunteer-based.

DO'S AND DON'TS OF MOTIVATING YOUR TEAM

The Eco-Info Garden
Solar Panel Powered Pumps and Lighting
Drip Irrigated Landscaping
Local Freshwater Fish Pond
Park Benches
Educational Environmental Signage
romoting Environmental Awareness and Providing Green Leisure Space

Central Pathfinders Environmental Foundation

FEB 21
COMPOST HAPPENS
Central Pathfinders Environmental Foundation
JTB Homesteads

Ever thought about the amount of plastic forks you've thrown away when you eat out? Here's an easy way to reduce that number to zero.
INTRODUCING
CUTLERY rollups
Take your cutlery with you wherever you go
These roll ups are easy to carry around in your bag or car and come in an array of assorted colours.
SAY NO TO SINGLE USE CUTLERY
#zerowastemovement

The NEW FIRE Public Environmental Empowerment Programme 2020 presents
ECO ENTERPRISE
SKILL BUILDING WORKSHOPS
JANUARY TO FEBRUARY 2020
INTRODUCTION TO COMPOSTING
Facilitated by JTB Homesteads | in partnership with the Central Pathfinders Environmental Foundation
• Develop New Skills
• Become an Ambassador for Sustainability in your community
• Build your Network
NEW FIRE
SGP

Organic waste management in T&T

Organic waste problem

Core problem:

Improper disposal of organic waste

- High volume (27%)
- Environmental impacts

Identified through:

- 2010 waste characterization study
- Stakeholders
- Observation
- Local articles and reports

Type of Waste	Beetham	Forres Park	Guanapo	Guapo
Organics	32.0%	22.4%	21.7%	10.5%
Paper	21.4%	13.7%	18.0%	18.7%
Glass	8.7%	11.6%	10.3%	23.0%
Metals	2.8%	4.0%	6.3%	3.5%
Plastics	16.0%	26.0%	19.1%	17.0%
Textiles	8.2%	7.8%	6.6%	8.6%
Beverage Containers	0.8%	1.3%	0.9%	0.6%
Other	1.8%	2.7%	5.2%	5.5fh%

Table 1: Waste characterization at landfills in T&T, 2010

Source: National Recycling Policy, 2015

Composting as a solution to the problem

The process uses various organic materials otherwise regarded as waste products.

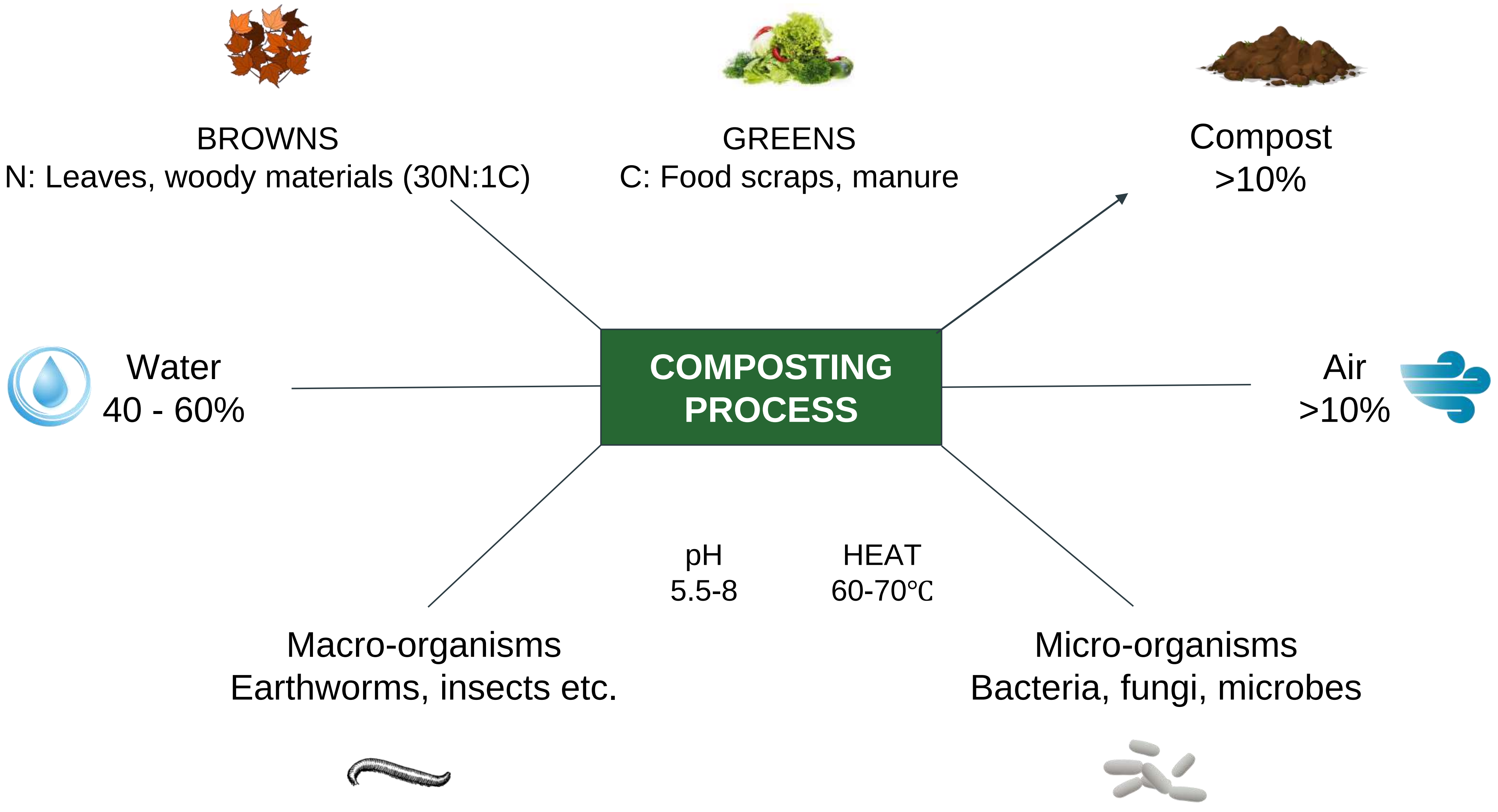
↓

A good **compost** is rich in plant nutrients and beneficial organisms.

Compost is regarded as an organic stable soil amendment (moisture, pH etc).

Benefits of composting as an alternative

National	• Less finances required for waste management • Tool to assist with a circular economy • Increased awareness of greener practices
National - Landfill	• Reduces landfill waste • Increases landfill longevity • Reduces GHG emissions
Household	• Saves money • Reduced need for synthetic fertilizers • Encourages home gardening • Healthier plants (due to soil structure & nutrients)


BROWNS
N: Leaves, woody materials (30N:1C)
GREENS
C: Food scraps, manure
Compost
>10%
Water
40 - 60%
COMPOSTING PROCESS
Air
>10%
pH
5.5-8
HEAT
60-70℃
Macro-organisms
Earthworms, insects etc.
Micro-organisms
Bacteria, fungi, microbes

Urbanized composting unit

UCU Project

CPEF sought UNDP GEF SGP funding to:

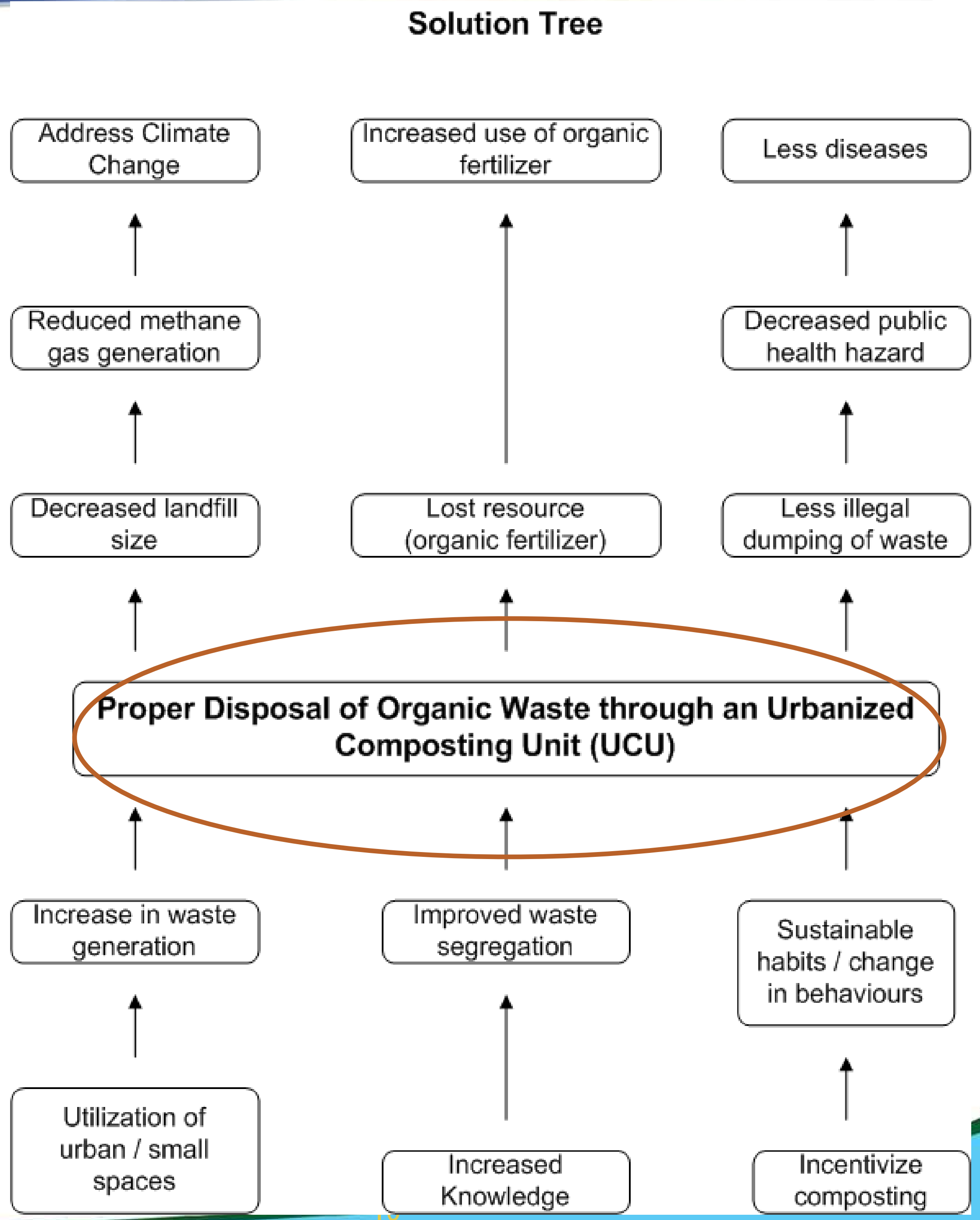
- Utilize urban spaces through creation of a UCU
- Educate individuals in urbanized composting techniques

Incentivize composting through

(i) Accessible & affordable means

(ii) Generation of revenue

(iii) Production of organic fertilizer



Household composting methods

Open-air	Partially Sealed
Small organisms such as earthworms helping the process	Small organisms not always involved
Moisture content affected by weather	Controlled moisture content
Large dedicated space required	Compact space / often movable

CPEF's tumbler

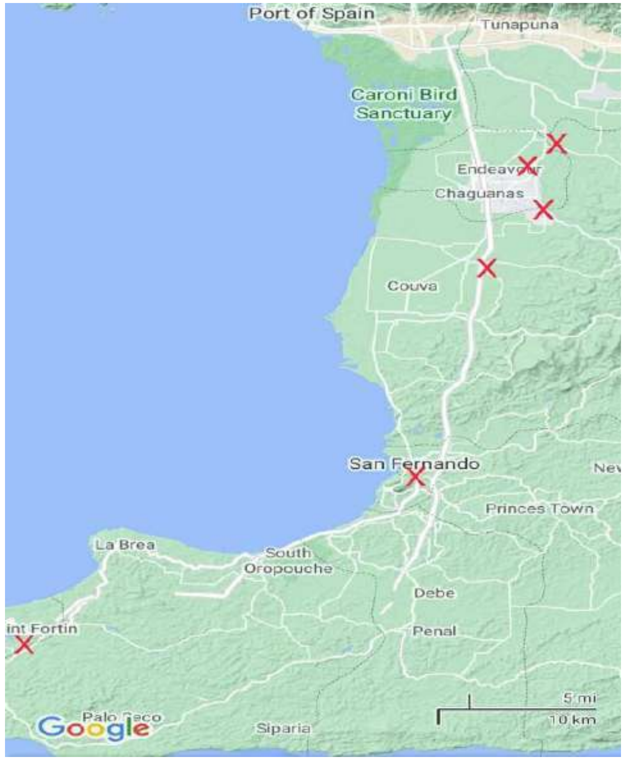
- Compact for small space
- Tumbling action
- Deters rodents
- Odour control
- Kid friendly

- Trial/testing period
- User manual & videos

Methods & materials

Sample characteristics

- 6 households (see map for locations)
- 12 tumblers
- Av. household size: 3 persons
- Age group 36 - 60 (main user)
- Equal male and female participants
- No experience in container composting



Map of participant locations

Programme of evaluation and operation

Weigh greens

No meat or bones
Crushed eggshells
Covered bucket

+

Weigh browns

Sawdust / Sawdust mix
Leaves not suitable
Ratio by volume 1-2:1

+

Moisten & tumble

Add water if necessary
Tumble 3 -5 times
Continue until filled

Monitor

Temp & humidity readings
Tumble and open every 2-3 days
Drain when wet
Report on odours, colours etc.

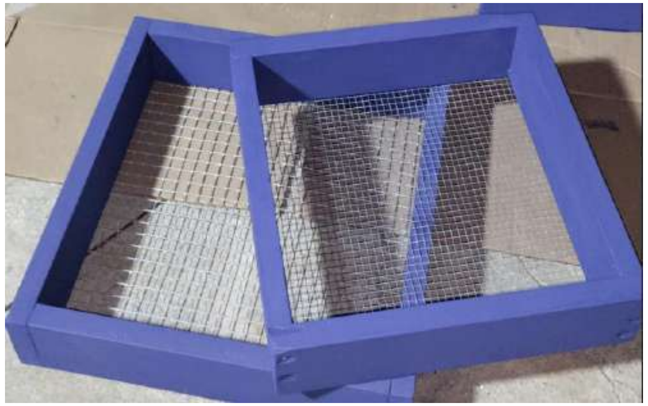
Complete

pH reading
Weigh
Dry
Final weight

Training

April - August, 2021

Photos of items and process

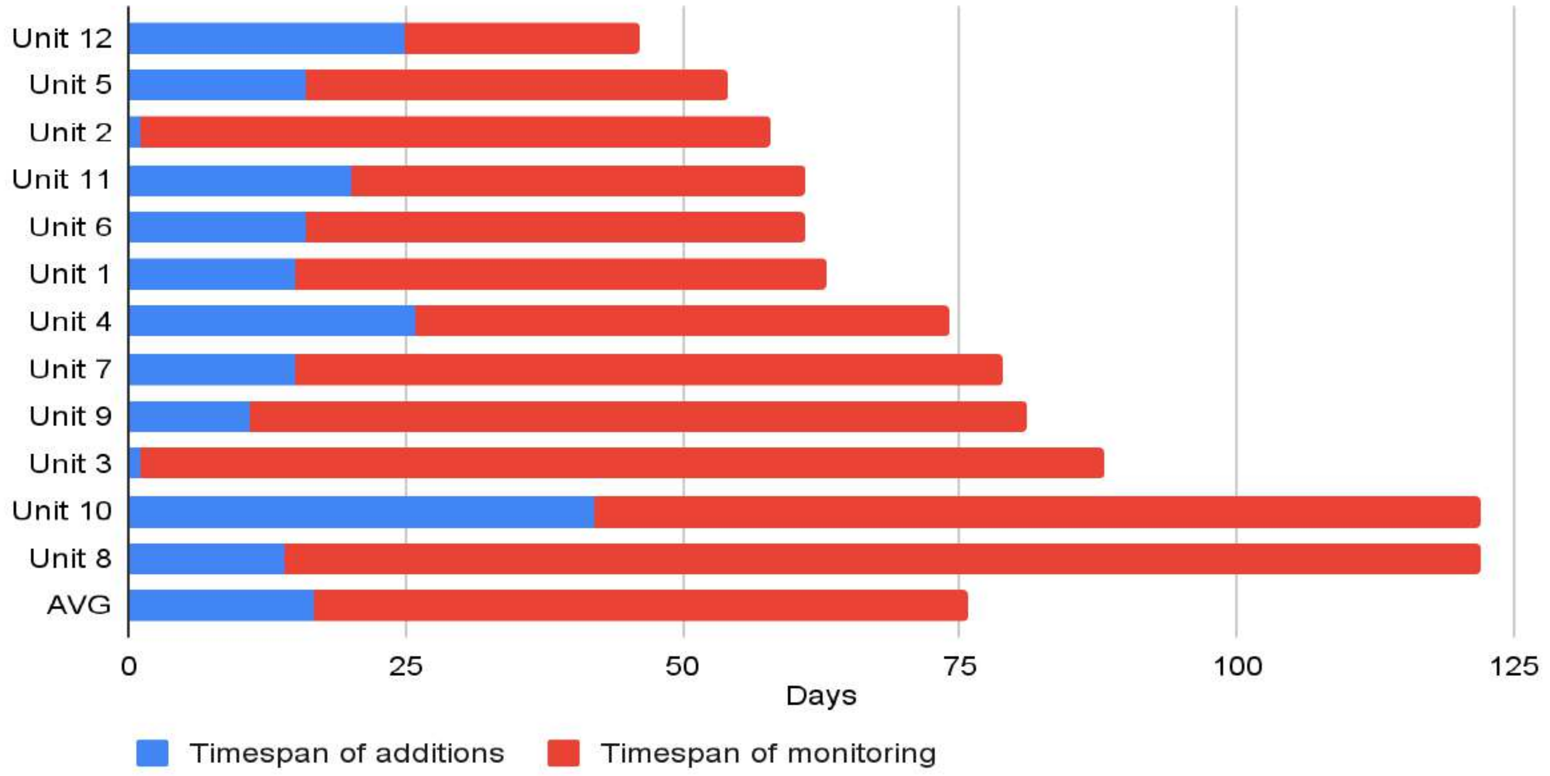


Photos of items provided to participants

Photos of the tumbler in use

Results

Time taken for compost generation



Time to fill:
1 - 42 days
Avg: 17 days

Time for compost maturity:
21 - 108 days
Avg: 60 days

Efficacy

	Input			Output (Compost)
	Range	Average	Total	Average
Greens (kg)	3.38 - 12.86	7.83	93.90	8.29
Browns (kg)	0.70 - 4.17	2.93	35.10	
Total (kg)	4.58 - 16.80	10.75	129.00	

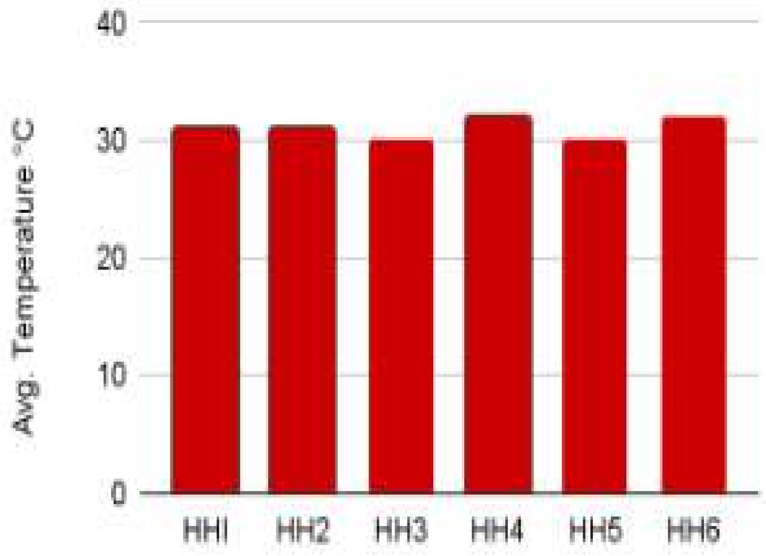
Table showing the range, average and total of tumblers for the testing period

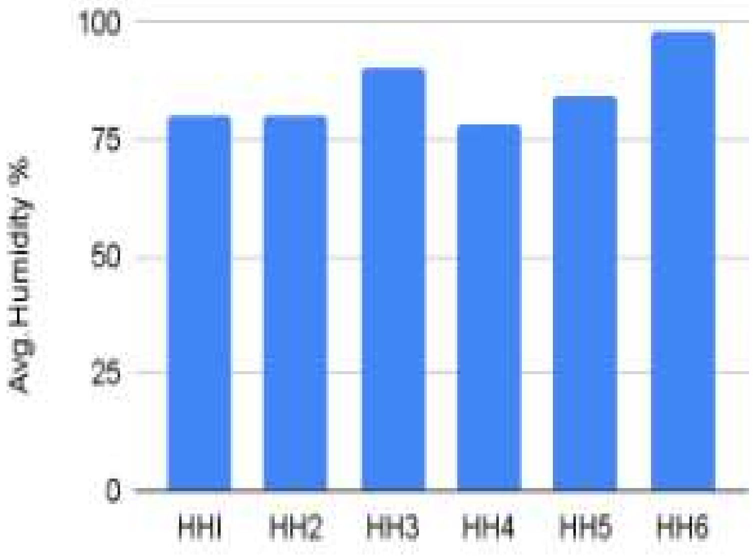
With further testing, large-scale disruptions can be calculated:

One unit: 7.83kg/77 days; 31.12kg/year

Several units: 168kg/year

Humidity & temperature readings





Charts showing avg. surface temperature and humidity readings for 6 households

Surface range:
28°C - 36.2°C

Limited internal range monitoring-
Internal range:
37°C - 43°C

Humidity:
>75%

Odours

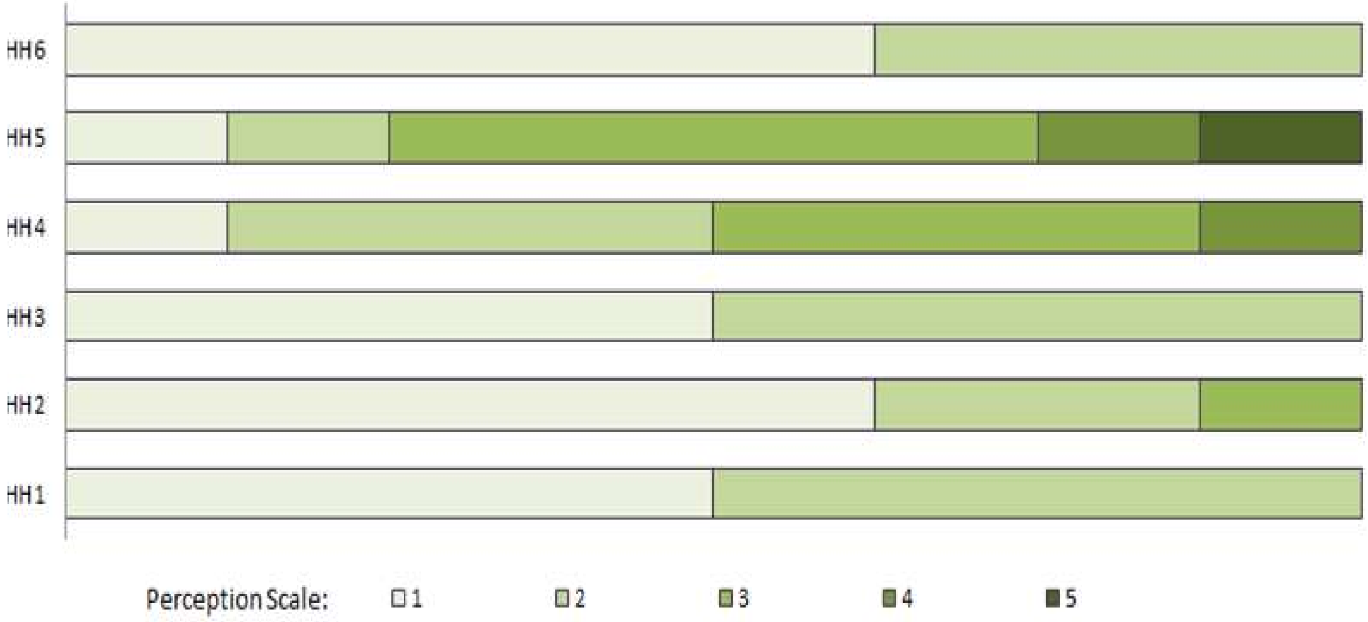


Chart showing odour perception for 6 households by proportion (not time)

2 households
had offensive scents

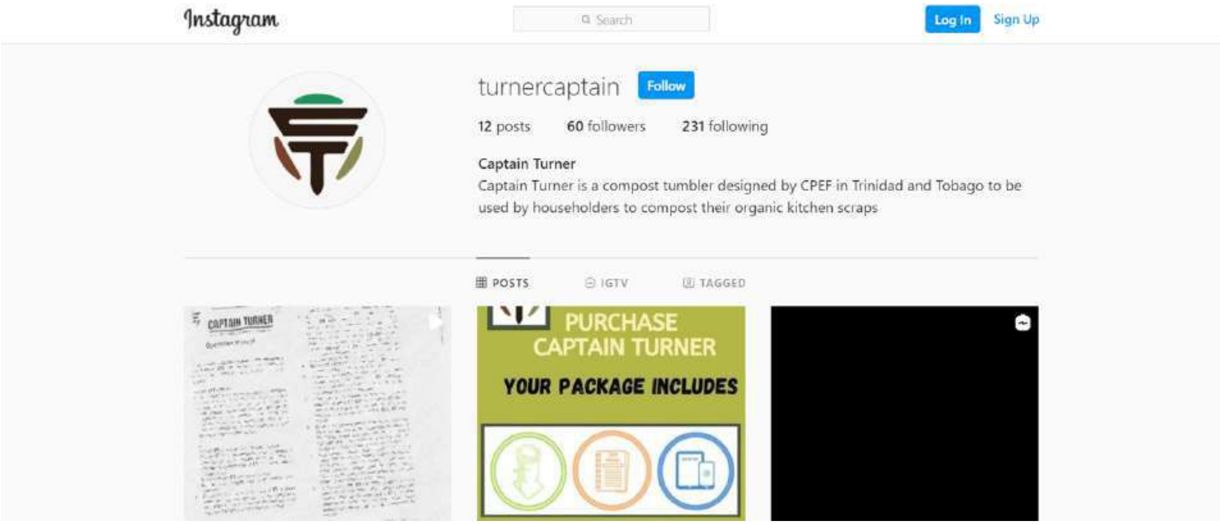
Highly tied to waterlogging
and not enough browns

Possible shifts from aerobic
to anaerobic composting

Next steps and conclusion

Marketing


CAPTAIN TURNER
THE HOUSEHOLD COMPOST TUMBLER
Features
Compact & Light weight
Low odours & no pests
Cheaper alternative
Locally made
Benefits
Generate organic fertilizer
Reduce & Recycle Household Waste
Less manual than traditional composting
ttcaptainturner@gmail.com
@captainturner
Inquire now for
special prices!
CPEF


Instagram
Search
Log In
Sign Up
turnercaptain
Follow
12 posts
60 followers
231 following
Captain Turner
Captain Turner is a compost tumbler designed by CPEF in Trinidad and Tobago to be used by householders to compost their organic kitchen scraps
POSTS
IGTV
TAGGED
PURCHASE
CAPTAIN TURNER
YOUR PACKAGE INCLUDES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Captain Turner
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Home
Posts
Reviews
CAPTAIN TURNER
THE HOUSEHOLD COMPOST TUMBLER
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Like
Share
Send Message

Recommendations

- A programme of further research to gain additional data
- Public education campaigns
- Use of the tumbler as both an educational and waste management tool
- The expansion of the use of the UCU in communities on a large-scale basis

Conclusions

- The tumbler can produce mature compost within 60 day or less in ideal conditions

- The produced compost was useful for the participants

- The tumbler was made available publicly with notes on challenges posed to participants, such as water-logging.

The tumbler is an effective method of reducing household organic waste which can culminate in a significant disruption of organic waste directed to landfills while promoting sound agricultural practices and improving environmental and human health.

Thank you.

CAPTAIN TURNER

THE HOUSEHOLD COMPOST TUMBLER

MADE IN TRINIDAD & TOBAGO

ttcaptainturner@gmail.com | @captainturner

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PPP Project for Integrated Solid Waste Management in Cayman Islands

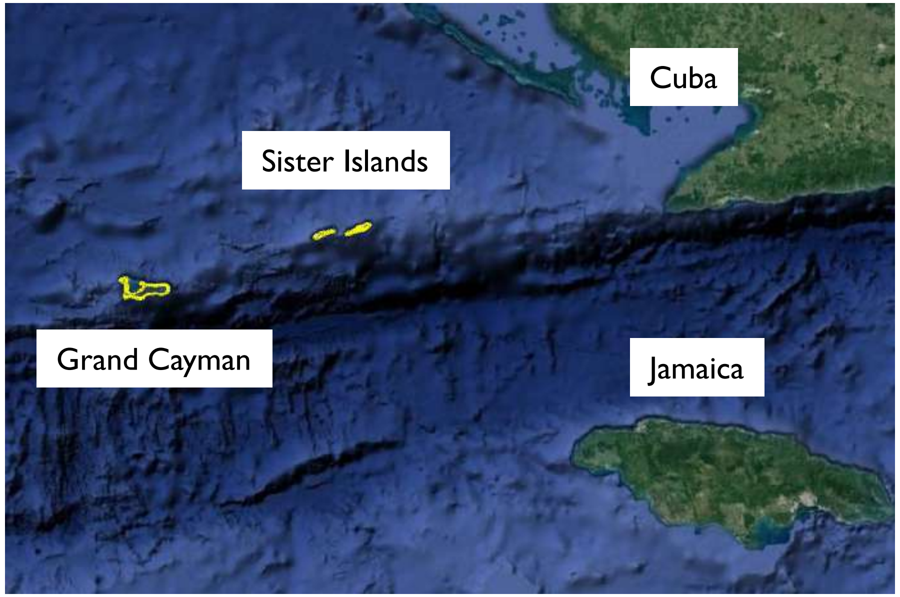
Presented by:
Martin Edelenbos
Engineering Coordinator – Waste Management
Dart Enterprises

Agenda

- Background on the Cayman Islands and waste management
- Development of the Integrated Waste Solid Waste Management System
- Procurement Process
- The preferred bidder and proposed solution
- Current refined solution
- Status of project and next steps

Cayman Islands Overview

- First recorded sighting by Christopher Columbus on 10th of May 1503
- Low lying limestone base surrounded by corral reef
- Total Land area ~ 102 sq. miles
- Population: Grand Cayman (66,000), Cayman Brac (1800), and Little Cayman (300)
- GDP/capita approx. USD 78,000
- Economy based on international finance and tourism
- George Town is the capital



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Waste Management in Cayman

- Since the 1970s, trash has been accumulating at the George Town Landfill
- Currently peaking at 90 feet above sea level and approaching 2 Million cubic yards, the existing landfill is growing at a rate of approximately 100,000 tons per year and is running out of space
- Current landfilling practices are unsustainable
- PPP Project will turn the landfill site into a green space and create a modern energy recovery and waste reduction centre

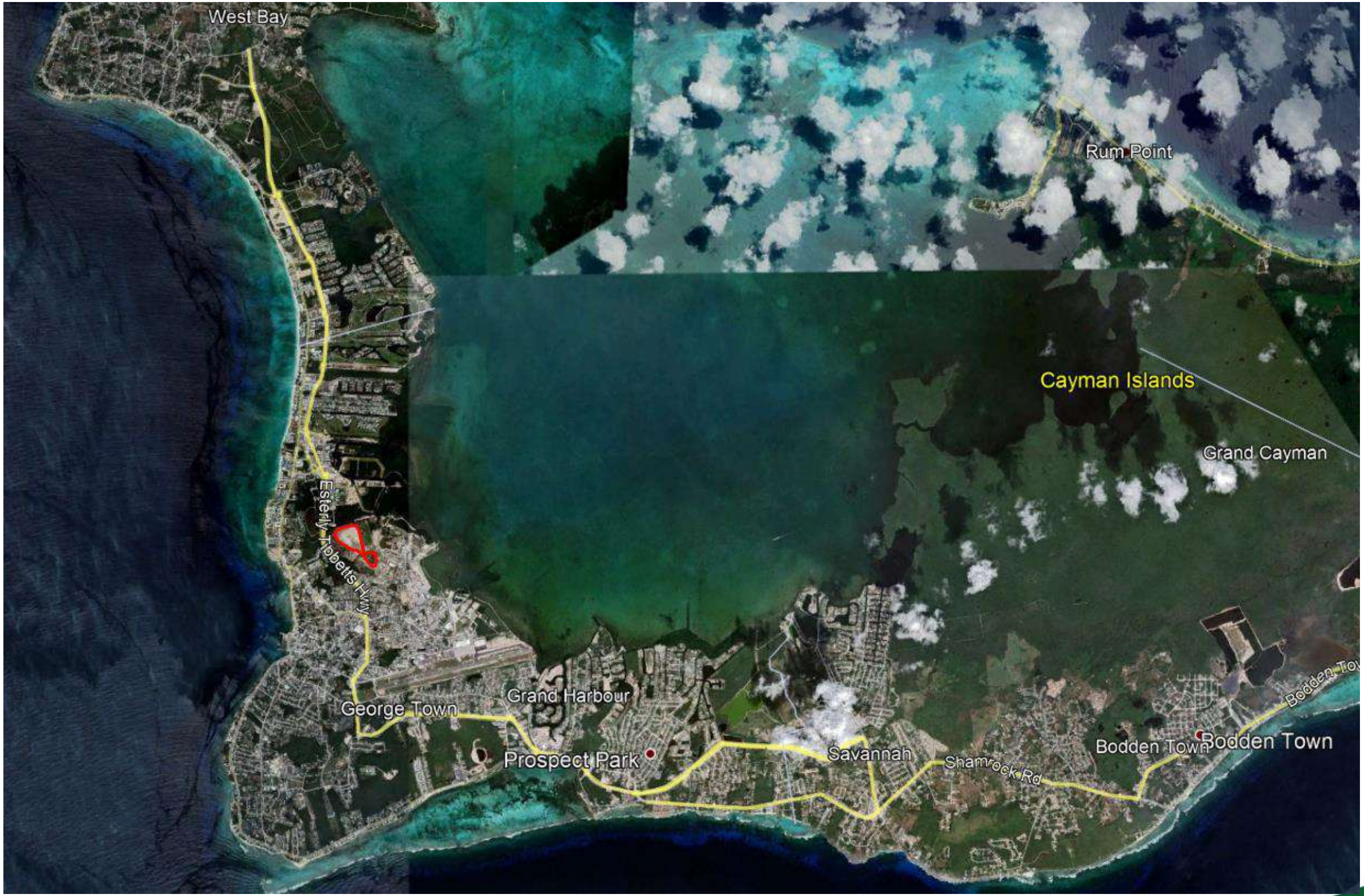
George Town Landfill

non-Engineered ad hoc landfill; running out of space

- Receives all waste generated on Grand Cayman
- Unlined site on relatively porous karst limestone
- History of several large fires in waste and stockpiled metals (mixed waste)
- Liquid waste and hazardous waste management area (mostly shipped overseas)
- Small batch-loaded starved air incinerator to treat infectious, pathological, and special wastes
- Recycling compound for sorting and bailing source separated dry recyclables through a depot collections system – glass, cardboard, paper, tin and aluminium cans, plastics #1 and #2,
- Glass is chipped and used locally, other materials baled and shipped overseas
- Metals and end of life vehicles have been separated and stored since about 2004 and now are depolluted and shipped overseas, large legacy piles yet to be recycled.

Landfill Location (red)

Western end of Grand Cayman



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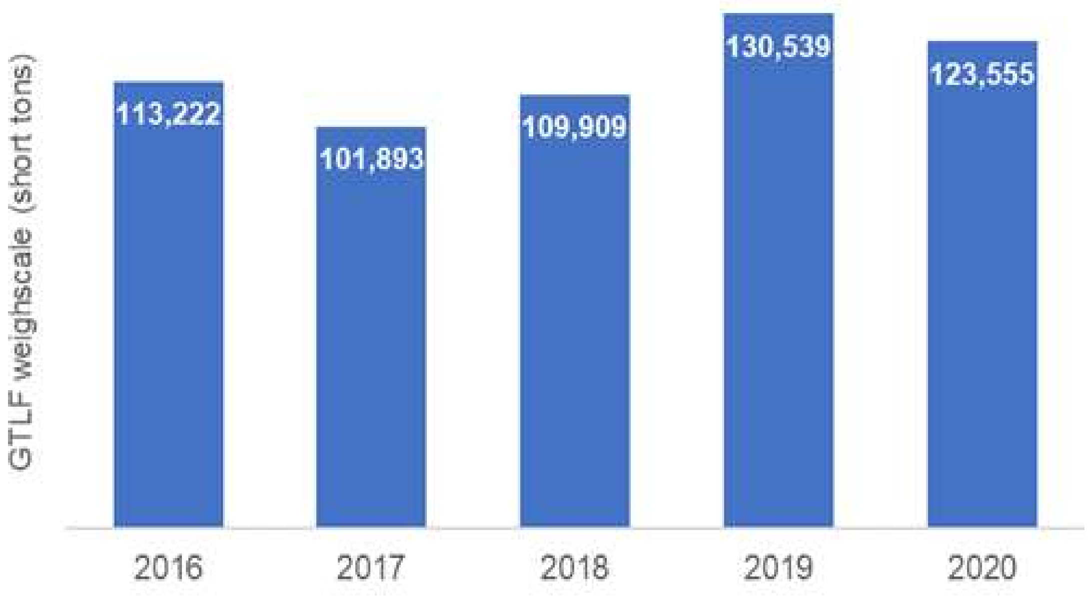
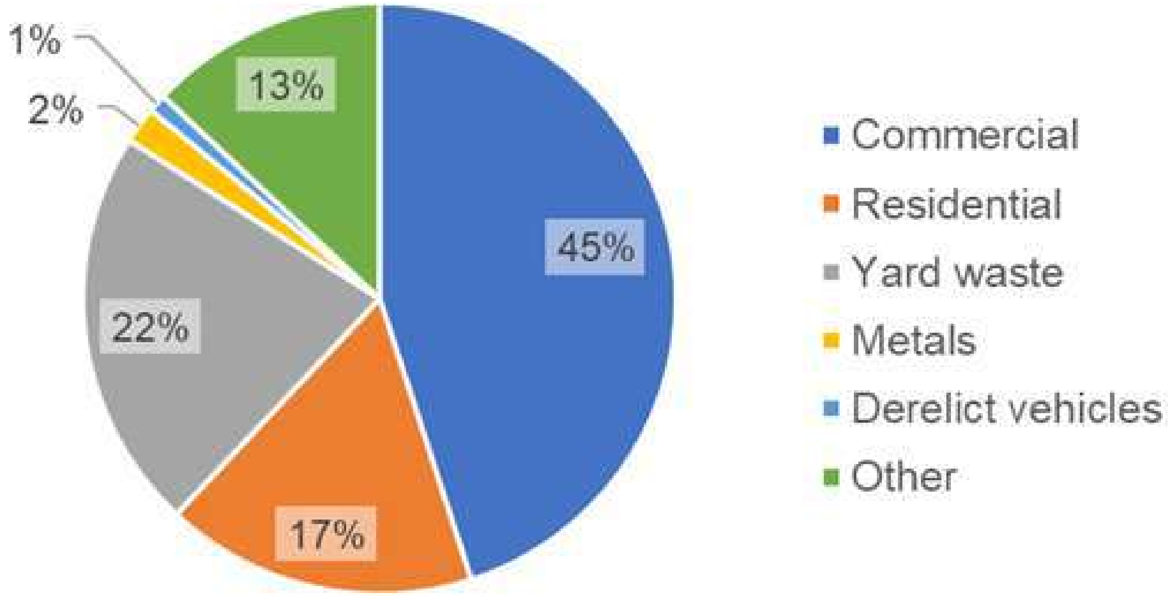
Waste Generation and Composition





Strategic Outline Case – CIG - April 2014

Purpose is to outline broad policy direction

- Develop a National Waste Management Strategy
- To provide the Cayman Islands with an environmentally sound and cost- effective Integrated Solid Waste Management System (ISWMS)
- Provide an efficient and economical balance of public and private services
- No investigation of alternative landfill sites on Grand Cayman
- Anticipated that the Cayman Islands Government will enter into a Public Private Partnership (PPP) at some point in the project
- Pursuant to transparent and accountable procurement, the target operational date for ISWMS is as soon as possible

National Solid Waste Management Strategy

AMEC Foster Wheeler - October 2015

- Key strategies include:
- Follow the waste hierarchy
- Recover energy through waste combustion
- Develop an engineered landfill for residuals that can not be recycled or combusted, as well as disposal the ERF air pollution control residue
- Remediate three existing landfills

Reduction	Using less material in design and manufacture, keeping products for longer, using less hazardous materials;
Re-use	Checking, cleaning, repairing, refurbishing, repair, whole items or spare parts;
Recycling	Turning waste into a new substance or product. Includes composting if it meets quality protocols;
Recovery	Energy is recovered from waste through a variety of methods such as thermal treatment and digestion; and
Disposal	Landfill and incineration without energy recovery.

Outline Business Case

Consultative Draft – AMEC Foster Wheeler September 2016

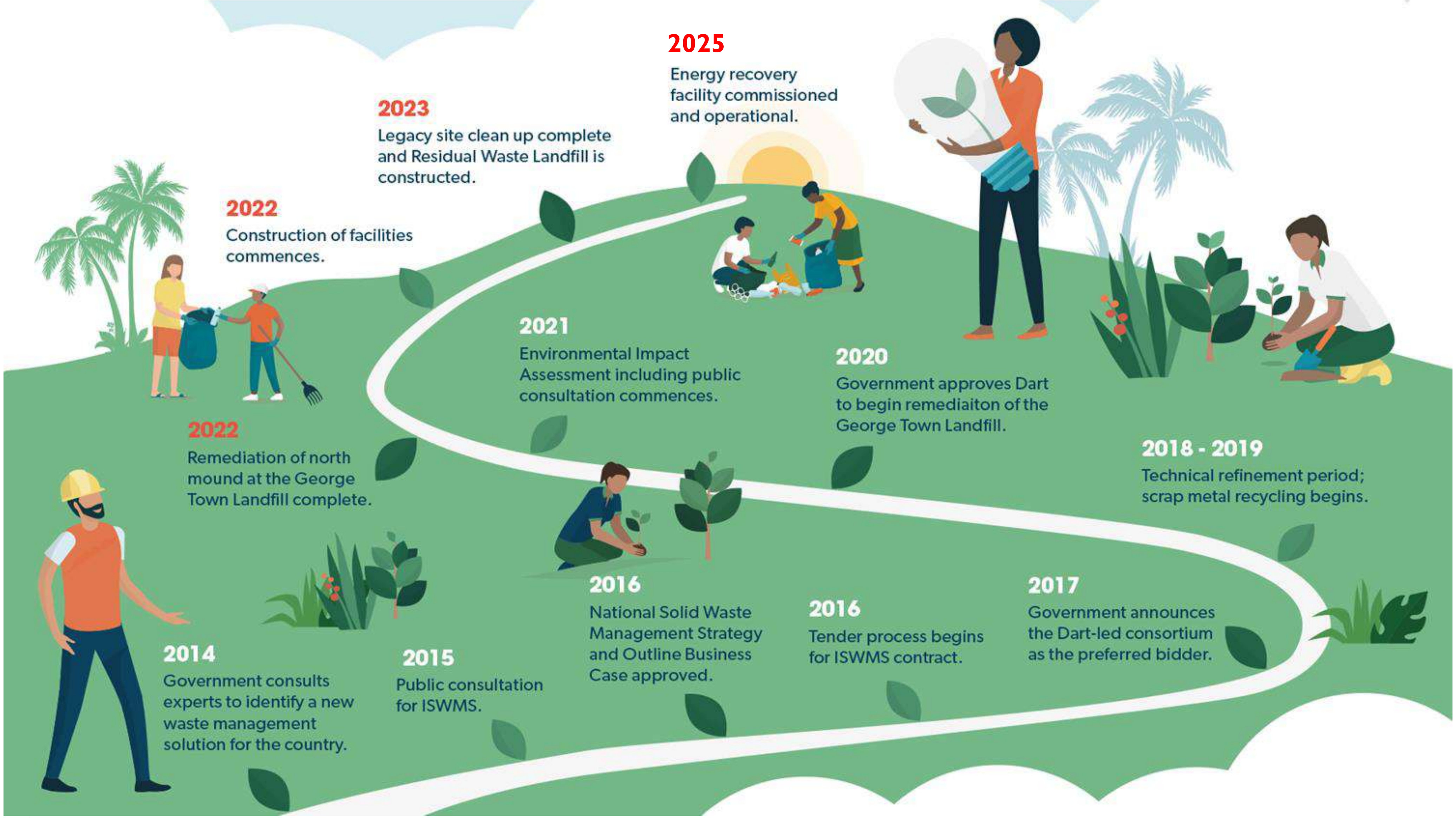
- Focus on comparative analysis of alternative waste management systems that encompass waste reduction, re-use, recycling and recovery which minimize the reliance on landfill.
- Recommends a Design, Build, Finance, Operate, & Maintain contract (DBFOM)
- Recommends a Public Private Partnership
- Suggests most viable procurement procedure is a streamlined Competitive Dialogue procedure for the DBFOM/PPP contract

Tender Process

Integrated Solid Waste Management System for the Cayman Islands

- Pre –qualification (28th October 2016)
- Invitation to Participate in Dialogue (ITPD)/ Invitation to Submit Outline Solutions (ISOS);
- Invitation to Submit Final Tenders (ISFT); (April 2017)
- Appointment of Decco Consortium to Preferred Bidder (14th September 2017)
- Contract Award (26th March 2021)
- Financial Close (Q4 2021;TBD)

Path to an Integrated Solid Waste Management System



The Proposed Solution

Integrated Solid Waste Management System: ReGen Components

- Remediate landfills on each island by capping the waste including long term monitoring and landfill gas collection for George Town Landfill
- Transfer recyclables and residual waste from Little Cayman and Cayman Brac to Grand Cayman
- Divert up to 95% of waste from landfill disposal
- Public Education
- Energy Recovery Facility (ERF) on Grand Cayman mainstay of waste treatment; 8 additional physical components to compliment ERF

The Proposed Solution; Financial

Integrated Solid Waste Management System: ReGen Components

- Capital cost of the infrastructure will be financed by the Decco Consortium and is estimated at USD 244 million
- The Cayman Islands Government will pay for the project through a unitary cost per ton of contract waste managed over the 25-year contract period
- The unitary charge will include capital cost repayment component and operating costs for those functions operated by the Decco Consortium
- At the end of the 25-year contract the facilities will be transferred to government ownership
- There are no disposal fees to the public and no plans to introduce disposal fees for commercial operators at this time.

What facilities does the project include?

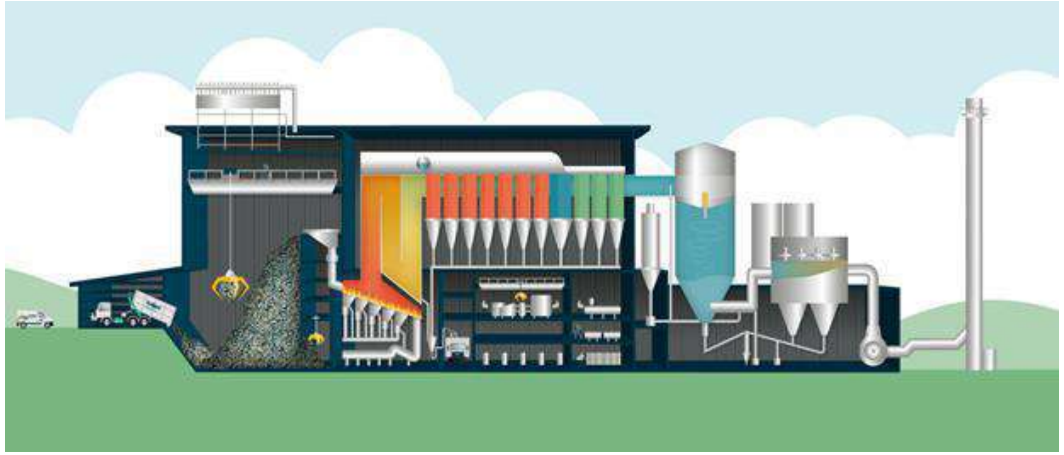
Nine, integrated facilities with capacity to divert up to 95% of waste from landfill:

- Energy recovery facility
- Bottom ash processing
- Construction & demolition waste processing
- Residual waste landfill
- End-of-life vehicle and scrap metal recycling
- Materials recovery facility, paper & OCC, metal cans, glass, plastic #1 & #2
- Green waste mulching or composting
- Household waste recycling centre
- Medical waste incinerator

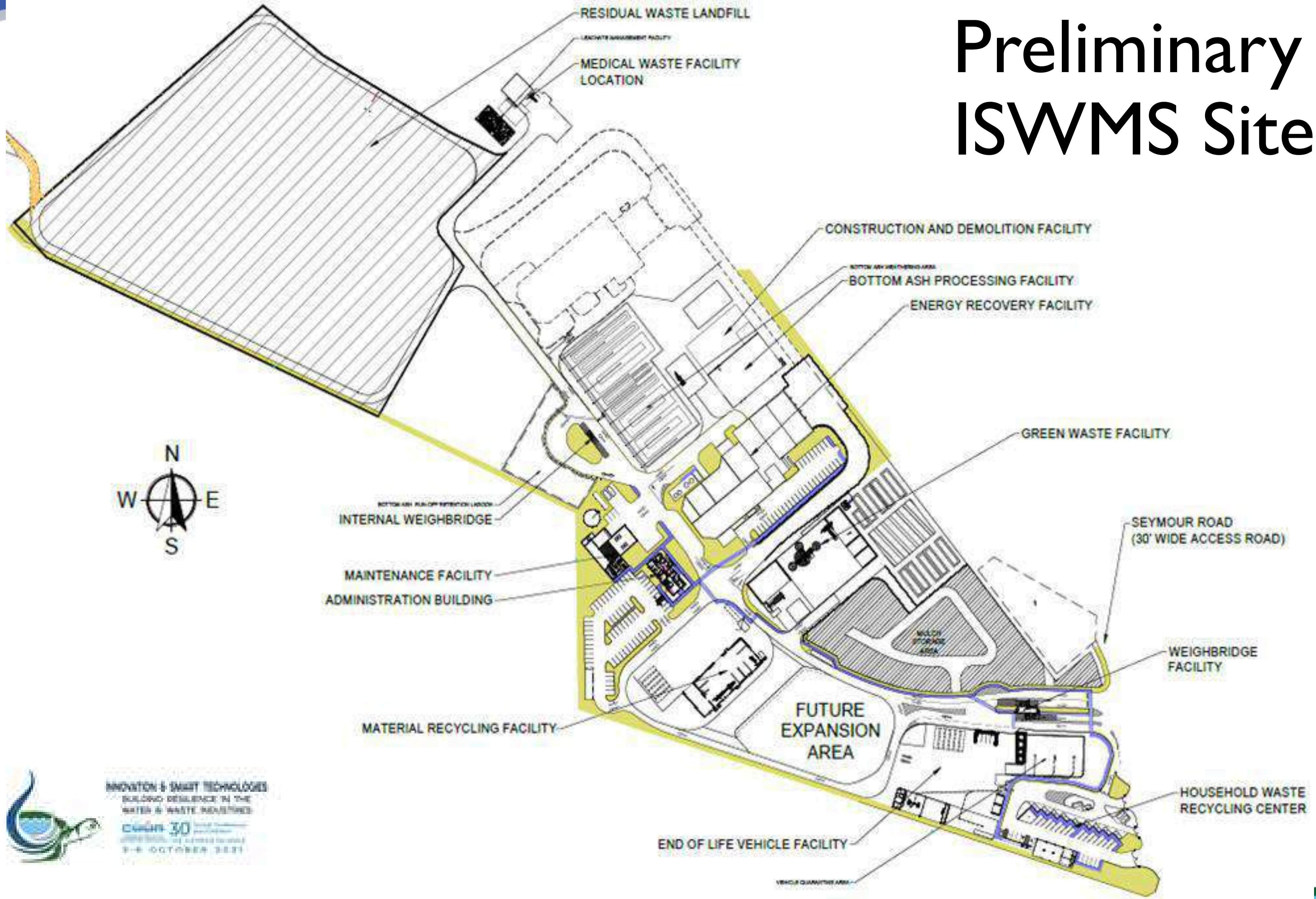
Energy Recovery Facility

Waste to Watts; Turning trash into electricity the sustainable way.

- Trash is used to fuel a boiler and burned at high temperatures; approx. 1100 °C
- The boiler produces high pressure steam that drives a turbine to generate 9.3 MW (net) electricity
- After the waste is completely burned, 25% of the weight remains as bottom ash which is processed to recover metals, such as steel and aluminium, which are recycled
- Stabilised Non-Catalytic Reduction (SNCR) and a bag house filter system scrubs emissions to European Union Industrial Emissions Directive standards



Preliminary ISWMS Site Plan



Environmental Impact Assessment (EIA)

Where are we and what's next?

- EIA examines the anticipated environmental consequences of a new project
- Currently completing the Terms of Reference which began with a 21-day public consultation period
- Once finalised, the Terms of Reference will guide necessary studies that form the basis for an Environmental Statement (ES)
- Environmental Assessment Board will review the ES and write a final recommendation for consideration by Government
- Expected to be complete mid-2022

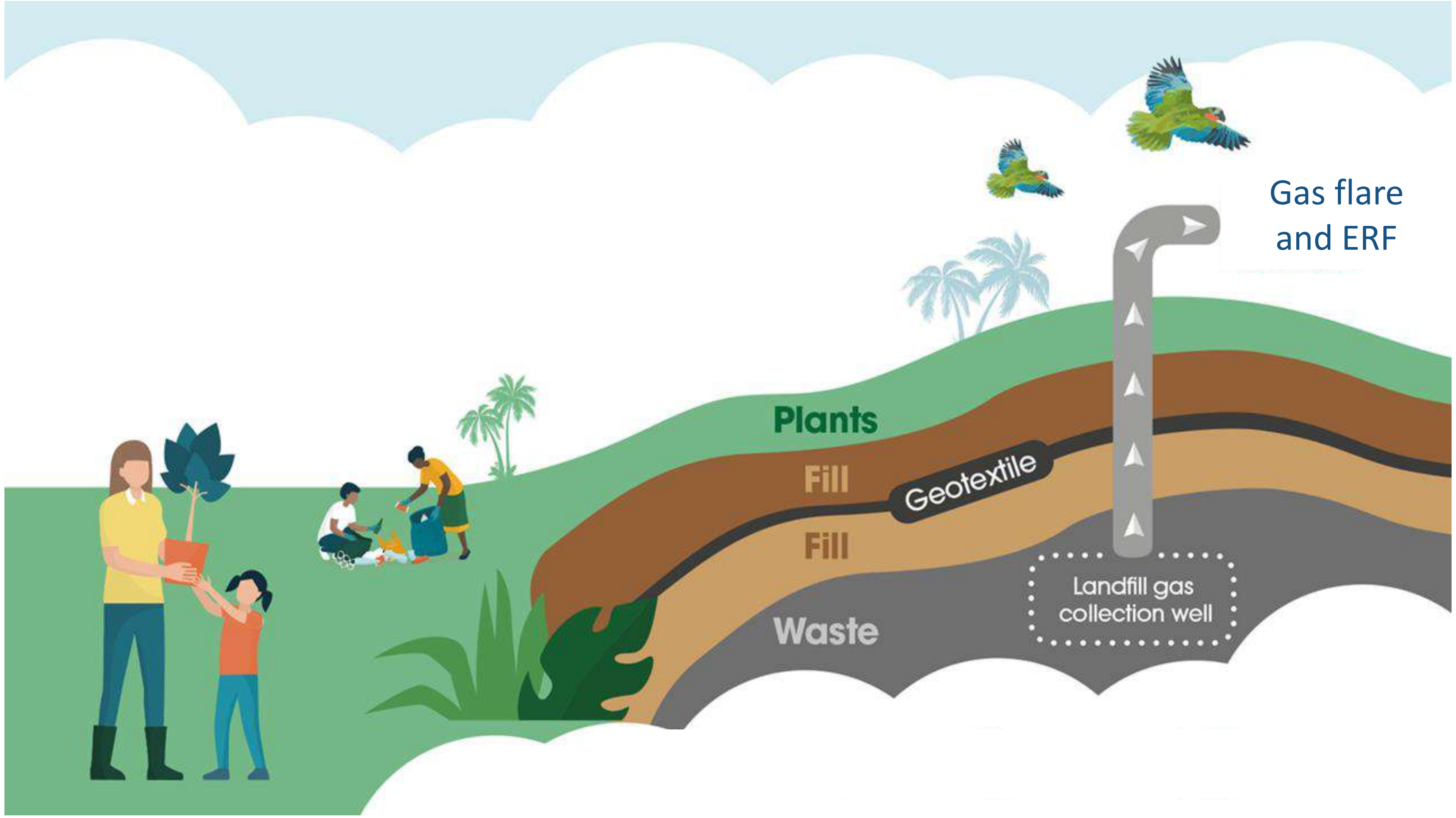
Landfill Remediation

- Landfill Site Environmental Review - identified the environmental impacts of Current sites (AMEC Foster Wheeler, 2016)
- Remediation Options Report – considered options for closure (GHD,2020)
- Risk Base Assessment – performed to assess the risks remaining once the site had been remediated according to the options plan
- Cost of the landfill remediation is estimated at USD 27 Million.

Based on the above studies, concluded that technical closure, involving low permeability cap, landfill gas management and environmental monitoring was an environmentally sound project that would contain contaminants and provide for public open space amenity.

Next Steps in Landfill Remediation

- Complete Design
- Landfill gas wells and piping installation
- Low permeability cap installation
- Landfill gas flare compound
- Establish Vegetation



Conclusion

The ISWMS project will provide a long-term waste management solution for the Cayman Islands and bring about the end of the current dilute and disperse landfilling activities; but has highlighted the complexities of realizing a sustainable alternative to landfilling in an island setting.

Thank You

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Making Peace with Nature - Using the IWEco Approach to Ecosystems Restoration in St. Kitts and Nevis

Halla Sahely, Ph.D.

IWEco SKN National Project Coordinator

IWEco.StK&N
Integrating Water, Land and Ecosystems Management in Caribbean Small Island Developing States
#CaringForOurFuture

Agenda

IWEco.StK&N
Integrating Water, Land and Ecosystems Management in Caribbean Small Island Developing States
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- Introduction to the IWEco project
- Definition of Nature-based solutions (NbS)
- Examples of NbS in action under IWEco SKN
- Land degradation control works in College Street Ghaut, St. Kitts
- Reforestation and restoration activities at three sites in Nevis
- Concluding remarks

Introduction to IWEco

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Integrating Water, Land and Ecosystems Management in Caribbean Small Island Developing States
#CaringForOurFuture

Introduction to IWEco (www.iweco.org)

- IWEco - Integrating Water, Land and Ecosystems Management (IWEco) in Caribbean Small Island Developing States
- Multi-focal regional project with 10 participating countries
- Funded by the GEF, implemented by UNEP
- IWEco SKN implemented by DOE SKN
- 3-year project with funding just under 1 Million USD
- Strengthen the institutional capacity, improve the policy framework and facilitate pilot projects within the College Street Ghaut watershed (St. Kitts), and key quarry sites and nearby wetlands and coral reefs (Nevis)

IWEco approach

- Integrative approach which focuses on systems, people and values
- **SYSTEMS**: whole ecosystems (such as watersheds) and focus on relationships and processes within the system
- **PEOPLE**: ensures intersectoral cooperation and stakeholder engagement
- **VALUES:** our environment provides us with important and valuable benefits (also called ecosystems goods and services) which support all life and seeks to enhance the sharing of those benefits.
- Many interventions taken on-the-ground are Nature-based Solutions (NbS)

What are Nature-based solutions?

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Definition of Nature-based solutions

- Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits (IUCN 2016)

NbS in action
Land degradation control works in College Street Ghaut, St. Kitts

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Land degradation control works

College Street Ghaut, St. Kitts

- The College Street Ghaut watershed covers 662 hectares
  - Complete range of features from upland natural forest, former sugar cane lands and urban development
- Land use changes especially due to urban growth have resulted in more rapid surface water runoff and severe soil erosion following rainfall events
- Negative impacts of this land degradation are far-reaching
  - Public health risks due to flooding and inappropriate disposal of liquid and solid waste
  - Loss of top soil
  - Poor water quality at the outlet of the ghaut

Land degradation control works

College Street Ghaut, St. Kitts

- Early 2020 – clean up of solid waste, removal of invasive plants
- Installation of over 300 gabion baskets
  - Effective against soil erosion on the banks of ghaut
- Repair of 2 weir structures
  - Act as a barrier to retain excessive soil runoff
- Removal of soil / debris from culverts and drains and at the outlet
  - Over 500 metric tons of sediments dredged in September 2021
- Planting of deep-rooted vetiver grass

Supporting activities
College Street Ghaut, St. Kitts

- Pilot greywater collection, treatment and reuse system using constructed wetlands (Daniel and Paul 2021)
- Development of a management plan to bring together key stakeholders to continue effective actions in the ghaut
- Public awareness and outreach
  - Key features of the ghauts in SKN
  - How can I care for the ghaut?
- Knowledge sharing and lessons learnt documented

NbS in action
Reforestation and restoration at three sites in Nevis

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Reforestation

Coconut Walk Estate, Nevis (10 acres)

- Persistent land degradation over decades due mostly to overgrazing, unsustainable farming practices and upstream quarry operations.
- Site characteristics –
  - Wind-swept landscape with constant sea-blast
  - Rocky and barren soil conditions
  - Degradation of original vegetation
  - Diminished rainfall in recent years
  - Lack of water retention capacity

Reforestation

Coconut Walk Estate, Nevis (10 acres)

- Site fully contoured with berms to restrict erosion, under which swales were developed for water retention
- Sediment traps and small catchment areas were constructed to aid water retention and vegetation regrowth, including cactus gardens
- Small-scale compositing was developed at the site to promote soil nutrient health
- Fencing, and electrical wire were erected as deterrents from ruminants
- Native sea grape, coconut, almond, and vetiver grass including a variety of forest species and fruit trees have been planted

Restoration at an abandoned quarry
Potworks Estate, Nevis (5 acres)

- Quarrying operations ceased at Potworks Estate over 10 years ago
- No restoration efforts leaving a denuded exposed hillside prone to severe erosion after heavy rainfall and proliferation of invasive plant species
- Abandoned equipment littered the landscape
- Hotspot for illegal dumping of waste
- Robust effort to clean up site and remove invasive species and prepare the land for reforestation activities
- Active planting has started

Restoration at coastal wetland
Nelson's Spring, Nevis (8 acres)

- Coastal wetland subject to many negative environmental pressures
- Increased urban development has cut off links to other wetlands
- Indiscriminate removal of vegetation
- Invasion of the whole area surrounding the pond with non-native species thus suppressing native species
- Pond also colonized by invasive vigorous fast-growing type of cattail

Restoration at coastal wetland
Nelson's Spring, Nevis (8 acres)

- Together with a local community group, clean up activities started by removing the cattails and scrub thus reopening the beautiful vista to the sea
- Replanting started with the relocation of surviving coconut trees and red mangrove was planted near the mouth of the pond
- Other native species also planted
- Encouraging regrowth of native species of sedge, spike reed and water lilies
- Evidence of return of water birds, fish, crabs and butterflies

Concluding remarks – St. Kitts

- **Actions** to protect, sustainably manage, and **restore** natural or modified **ecosystems**, that address societal **challenges** effectively and adaptively, simultaneously providing human well-being and biodiversity **benefits**
- *Actions*: Land degradation control through gabion baskets, planting of vetiver grass
- *Ecosystems*: Restore the fragile modified ghaut ecosystem
- *Challenges*: Reduced disaster risk, soil erosion and pollution
- *Benefits*: Enhanced public health, biodiversity especially in the receiving coastal waters

Concluding remarks - Nevis

- **Actions** to protect, sustainably manage, and **restore** natural or modified **ecosystems**, that address societal **challenges** effectively and adaptively, simultaneously providing human well-being and biodiversity **benefits**
- *Actions*: Restoration of over 20 acres of degraded lands
- *Ecosystems*: Wetland and coastal ecosystems
- *Challenges*: Reduced disaster risk, soil erosion and unsustainable practices such as overgrazing and improper quarrying
- *Benefits*: Enhanced community cohesion and stewardship, re-establishment of native biodiversity

Final concluding remarks

- Although NbS can be both labour and time consuming and require sustained financing and active collaborations –
- The long-term benefits are clear with the creation of **win-win** situation were human well being and biodiversity are enhanced
- These types of solutions are the best way forward as we seek to *make peace with nature* and truly become **"Generation Restoration"**

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Thank you!

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Nature-Based Solutions for Wastewater: Opportunities and Barriers in the Caribbean

Amrita Mahabir, Conservation Community Specialist
The Nature Conservancy (TNC)

The Nature Conservancy

Agenda:

Nature-based Solutions for Wastewater

- Purpose of Assessment
- Components of Assessment
- Key Findings
- Looking Ahead

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Who is The Nature Conservancy?

The mission of The Nature Conservancy is to conserve the lands and waters on which all life depends.

The Nature Conservancy in the Caribbean

WHERE WE WORK

17 countries and territories

★ Caribbean Division Offices

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Purpose of Assessment

Why do we care?

Photos (l-r): © Carolyn Drake, © Lily Haines

What are nature-based solutions (NBS)?

Examples of some interventions currently used in the Caribbean:

- Gravity-flow constructed wetland systems
- Riparian wetland side-stream systems
- In-stream mycofiltration systems
- Constructed wetlands, mostly reed beds
- Waste stabilization ponds
- Anaerobic digesters/reactors
- Natural wetlands
- Reuse of treated effluent for irrigation
- Vegetated sand filter wastewater treatment systems

© Tim Calver

Questions we asked…

- What are the scientific, policy, and stakeholder barriers and opportunities for wastewater management in the **Dominican Republic, Grenada, Haiti,** and **Jamaica**?

- What are some case studies of where nature-based solutions (NBS) are, or could be, contributing to wastewater management in these four countries?

Components of Assessment

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Components of Assessment

Desk research

existing scientific studies, policies, and stakeholders related to wastewater management

Interviews with academics, professional staff, and NGOs

impressions of wastewater and the role of NBS

Public opinion study

focus groups to learn public attitudes about the issue and potential solutions

Key Findings

Desk Research & Interviews

- Inadequate wastewater management is recognized as a significant issue in the Caribbean

- Governments recognize the problem, but lack the resources and in some cases the policies to address the problem

- NBS for wastewater are fledgling, but there are signs of increased momentum for NBS

Public Opinion Research

- Clear concern about the health of the waters
- Understanding of how sewage pollution affects life at every level
- Concern that those problems would also hurt the tourism and fishing industries
- Willingness to support NBS, but recognition that they could be a tough sell

Looking Ahead

Opportunities

- Improved governance and policies
- Increased education and awareness
- Public, private, and civil society partnerships
- More funding and greater prioritization

THANKS TO:

UN environment programme 50 1972-2022

Caribbean Environment Programme

Government Offices of Sweden
Ministry of the Environment

The Nature Conservancy

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Comparison of Methodologies for the Quantification of Hydrogen Sulphide Emissions at a Wastewater Treatment Plant

Marcela Martinez Ebanks, Laboratory Manager
Jerry Banks, Laboratory Technologist
Water Authority-Cayman

Agenda

- Introduction
- Summary of Methodologies
- Method Validation
- Project Phases & Results
- Discussion

INTRODUCTION

In 2017, following odour nuisance complaints from the community the Water Authority-Cayman (WAC) began the monitoring of hydrogen sulphide emissions from the Waste Water Treatment Plant (WWTP) owned and operated by the WAC.

- The original wastewater facility was commissioned in 1988 and consists of four large stabilization ponds which are located in the northwest of the treatment facility.

- In 2004 the stabilization ponds were replaced with Sequencing Batch Reactor (SBR) treatment system. The SBR treatment facility is located to the southeast of the waste stabilization ponds.

The treatment facility is located within an industrial area. The Islands solid waste facility is located to the west of the wastewater treatment facility. Swamp land is located to the north and northeast of the facility. Both the swamps and the solid waste facility are known to emit hydrogen sulphide.

METHODOLOGY

Data collection consisted of both grab samples and average-time-period samples.

- Grab samples were collected & analysed using Jerome J605 –Arizona Instruments, LLC following an internally developed and accredited (A2LA 1931.01) procedure (WAC SOP ENG001)
- Average-time-period samples were collected using radiello® passive diffusers for hydrogen sulfide (Sigma-Aldrich). Collection followed a modified NIOSH 6013 procedure for adsorption and SM 4500S^2 D (Methylene Blue) method for analysis.

Jerome J605

- Jerome® J605 Hydrogen Sulfide Analyzer is an ambient air analyzer with a range of 3 ppb to 10 ppm hydrogen sulphide (AZI, 2015).
- The instrument has known method interferences which included:
  - Ammonia (can be removed through the use of a filter)
  - Chlorine (can removed through the use of a filter)
  - Nitrogen dioxide
  - Most mercaptans

Jerome J605

- Instrument verification is conducted using Functional Test Modules (FTMs) from Arizona Instruments, LLC (part no. AZIZ2600-0930, AZIZ2600-0918)

Radiello Passive Diffusers

- Radiello® passive samplers consist of an adsorbent cartridge coated with zinc acetate. The cartridge is placed inside of a polyethylene diffusive body for protection.
- The diffusive body is mounted on a support plate and placed within a shelter to protect the body and cartridge from weather elements.
- The adsorption rate of the cartridge is temperature dependent.

https://www.sigmaaldrich.com/catalog

Weather Information

- Beginning in November 2020, the Authority installed several Vantage Pro 2 (Davies Instruments) at fixed locations at the WWTP.

- The Vantage Pro 2 records a number of parameters including temperature, wind speed, and wind direction which is recorded as secondary intercardinal directions.

E
Vantage Pro
F
Vantage Pro
D
G
Mt. Trashmore
A
Vantage Pro
C
Image © 2021 Maxar Technologies
B
Google Earth
1985
Imagery Date: 1/13/2021 19°18'38.03" N 81°22'16.64" W elev 21 ft eye alt 1841 ft

METHOD VALIDATION

The Functional Test Module (FTM) manufactured and calibrated by Arizona Instruments for the verification of the Jerome series of instruments generates a hydrogen sulphide gas sample of known concentration.

A verification of the **J605** per the manufacturers instructions was performed with a result of **31.06 ppb H_2S.**

On the same day a **Radiello** cartridge was placed inside of a tube connected to the FTM and allowed to sit for 60 minutes. The cartridge was then desorbed and analysed for H_2S using the methylene blue method. The result was **44.0 ppb H_2S**

Method Validations

Comparison of Jerome J605 and radiello® passive samplers with known concentration gas

Standard	Radiello Average (ppb)	Reference Value (ppb)	% Rec
LL_FTM	44.0	30	147%
LL_FTM	44.0	30	147%
LL_FTM	32.7	30	109%
FTM	402.9	250	161%
LL_FTM	39.1	30	130%
FTM	338.1	250	135%

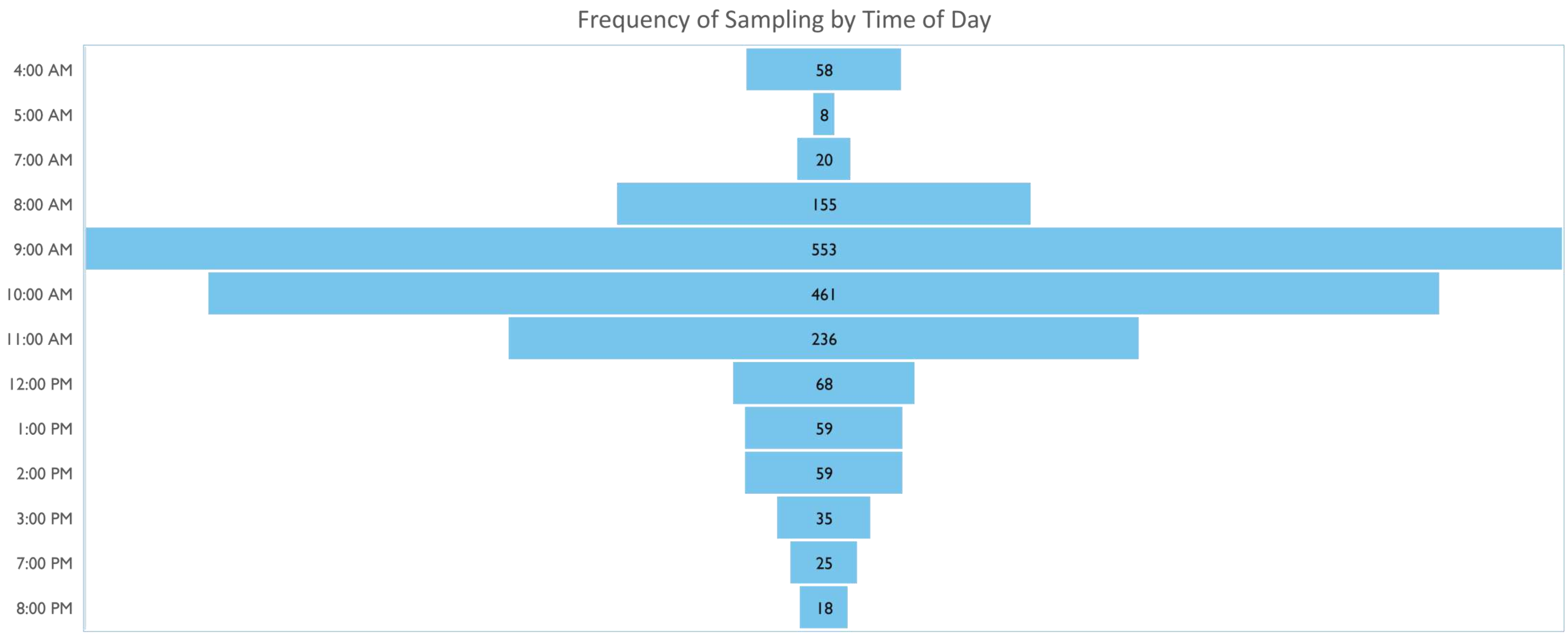
PROJECT PHASES 1

Grab Samples—Jerome J605

- Monitoring Period: November 2017 – April 2021
- Sampling sites are fixed locations.
- The reported values are the average of multiple readings collected over a 2 to 5 minute period.
- A total of 2280 (averaged) data points were collected for the time period.
- A total of 1624 (71.2%) values were below the instrument detection level (3 ppb).

Routine Monitoring Sites
For Grab Samples

Sample Times for Grab Samples



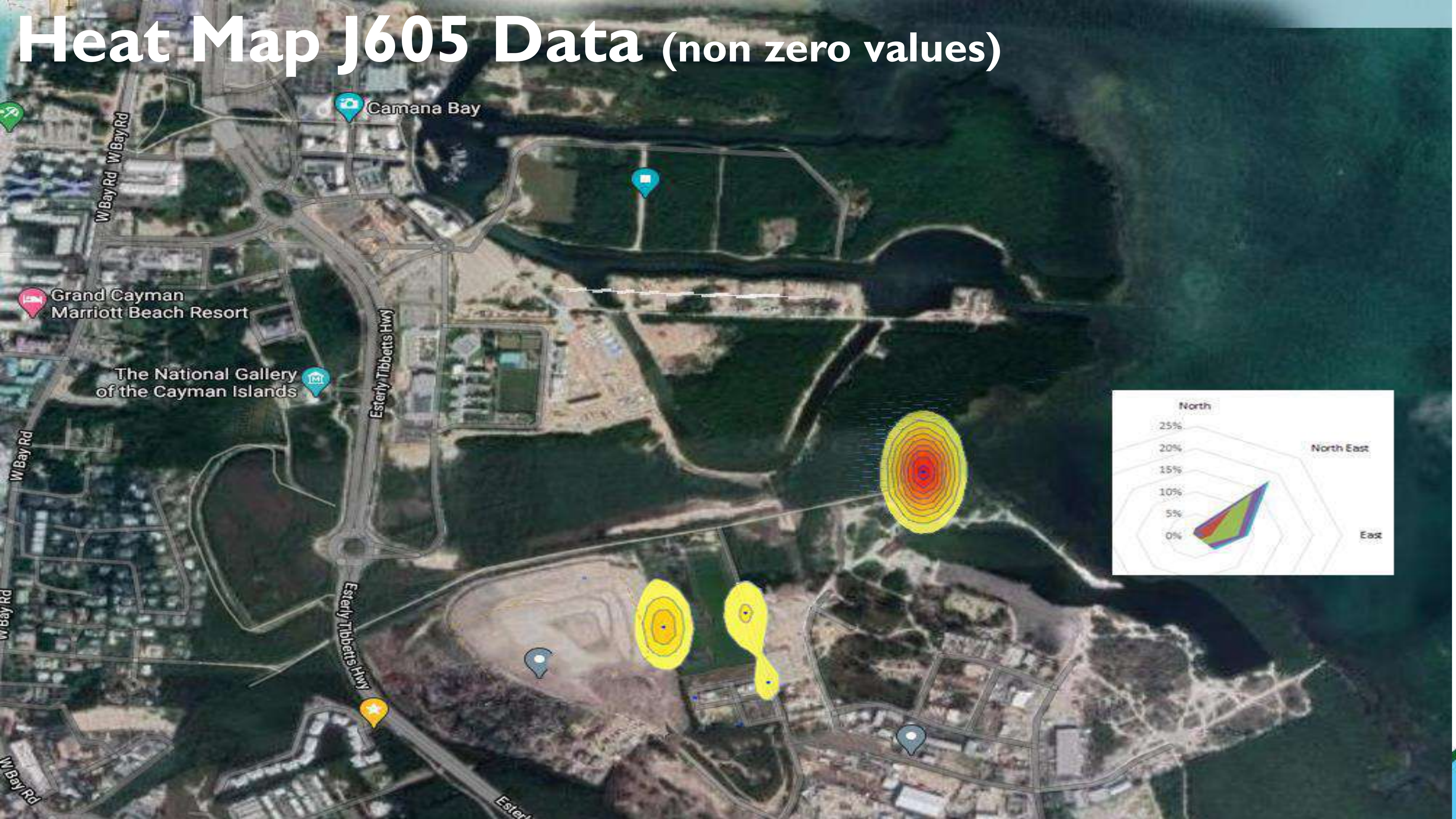
Range of H_2S (ppb) in Grab Samples

Percentage of Results by Year and H_2S Range (ppb)					
Range (ppb)	**2017**	**2018**	**2019**	**2020**	**2021**
BDL	92.3%	75.2%	69.7%	51.7%	50.0%
3-100	0.0%	12.7%	21.5%	33.9%	27.6%
100-500	7.7%	9.6%	6.9%	9.5%	17.2%
500-1000	0.0%	0.7%	1.2%	1.2%	1.7%
1000-2000	0.0%	1.4%	0.6%	3.3%	3.4%
>2000	0.0%	0.3%	0.1%	0.4%	0.0%

Grab Sample Sites with Results >100 ppb

Site	No. of Results < 100 ppb	No. of Results >100 ppb	% Results >100 ppb	Total Number of Results
A	208	27	12.4%	235
B	229	5	2.1%	234
C	223	11	4.7%	234
D	206	36	14.9%	242
E	227	15	6.2%	242
F	221	16	6.8%	237
G	172	48	21.8%	220
Barcadere	186	31	14.3%	217
Dyke Rd. at Sound	136	76	35.8%	212
South Sound Dock	185	8	4.2%	189
DEH	9	5	35.7%	14
Grand Total	**2002**	**278**		**2280**

Heat Map J605 Data (non zero values)



Average Time Period Samples—radiello passive samplers

- Monitoring Period: December 2020 – April 2021
- Various locations.
- Reported values are the average over the exposed period and reported as ppb/min.
- Total of 67 data points.
- Exposure times ranged between 45 minutes to 3 days.

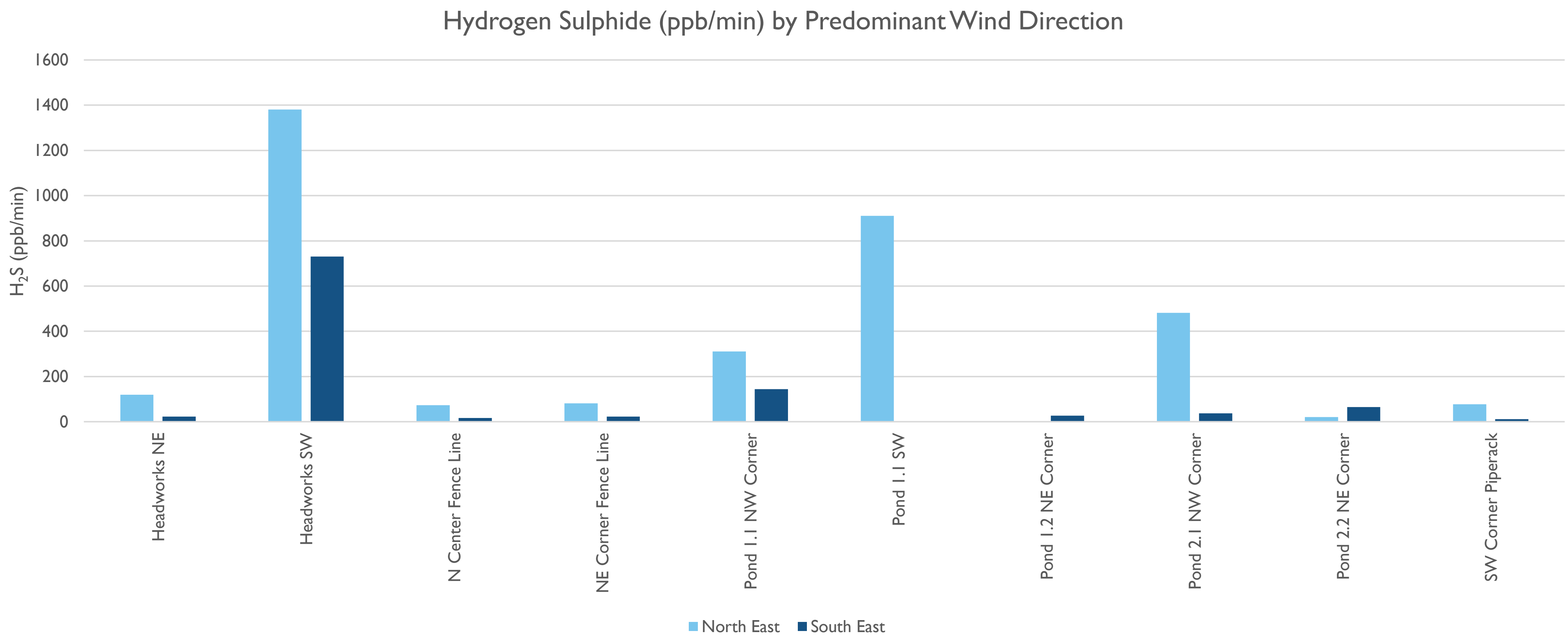

Passive Sampler Location
Passive Sampling Location December 2020 - April 2021
4
5
6
NE Corner Fence Line
NW Corner
N Center Fence Line
Pond 1-2 NE Corner
Pond 1.1 NW Corner
Centre East Fence Line
Pond 1.1 SW
Pond 2.2 NE Corner
Pond 2.1 NW Corner
Pond 2.2 SE
Pond 2.1 SW
Headworks NE
Headworks SW
SW Corner Piperack
1
7
Google Earth
2021 Google
ge © 2021 Maxar Technologies
N
800 ft

Passive Sampler Results by Wind Direction

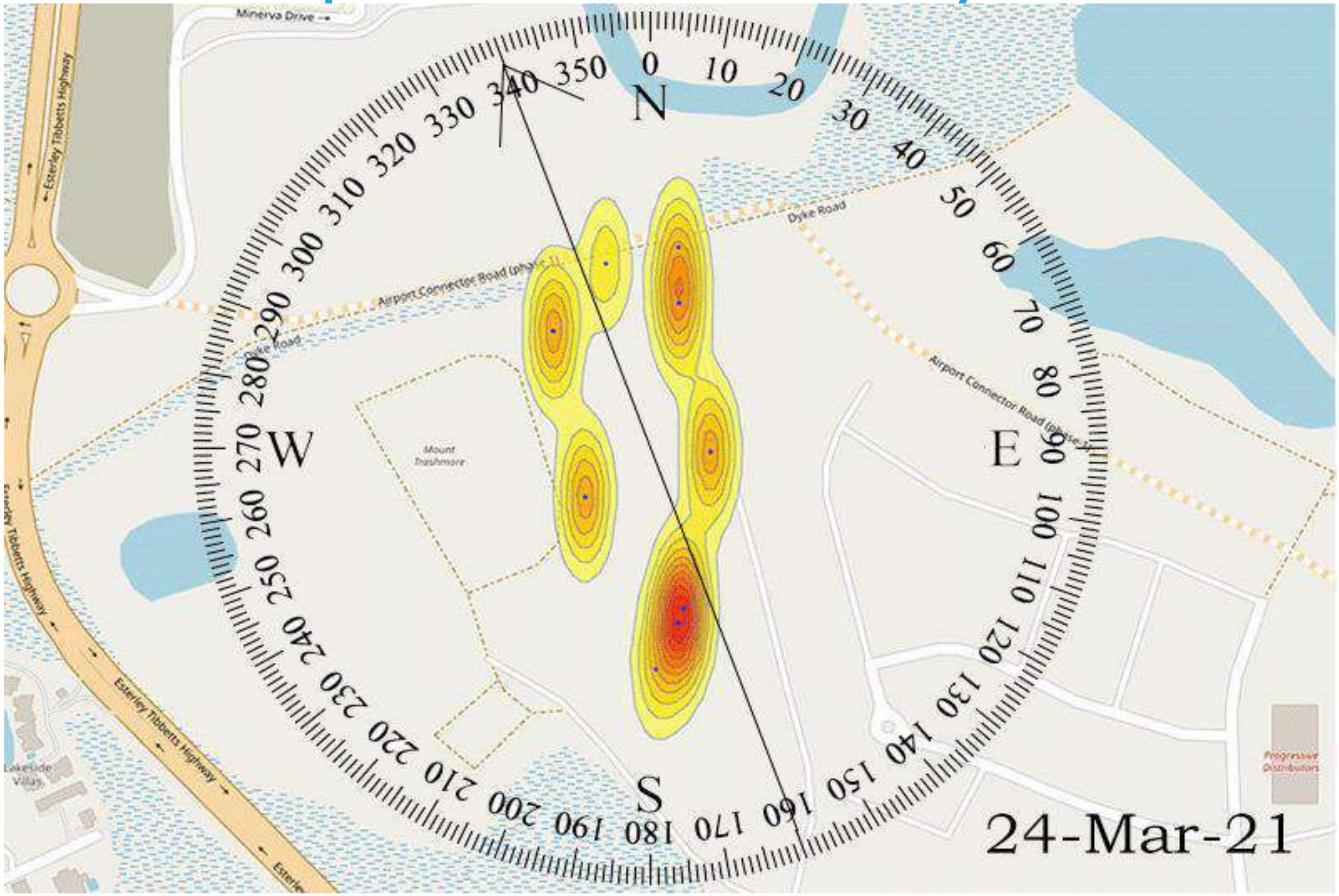
Average Hydrogen Sulphide (ppb/minute)

Site	Wind Direction	
	North East	South East
WWTP Headworks NE	119.5	23.5
WWTP Headworks SW	1380.9	730.7
WWTP N Center Fence Line	73.6	16.6
WWTP NE Corner Fence Line	82.2	23.4
WWTP Pond 1.1 NW Corner	310.5	144.1
WWTP Pond 1.1 SW	911.1	
WWTP Pond 1.2 NE Corner		27.0
WWTP Pond 2.1 NW Corner	481.5	37.2
WWTP Pond 2.2 NE Corner	21.3	65.0
WWTP SW Corner Piperack	77.9	11.7

Passive Sampler Results by Wind Direction

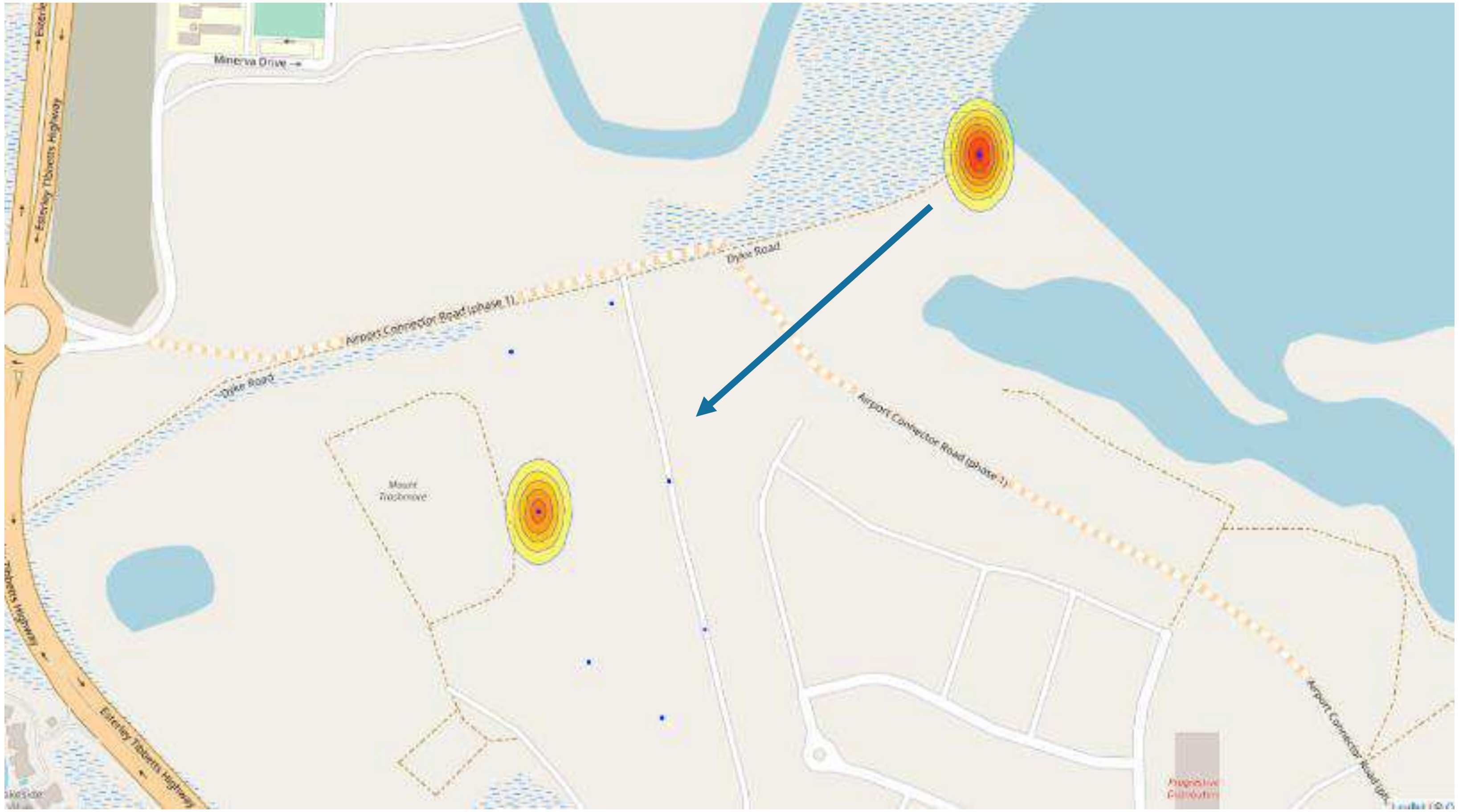


Changes in Passive Sampler Concentration by Wind Direction



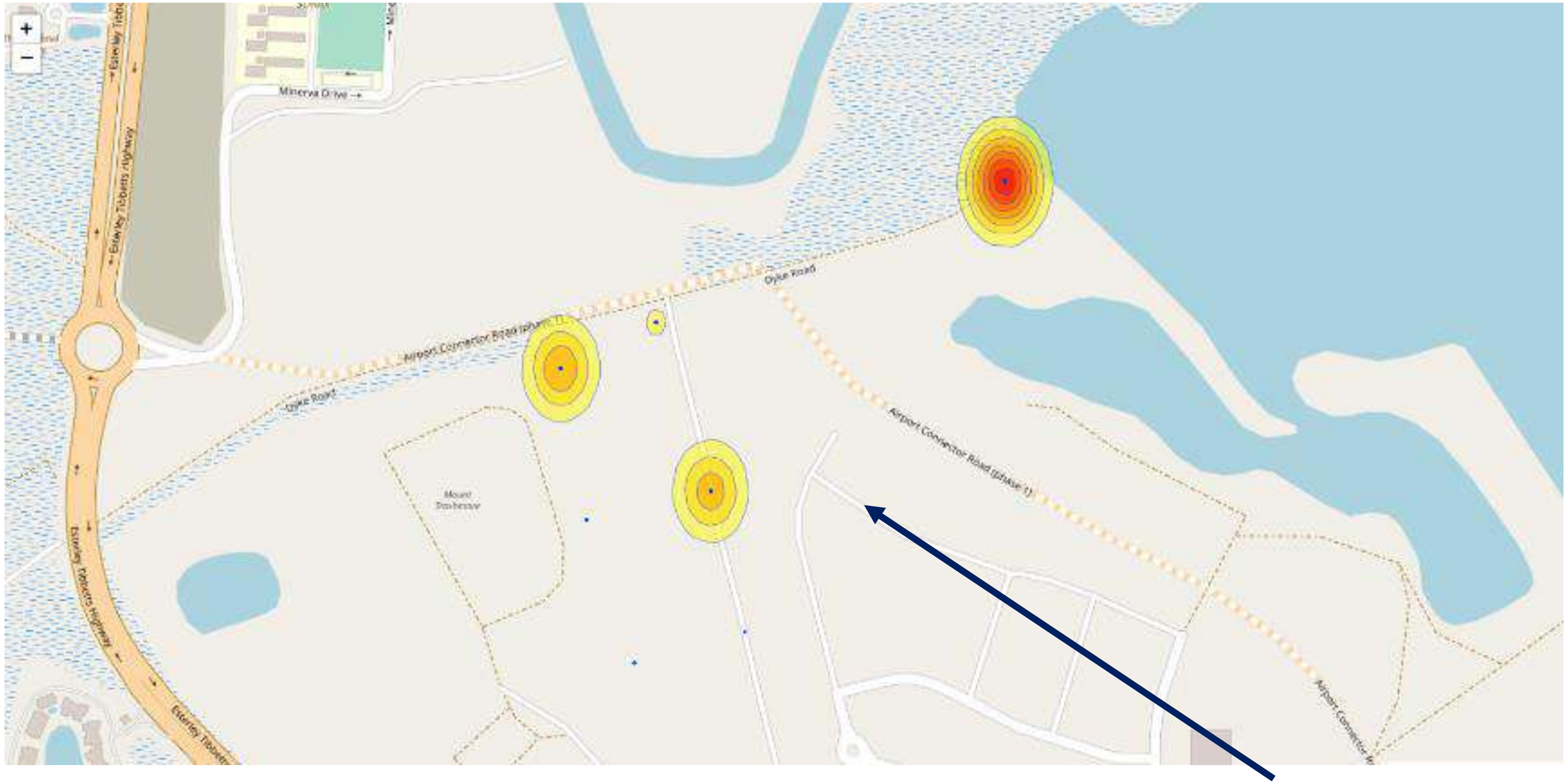
Passive Sampler Results by Wind Direction

Heat Map of Results for Predominant **North East Wind**



Passive Sampler Results by Wind Direction

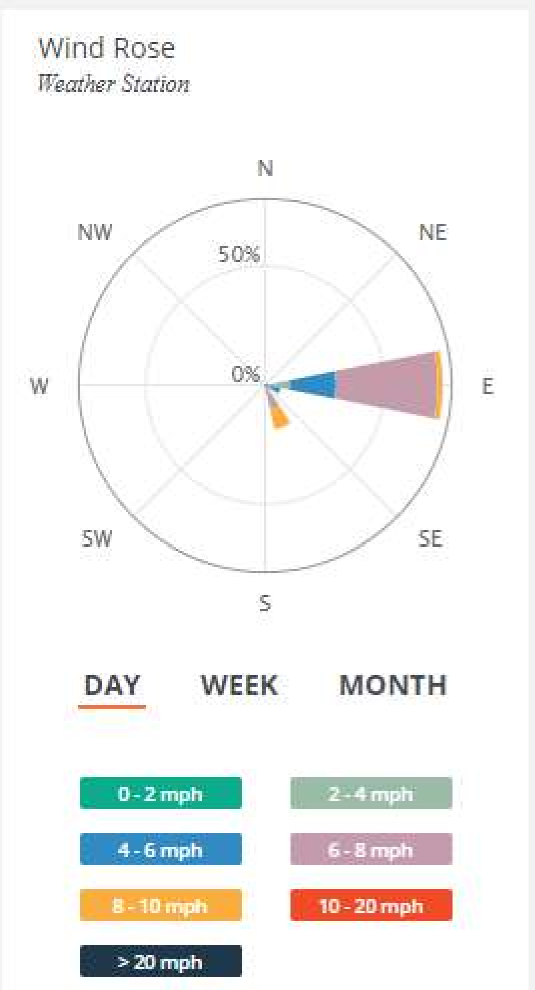
Heat Map of Results for Predominant **South East Wind**



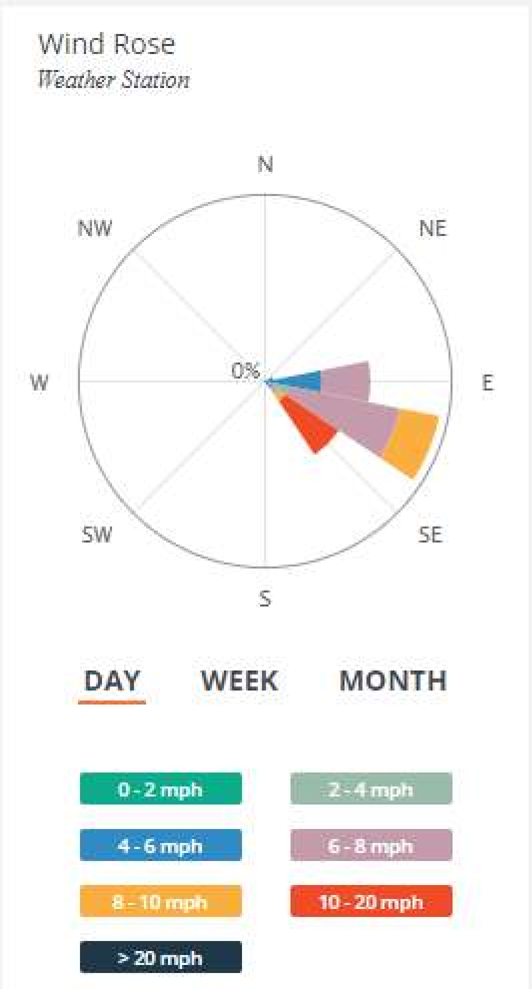
INNOVATION & SMART TECHNOLOGIES

PROJECT PHASES 2

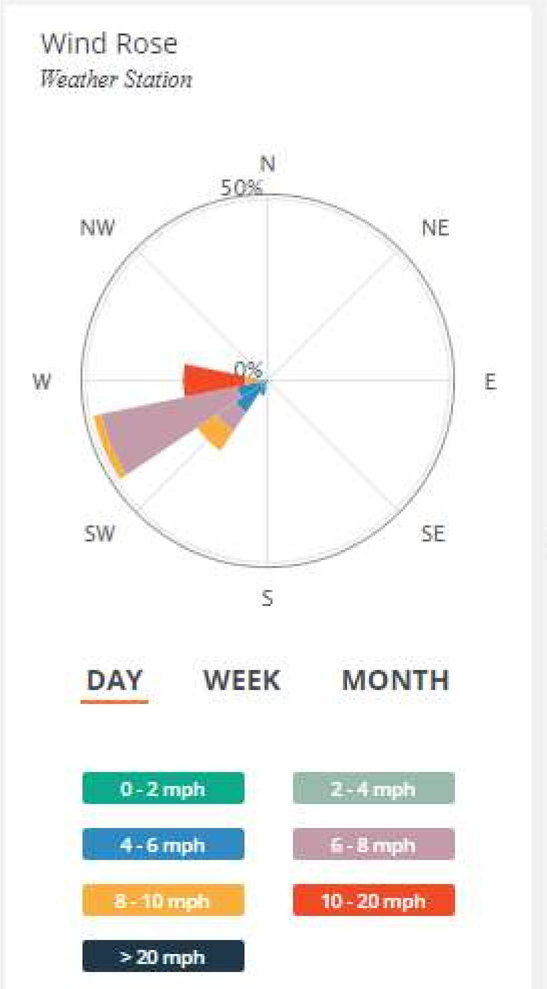
NE 50m
NE 25m
p2
p4
p9
15m from edge centre
p1
J605
p8
p5
p7
p6
p3
10m from edge centre
Image © 2021 Maxar Technologies
Google Earth



Headworks



WWTP NW Corner



NW Pond Discharge Pipe

DISCUSSION

- Data from this study indicate that H_2S also originates from natural sources i.e. dyke roads and wetlands. H_2S levels at the canal ending in the North Sound are consistently higher than anywhere at the WWTP.
- Analysis of wind and H_2S data at the WWTP indicates presence of H_2S "upwind" of the WWTP.
- Wind patterns around the WWTP vary
- The canals north and east of the WWTP have favorable conditions for anerobic production of H_2S.

Next steps

- Additional studies with passive samplers
- Further comparison with Jerome – mercaptan issue?
- Different configurations to better identify H_2S sources

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QUESTIONS

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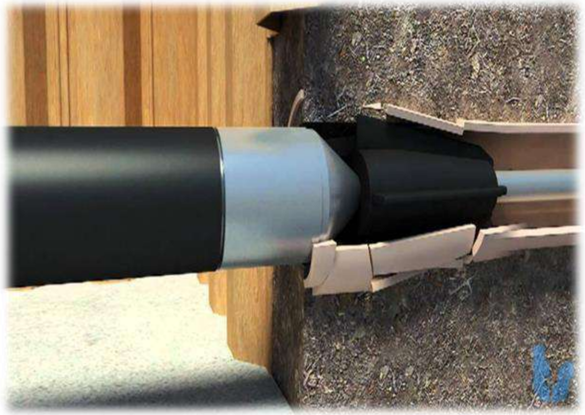
Pipe Bursting-Improving the Cayman Islands Waste Water Collection System

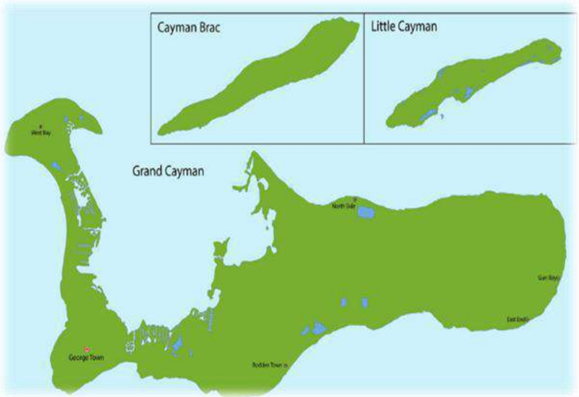
Breandan McDonnell - Project Engineer, Water Authority Cayman

Presentation Introduction

Pipe Bursting – The Cayman Experience

1. History of Pipe Bursting.
2. Types of Pipe Bursting.
3. Rationale for this method on Grand Cayman.
4. Overview of the existing wastewater collection network.
5. Previous condition assessments of our network.
6. Previous remediation methods of our network.
7. Why we implemented Pipe Bursting on Grand Cayman.
8. WAC's first Pipe Bursting Project.
9. Cost Comparatives and Parameters in deciding to use Pipe Bursting Method
10. Planning associated with Pipe Bursting.
11. Local availability of specialist contractor.
12. Challenges of Pipe Bursting project on Grand Cayman.
13. Conclusions.





History of Pipe Bursting

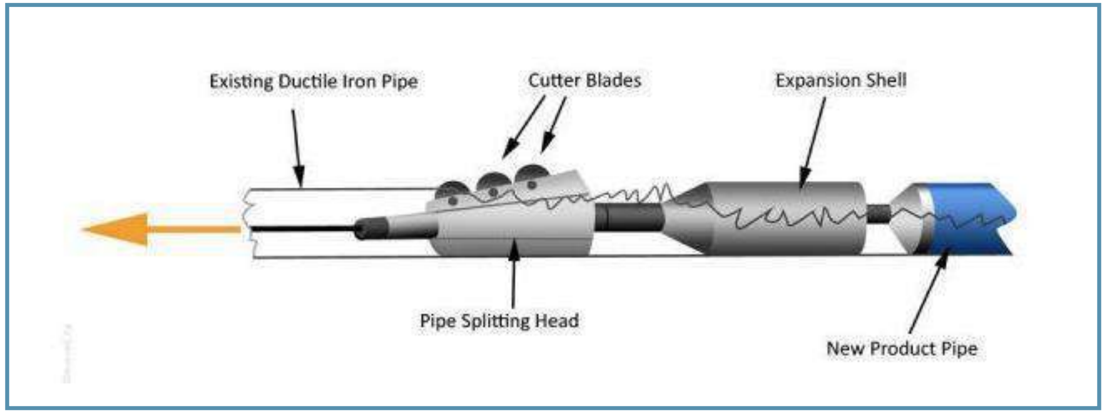
- First developed in the UK in the late 70's and early 80's by DJ Ryan & Sons in collaboration with British Gas Technology Inc. *(Now called Advatica Technologies Inc)*

- In addition to British Gas's need for pipe bursting, a substantial amount of cast iron piping, already in place throughout Europe was failing. And thus, the pipe bursting industry was born.

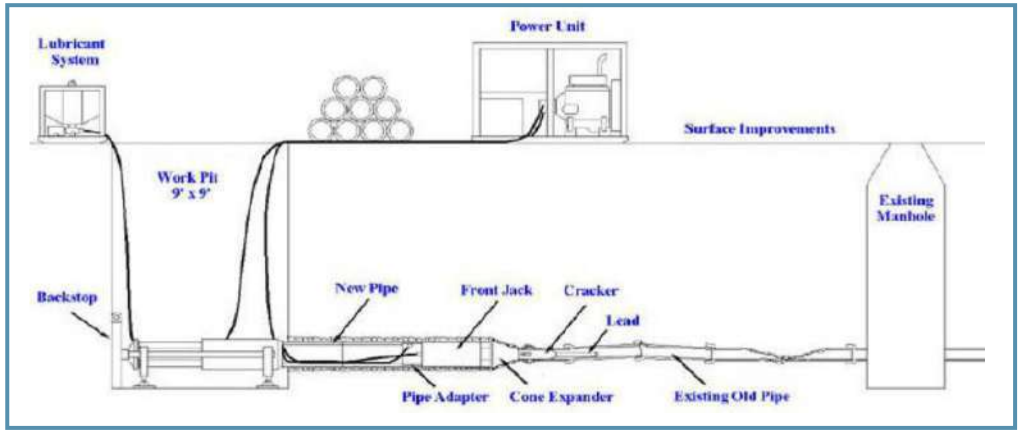
- The System incorporated a Pneumatically driven cone shaped bursting head to displaced an existing cast Iron pipe.

Germany	1983
Australia	1985
Finland	1989
Sweden	1986
Norway	1988
Denmark	1987
Russia	1990
Ireland	1990
France	1995
Argentina	1995
Chile	1995
Brazil	1995
Spain	2000
Cuba	2001
South Africa	2003
China	2003

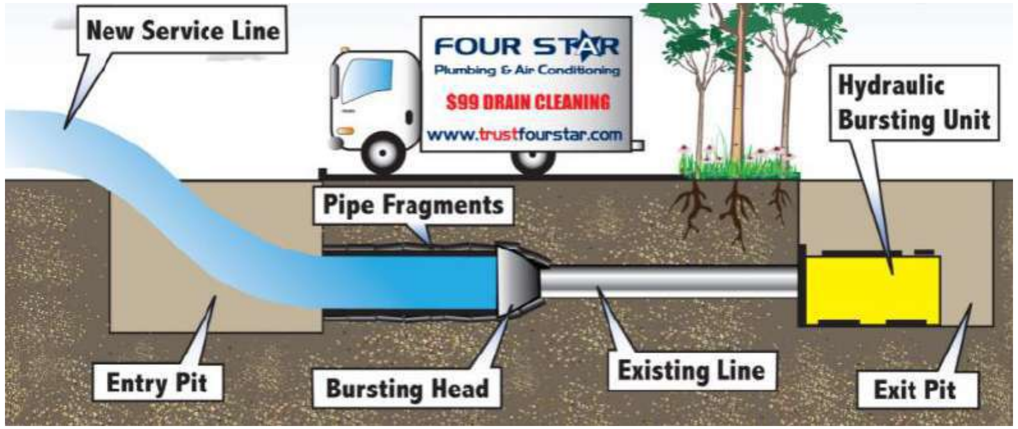
Types of Pipe Bursting



Pneumatic Pipe Bursting/ Hydraulic Pipe Bursting



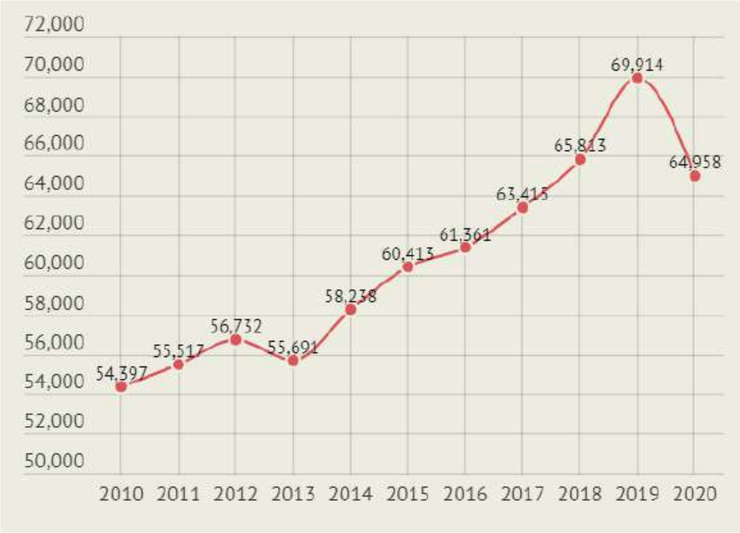
Static Pull



Rationale for this method

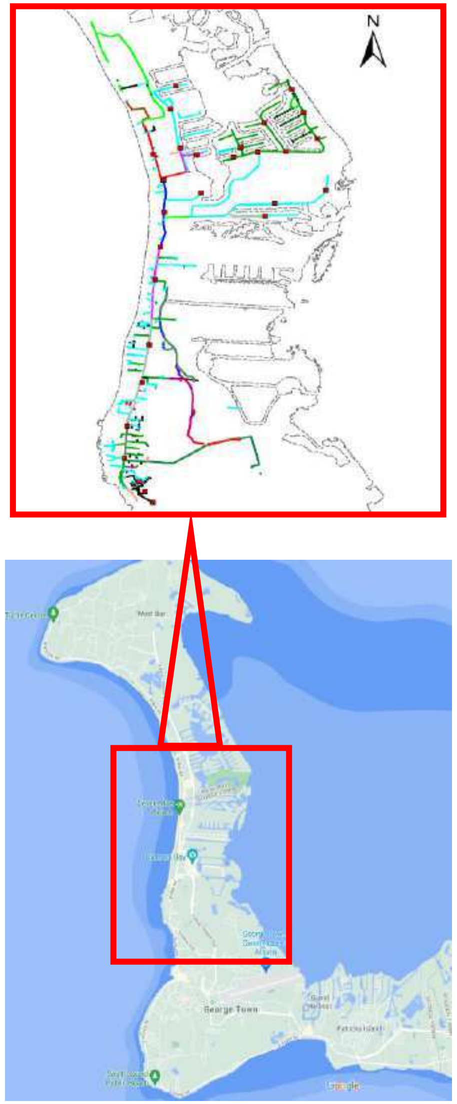
An ageing waste collection system

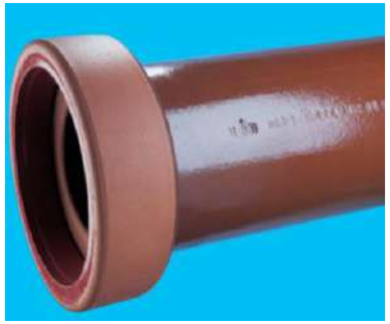
Pipe network expansion needed due to population growth



Pipe network expansion needed due to increase in Property Developments

Overview of existing Network





- Pipe material consists of vitrified clay pipe.
- 12.5 miles of wastewater collection pipe.
- 525 Inspection Manholes.
- SBR capacity of 2.5 MGD.
- January 2020 Grand Cayman Experienced a 7.7 magnitude earthquake.

Previous Condition Assessments of our network

- Conducted mostly by a visual survey and Go-Pro camera for manholes and Rausch Min-cam for the pipe inspection.

- Completion of a field data survey sheet.

- Decision on repair or replacement based solely on visual results.

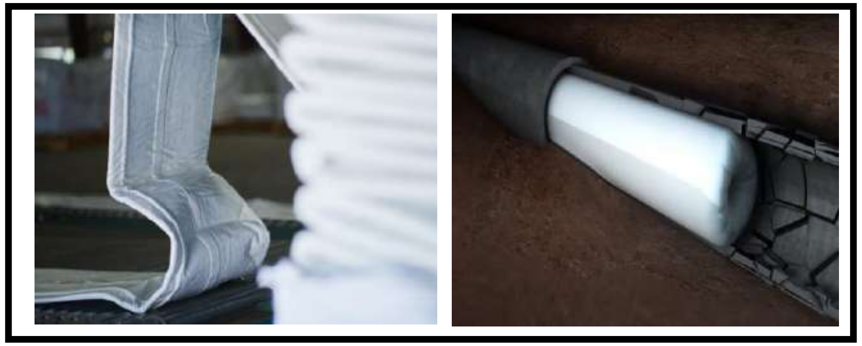
Previous Remediation methods of our Network

Sulphuric Acid attack

Root Ingress on clay pipe

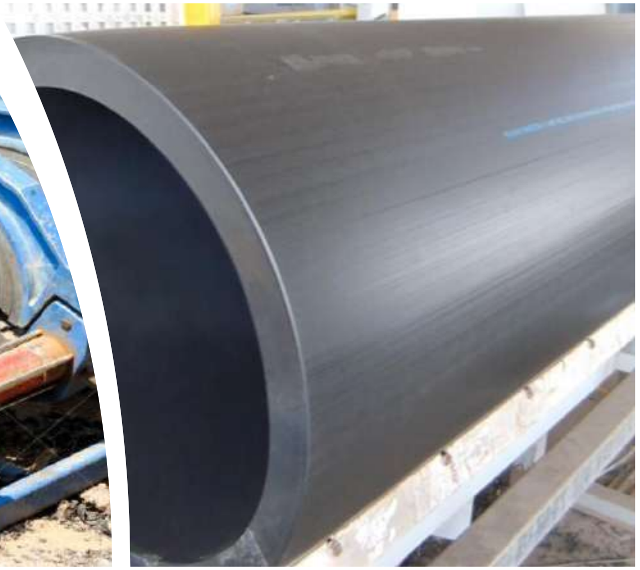
Ameron T-Lock Liner
1991/1992

FIPP Pipe Liner
1992/1993



CIPP Pipe Liner
1993/2013

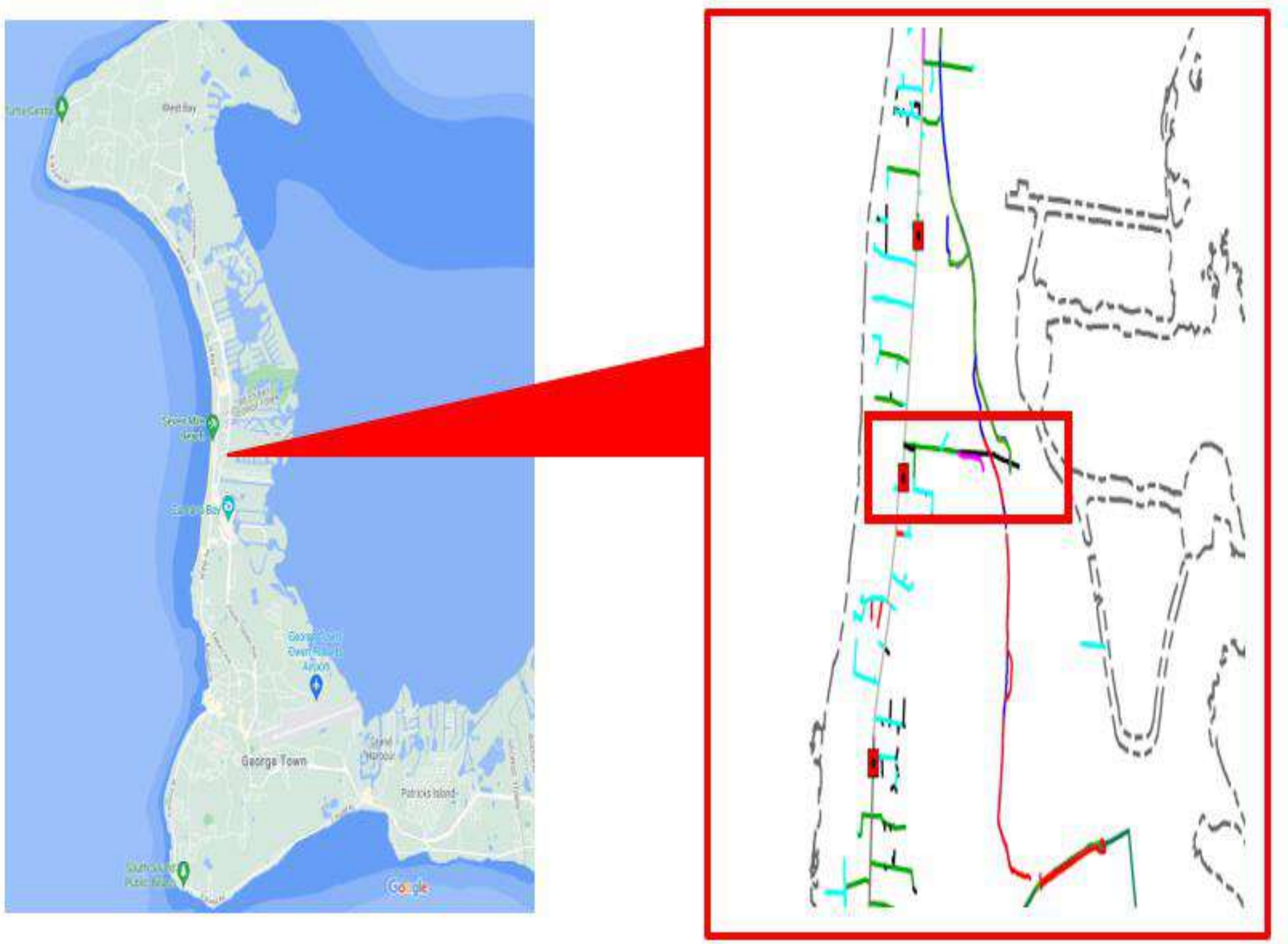
Remediation methods of our Network Continued



Why we implemented Pipe Bursting in Grand Cayman

- Liner methods discontinued in 2013.
- FIPP Method had a success rate of 98%.
- FIPP had 2 sections, out of 107 Sections become reinverted.
- In 2013 CIPP had a similar outcome.
- These Structural liner issues alongside contractor issues led to the method becoming Discontinued.

Water Authority Cayman first Pipe Bursting project in Grand Cayman



- Began on the 27th February 2019.
- Completed on 17th March 2019.
- Bursting conducted between Manholes 2401 and 2478A.
- Replacement of 200 feet of 8-inch vitrified clay pipe with 10-inch HDPE butt fused pipe.

Cost Comparatives and Parameters in deciding to use Pipe Bursting

Options presented for Lawrence Boulevard sewer pipe repair (2013)

Open Cut Method	HDPE Liner Method	Pipe Bursting Method
Works to be Completed	**Works to be Completed**	**Works to be Completed**
Replace clay pipe with PVC SDR 35	Install liner inside existing host pipe	Pipe busrting will allow SDR 18 pipe that is acceptable as direct burial
Existing Utilities. CWC Water mains Relocation		
Dewatering. At least two 6" pumps hard piped to drainage well		Dewatering well will be drilled
Traffic control. Lane closure and diversion needed		Discharge piping system will be required
Trench safety. Sheet piling or Trench boxes		
Restoration and reinstatement of curb, island, sidewalk and asphalt		
Connection and transition to existing clay pipe		
Sand collar at manhole		
Cost Concerns	**Cost Concerns**	**Cost Concerns**
Importing of Sheet piling material	Pipe lining was a concern based off the past projects of year 1992/93 and 2013. The HDPE would be 7.125-inch SDR 25 fitting inside the existing host clay pipe with no structural integrity of the host pipe near the manhole.	Cost of procuring equipment
Large hydraulic excvator to achieve sheet pile depth		Cost of shipping the equipment
Import of hydraulic sheet pile driver attachement to excavator		The relatively small scope of work would exceed the open cut method
Restoration		As a side note. The cost for feasibility would be offset by using the pipe bursting method for other repairs
Dewatering well, piping and discharge systems		

Planning associated with Pipe Bursting

- Host pipe examination

- Survey of existing pipes and underground structures in the proximity of the host pipe

- A "Serve notice on property owner", notification

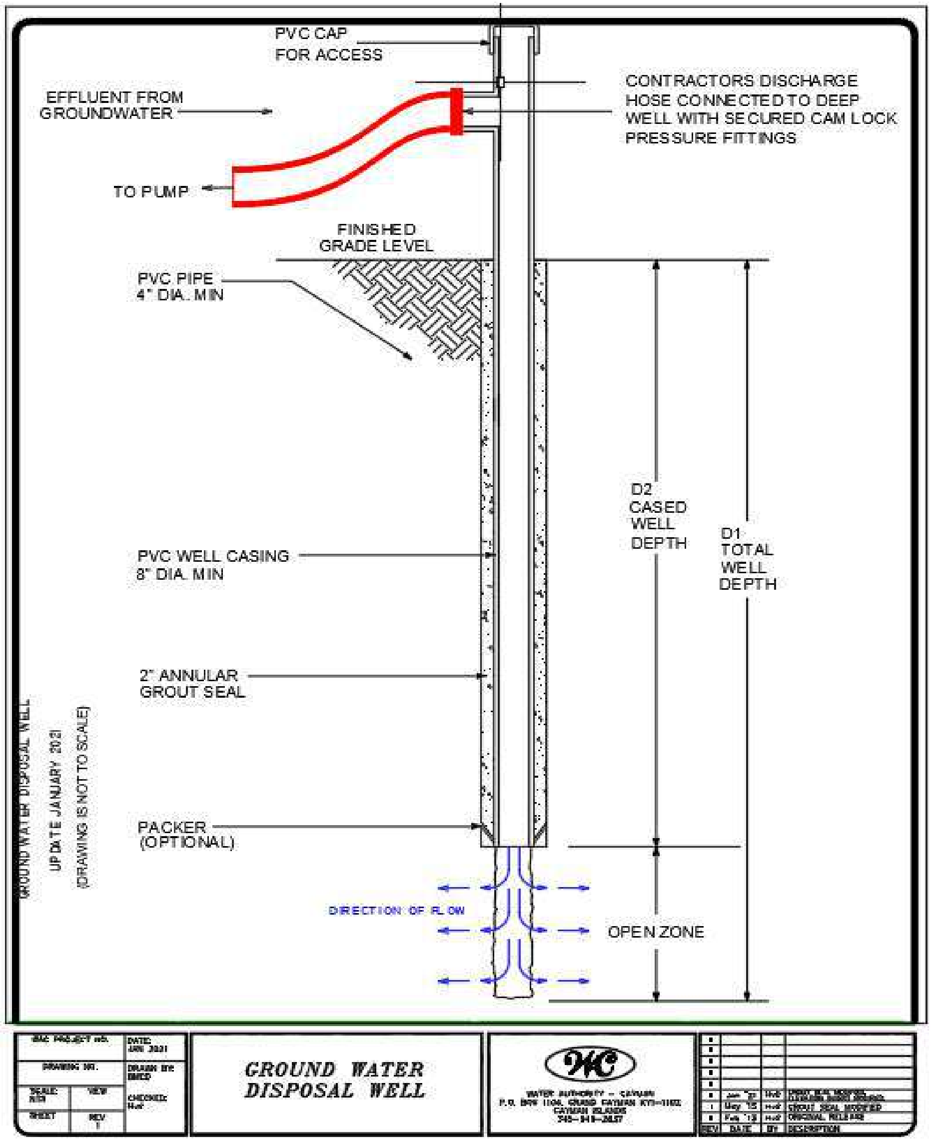
- Notification to Customers in close proximity

- Drilling of drainage wells

Local availability of Contractor

Challenges of Pipe Bursting on Grand Cayman

- WAC Sewer mains located in water table
- Geology consists of Coraline limestone & Jointing karst formation
- Most Pipe Bursting projects encounter fissure that allow high flow rates of ground water
- Remediation measured are the drilling of deep wells adjacent the entry and exit excavations
- Drilling of drainage wells



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Conclusions

Key Points

Existing Network.

Previous Conditions Assessments.

Previous Remediation Methods.

Alternative Trenchless Technologies.

Cost Comparative of Traditional method Vs Pipe Bursting.

Quote

" What we usually consider as impossible are simply engineering problems… there's no law of physics preventing them." By ***Michio Kaku***

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Onsite Wastewater Management Programme in the Cayman Islands

Where did we come from, where are we now, and where are we going?

Presented by Hendrik-Jan van Genderen, Water Authority - Cayman Islands

Co-Authors: Yasmin James, Kodie Scott, Trenton Forman and Corey Christian

Agenda

- Introduction
- Status of wastewater treatment in the Cayman Islands
- Development of the Onsite Wastewater Management Programme
- Next steps
- Conclusions

Introduction

Introduction

- Central wastewater system not available or feasible in many areas
- Situation throughout Caribbean is similar
- Follow up on WA presentations at 2003 and 2009 CWWA conference

Onsite Wastewater Management Programme is relevant and important

Status of wastewater treatment in the Cayman Islands

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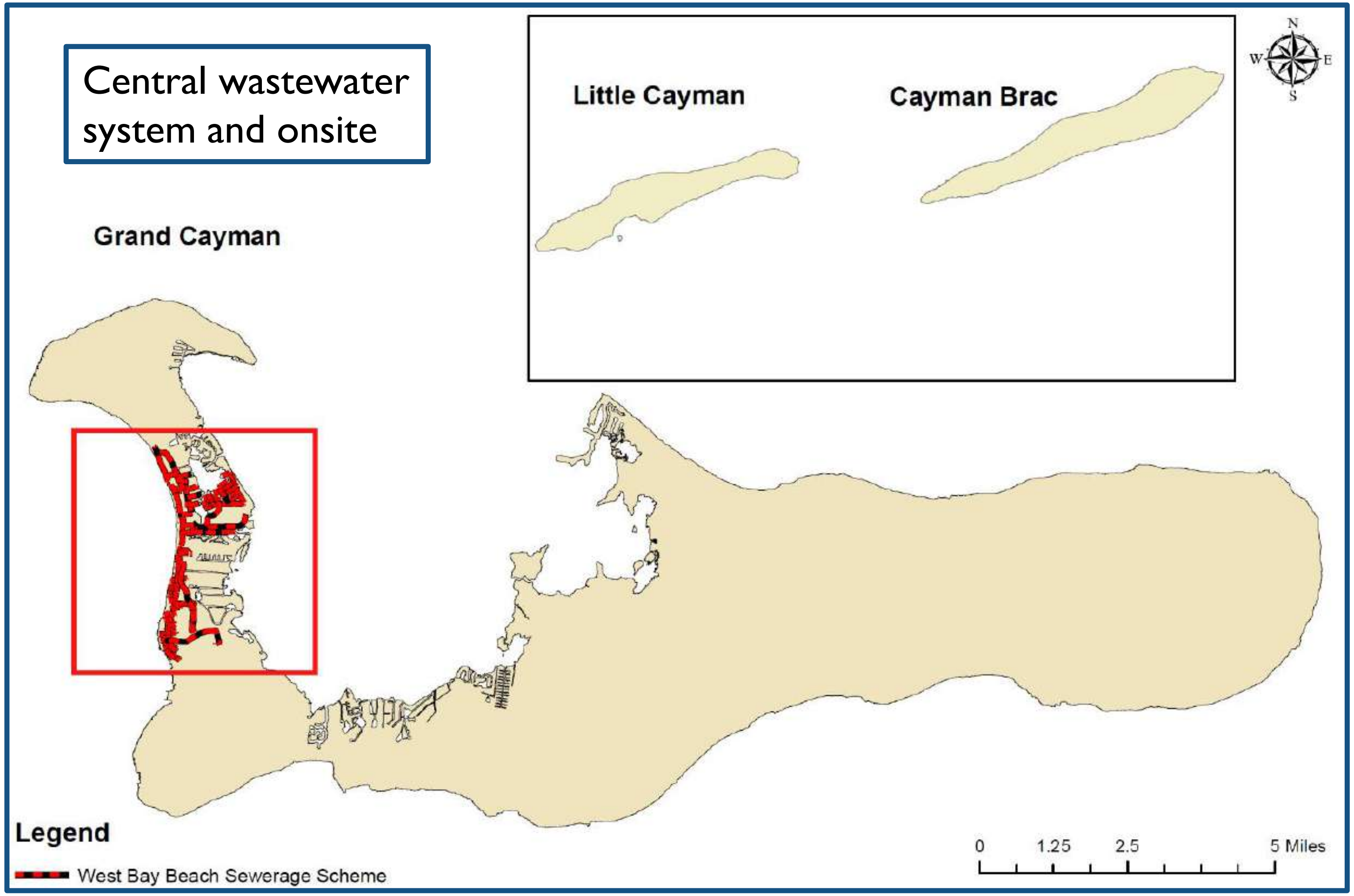
Wastewater treatment in the Cayman Islands

Water Authority Act (1982) and Regulations (1985)

- Water Utility
- Wastewater Utility
- Manage and protect groundwater
- Principle advisor to Government on water and wastewater
- Regulator for onsite wastewater collection, treatment and disposal

Wastewater treatment in the Cayman Islands (cont.)



Wastewater treatment in the Cayman Islands (cont.)

Treatment system	Treatment type	Volume		Meets standard of 30 mg/L BOD and 30 mg/L TSS	
		(mgd)	(%)	(mgd)	(%)
WWTP	secondary	1.2	23	1.2	23
ATU (onsite)	secondary	1.4	27	0.4	8
ST (onsite)	primary	2.6	50	0	0
none	n.a.	0	0	0	0
Total		**5.2**	**100**	**1.6**	**31**

Notes: WWTP = Water Authority Wastewater Treatment Plant that receives wastewater from the WBBSS

ATU = onsite Aerobic Treatment Unit

ST = onsite Septic Tank

mgd = million US gallon per day

Development of Onsite Waste Water Management Programme

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Onsite Wastewater Management Programme

Legislation

Water Authority Act (1982) and Regulations (1985) provide overall legal framework for the Onsite Wastewater Management Programme

Onsite Wastewater Management Programme (cont.)

Requirements for new development

New development is reviewed through the Planning Process

Water Authority sets requirements for onsite treatment:

- Development < 1,800 gpd: Septic Tank
- Development > 1,800 gpd: ATU

Water Authority—Cayman

"Suppliers of the World's Most Popular Drink"

August 2018

Website: www.waterauthority.ky

guidelines for onsite wastewater treatment

Wastewater Treatment Requirements for Developments Outside the West Bay Beach Sewerage System (WBBSS) Service Area

Note

The following information is provided for general reference only. Specific requirements are set out by Development Control after reviewing plans submitted via the Planning Department (hereafter referred to as Planning). Requirements set out by the Water Authority (hereafter referred to as the Authority) then become conditions of Planning Permission.

Onsite treatment system requirements

ATU certified to NSF/ANSI 40 Standard or equivalent

ATU Installed by registered service provider

ATU Detailed design criteria and specifications

Proposed ATU to be approved by WA before installation

WA signs off on system for issue of Certificate of Occupancy by Planning

Septic Tank follows basic design criteria

Effluent well specs

Onsite Wastewater Management Programme (cont.)

Registered Service providers

Installation and O&M of ATUs

Business needs to meets WA criteria:

- WA certified technician on staff
- Completed WA Onsite Wastewater Treatment Course
- Passed WA exam
- Registered by WA
- Submit O&M records

Quality Control and Consumer Protection

Carmody Database for ATUs

- Customized software
- Manufacturer and model
- Treatment capacity
- System details
- Geo location
- Owner details
- Test results
- O&M records
- Improved ease of use

Treatment capacity (gpd)	Number
<1,000	99
1,000-2,000	138
2,000-3,000	156
3,000-4,500	19
4,500-9,000	130
9,000-20,000	39
20,000-30,000	25
>30,000	4
Total	610

Data is knowledge

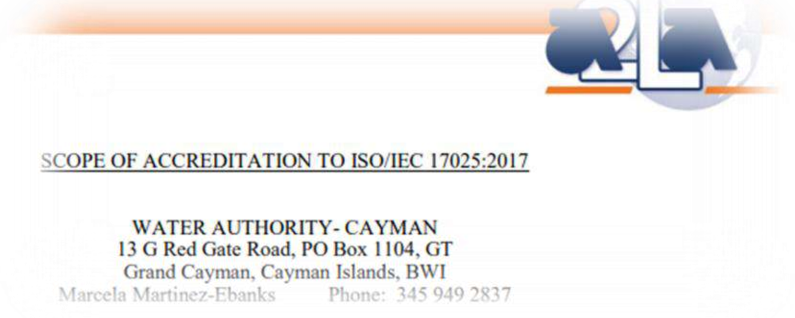
Onsite Wastewater Management Programme (cont.)

Inspections

- Inspections throughout installation process of ATUs
- Inspections of operating ATUs
- Complaints

Effluent testing

Water Authority Laboratory is accredited for BOD, TSS and nutrients



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

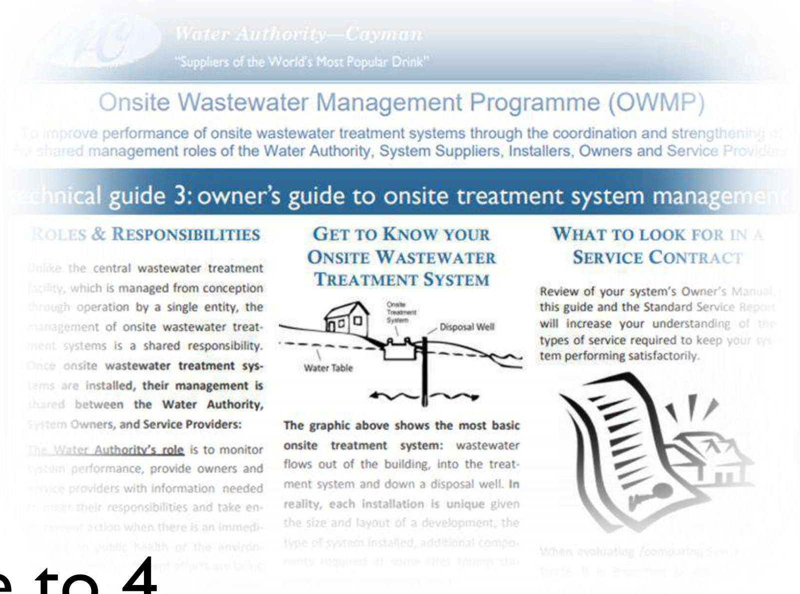
WATER AUTHORITY- CAYMAN
13 G Red Gate Road, PO Box 1104, GT
Grand Cayman, Cayman Islands, BWI
Marcela Martinez-Ebanks Phone: 345 949 2837

Onsite Wastewater Management Programme (cont.)

Public outreach

Close working relationship with service providers

Website with a wealth of information


Water Authority—Cayman

"Suppliers of the World's Most Popular Drink"

Onsite Wastewater Management Programme (OWMP)

echnical guide 3: owner's guide to onsite treatment system managemen

ROLES & RESPONSIBILITIES

GET TO KNOW YOUR ONSITE WASTEWATER TREATMENT SYSTEM

WHAT TO LOOK FOR IN A SERVICE CONTRACT

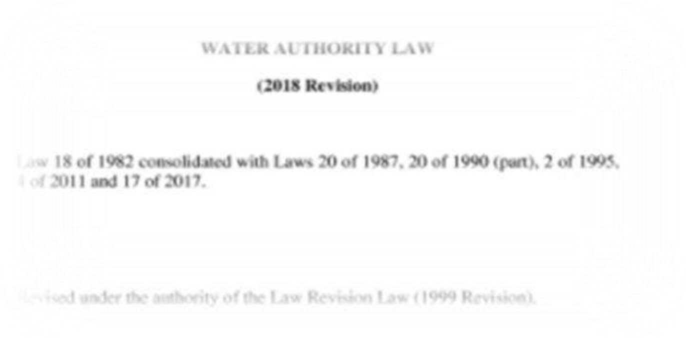
The graphic above shows the most basic onsite treatment system: wastewater flows out of the building, into the treatment system and down a disposal well. In reality, each installation is unique given the size and layout of a development, the

Staff

3 Designated staff at Water Authority, will increase to 4

Enforcement

Water Authority Act and Public Health Act


WATER AUTHORITY LAW

(2018 Revision)

Law 18 of 1982 consolidated with Laws 20 of 1987, 20 of 1990 (part), 2 of 1995, 4 of 2011 and 17 of 2017.

Revised under the authority of the Law Revision Law (1999 Revision).

Next Steps

Next Steps

Revisit criteria for allowing septic tanks

- ST does not achieve 30 mg/L BOD and 30 mg/L TSS
- Lower the 1,800 gpd criterium for ATUs
- Consider density of development

This will be challenging - likely pushback from the developing community because of cost implications for new construction

Next Steps (cont.)

Improve performance of ATUs

- ATUs can meet effluent standard, but that is not always the case
- Ongoing training of service providers
- Expand the training programme with additional topics and modules
- Advance inspections – employ dedicated inspector
- Continued public outreach and education

Next Steps (contd)

Energy Use of ATUs

Promote systems with low energy use

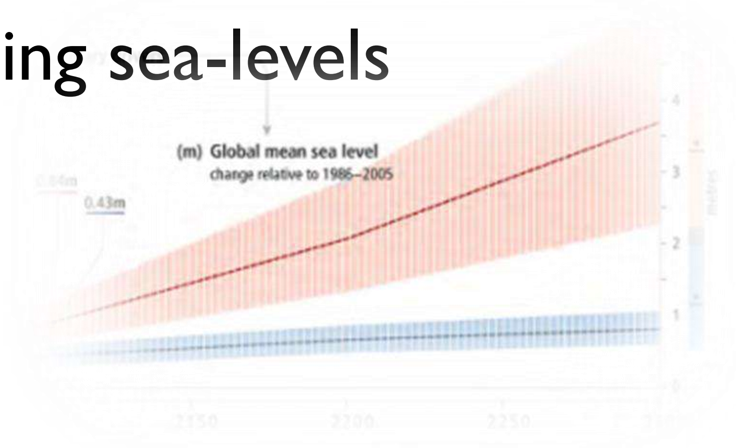
Section 6: Optional information recommended for consideration of cost of operation; i.e., kWh/year

For each electrical component; e.g., aeration device, pump, etc., list the following:

COMPONENT TYPE	MAKE / MODEL	WATTAGE	HOURS OF USE per DAY	kWH/day = WATTAGE x HOURS per DAY
			Total kWH / day:	

Climate Proofing

Installation of ATUs and STs need to consider rising sea-levels



Effluent re-use

Effluent of adequate quality can be re-used

Concluding Remarks

Conclusions

Onsite treatment will continue to play a significant role in managing wastewater. The Water Authority Act charges the Water Authority with the duty to regulate and manage onsite wastewater treatment. The Onsite Wastewater Treatment Programme (OWMP) has been developed over 40 years.

The various aspects over the OWMP have evolved with the growing needs of the Cayman Islands and the availability of new technology. The Water Authority continues its strategic approach to develop the OWMP. The programme is developed in response to ongoing development, data and evidence collected by the Authority and the anticipated impact of climate change.

Thank you for your attention

Any Questions

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Wastewater Treatment by Radiation Technology

Bumsoo Han*, Celina Horak, Valeriia Starovoitova, Joao Osso Junior, and Melissa Denecke

Division of Physical and Chemical Sciences
Department of Nuclear Sciences and Applications
International Atomic Energy Agency

International Atomic Energy Agency

Set up as the world´s "Atoms for Peace" organization in 1957

In 1953, Dwight Eisenhower, the President of the United States, called for the establishment of an international atomic energy agency

<u>173 Member States</u>

IAEA promotes safe, secure and peaceful nuclear technologies.

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Non-power nuclear applications in IAEA

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International Atomic Energy Agency

Promoting food security and sustainable agricultural development

Improving the diagnosis and treatment of diseases and nutrition

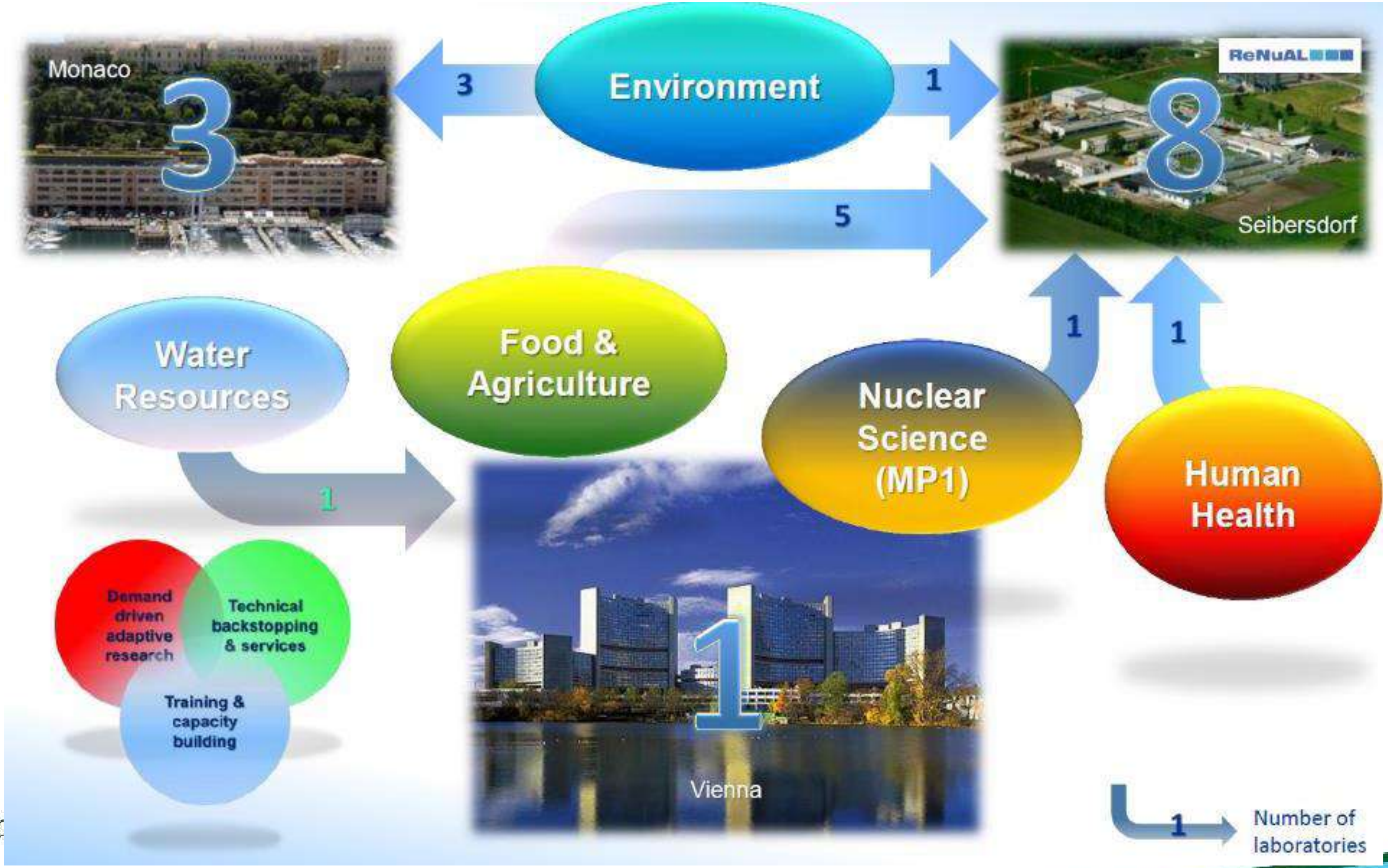
Providing knowledge and expertise for science and industry

Making cleaner water accessible to more people

Understanding and protecting the environment

INNOVATION & SMART TECHNOLOGIES

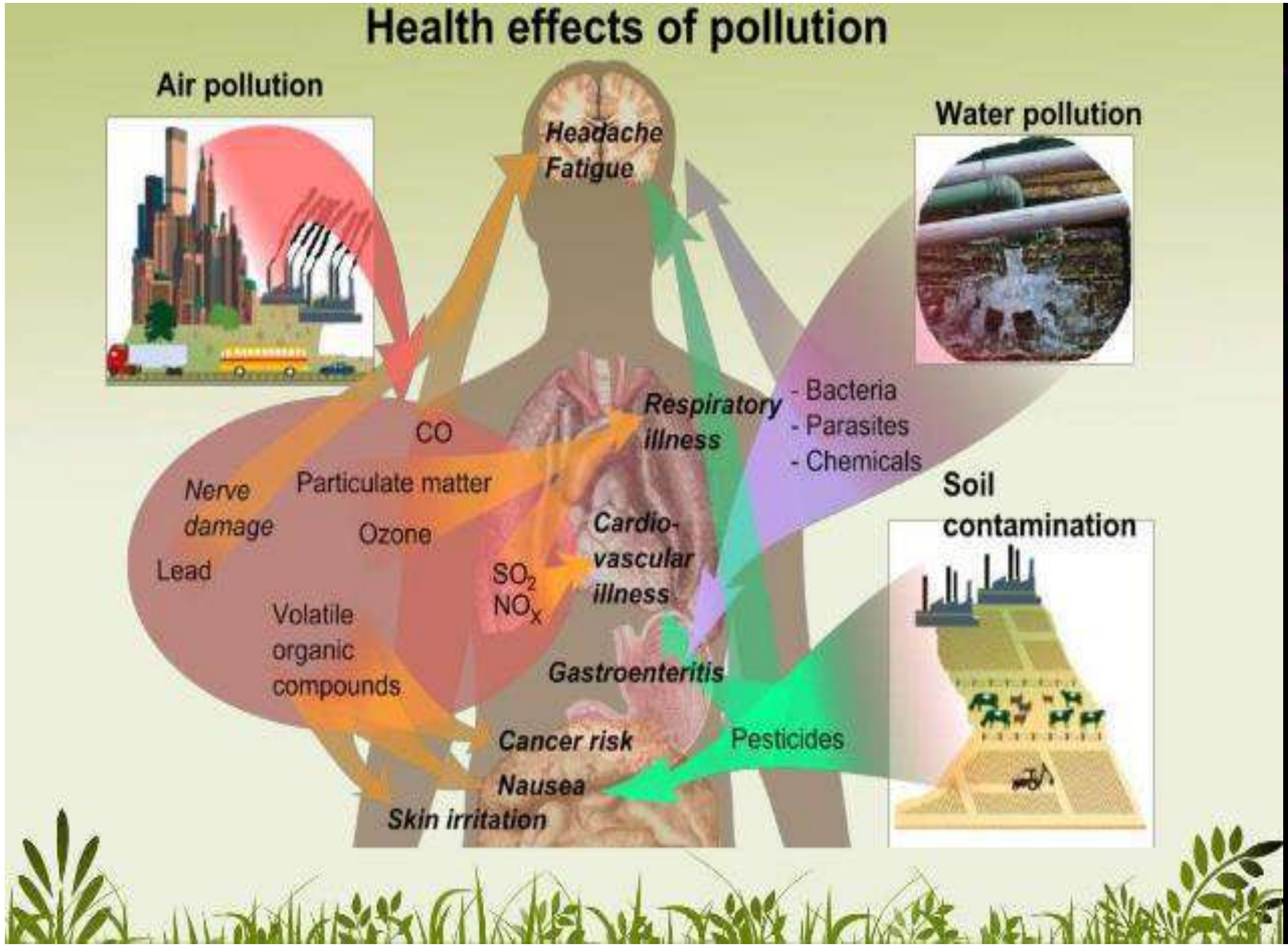
12 Laboratories supporting IAEA Programmes

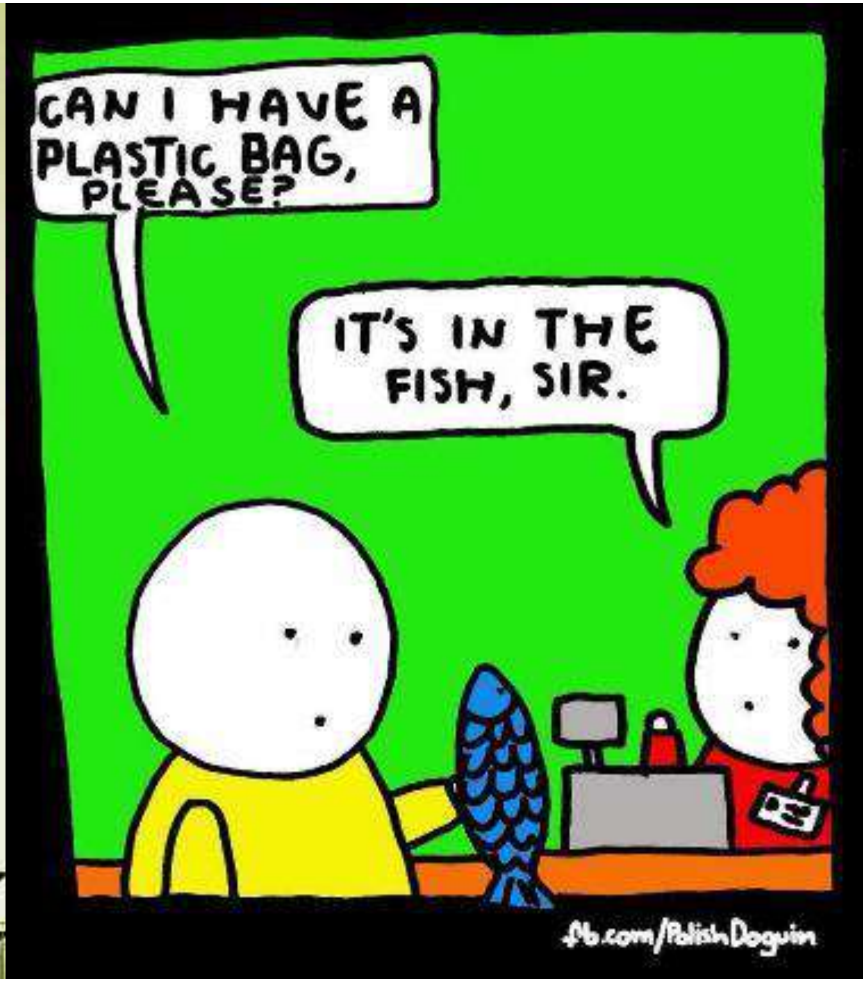


Polluted Environmental behind Development

IAEA
International Atomic Energy Agency

Health effects of Pollution





Radiation Technology for Remediation




Flue gas Purification | **Wastewater Treatment** | **Sludge Hygienization** | **Plastic Recycling**




Water/Wastewater Treatment by Radiation

Main purpose of wastewater treatment

-. Removal of harmful impurities (COD, BOD, S/S etc.)

-. Removal of color, odor etc.

-. Removal of T-N, T-P

Radiation Technology

-. Disinfection of microorganisms (Pathogenic organisms etc.)

-. Destruction of residual chemicals, such as POPs, endocrine disrupters, Pesticides, and Pharmaceutical residues.

-. to discharge to river, or to re-use in industries or irrigation

Water/Wastewater Treatment by Radiation

H_2O

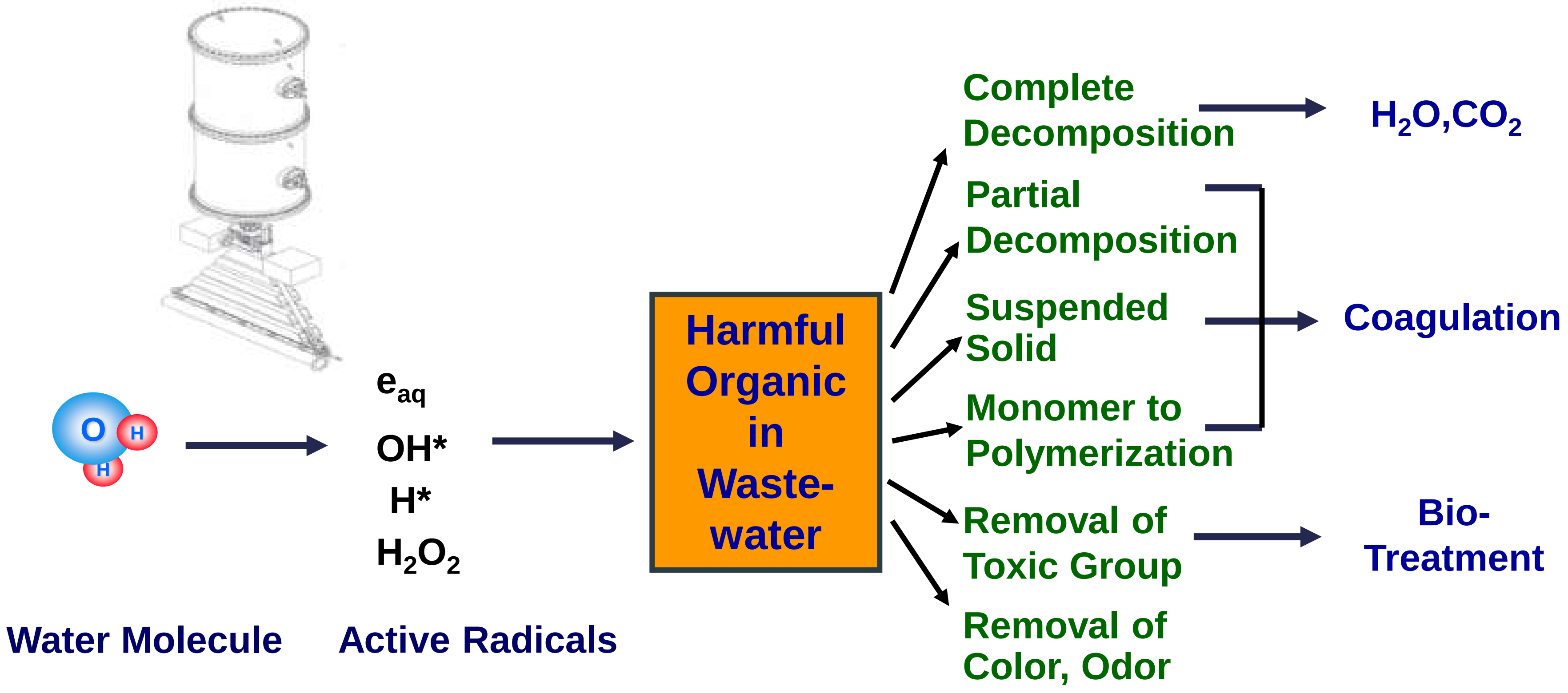
$e^-_{aq} + H_2O^+$ $\quad$ $H + OH$ $\quad$ $H_2 + O$

Ionization, decay of excited states $\leq 10^{-12}$ s

$$e^- \longrightarrow e^-_{therm} \longrightarrow e^-_{aq}$$
$$H_2O^+ + H_2O \longrightarrow H_3O^+ + OH$$
$$e^-_{aq} + H_3O^+ \longrightarrow H + H_2O$$
$$H + H \longrightarrow H_2$$
$$OH + OH \longrightarrow H_2O_2$$
$$e^-_{aq} + OH \longrightarrow OH^-$$

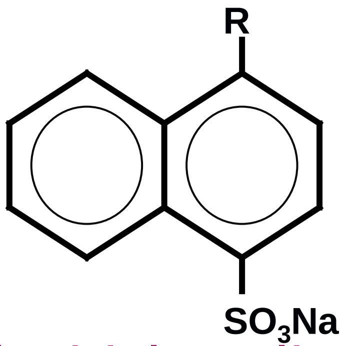
"Spur" reactions $\leq 10^{-8}$ s

Water/Wastewater Treatment by Radiation



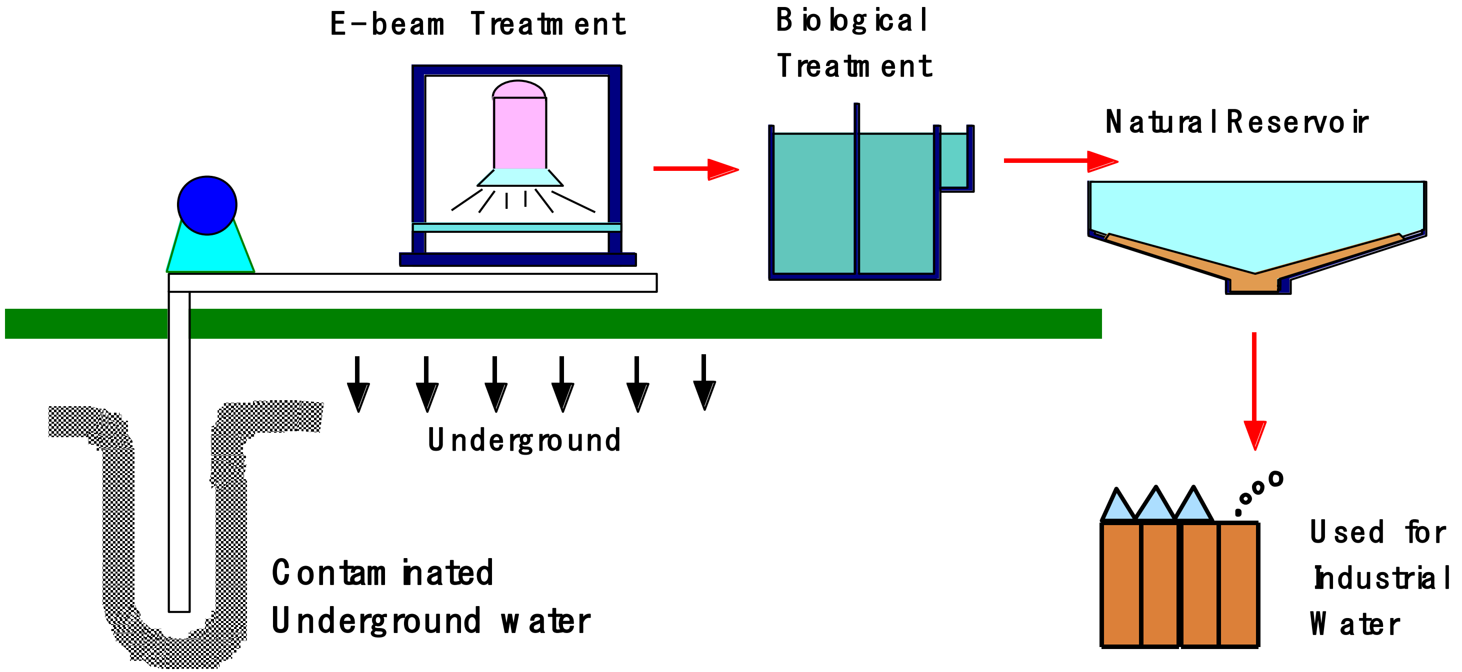
-. Removal of harmful impurities (COD, BOD, S/S etc.)
-. Removal of colour, odour etc.
-. Disinfection of microorganisms (Coli-form & pathogenic organisms)
-. Destruction of endocrine disrupter and synthetic chemicals

Polluted Underground water Treatment (Russia)



Nekal
(Isobutylnaphthalene sulfonates)

R = (CH3)3C-, (CH3)2CHCH2- or CH3CH2CH(CH3)-



	Before	after
BOD	500-1000	7-15
COD	1600-5000	60-100

IAEA supports Wastewater Treatment through Coordinated Research Projects

Previous CRPs on wastewater treatment

- Irradiation Treatment of Water, Wastewater and Sludge (1997~1999)

- Remediation of Polluted Waters & Wastewaters by Radiation Processing (2002~2006)

- Radiation Treatment of Wastewater for Reuse with Particular Focus on Wastewaters Containing Organic Pollutants (2011~2015)


Pilot plants for treatment of industrial wastewater, Brazil and Rep. of Korea


Commercial plant for treating textile dyeing wastewater (1,0000 m^3/d), Rep. of Korea

Pilot plant (1,500 m^3/d) in Zhejiang, China

Mobile e-beam plant for treating 500 m^3/d

Plants with Radiation Processing

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International Atomic Energy Agency

Full scale Textile Dyeing Wastewater Treatment Plant in Republic of Korea

Full-scale application of electron beam wastewater treatment plant for 10,000 m^3/d of textile dyeing wastewater with 1 MeV, 400 kW accelerator.

IAEA support Wastewater Treatment through TC projects

CPR1008: Treating Industrial Wastewater with Electron Beam Accelerator and Biological Treatment Methods (2012-2015)

Industrial plant (30 000 m^3/d) for textile dyeing wastewater constructed in China

IAEA support Wastewater Treatment through TC projects

Related TC projects on water treatment

- RAS/1/023 -Developing and Upscaling of Radiation Grafted Materials for Water Treatment (2018 -2021)

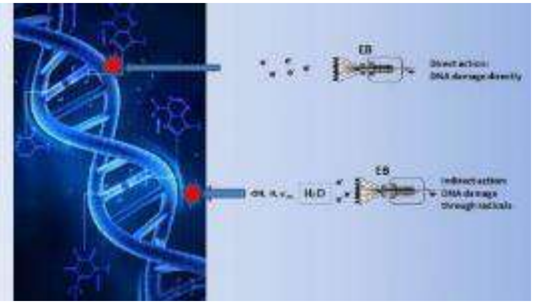
Objective: To make technologies affordable to small and medium scale industries in order to mitigate industrial wastewater pollution. Radiation grafted materials have to be easily available for emergency purposes, especially in cases of calamities. One of the possible alternatives would be the use of radiation grafted materials which can highly adsorb these contaminants.

- BRA/1/035 Establishing a Mobile Unit with an Electron Beam Accelerator to Treat Industrial Effluents for Reuse Purposes (2016 -2019)

Objective: To enlarge the national capacity to treat industrial effluents using electron beam accelerators, the mobile unit treating effluents on site from $1m^3/h$ up to $1000m^3/day$, will provide an effective facility between a laboratory-scale plant to a large-scale plant with the objective to demonstrate the efficacy and transfer the technology.

IAEA supports Wastewater Treatment through Coordinated Research Projects

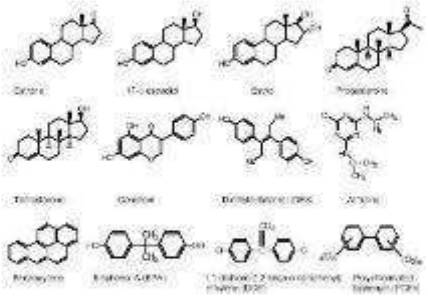
On-going CRPs on Wastewater/Sludge treatment



- Radiation Inactivation of Bio-hazards Using High Powered Electron Beam Accelerators (2018 -2022)

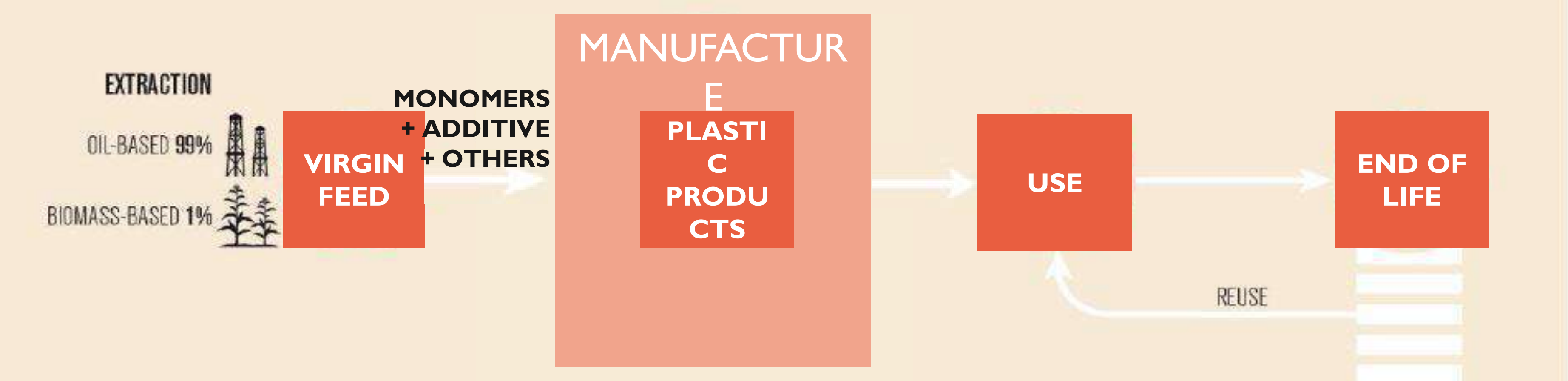
Objective: To enhance and strengthen use of electron beam accelerators for treatment of biohazards of concern under changing conditions such as at high dose rates, different ambient conditions, and varying substrates in applications such as radiation sterilization, hygienization of bio-solids, sanitizing infectious hospital waste or toxic effluents and eliminating deliberate biohazards.

- Removal of Emerging Organic Pollutants in the Wastes by Radiation (2019 -2023)



Objective: To exploit the innovative methodologies and technologies to remove the emerging pollutants such as endocrine disruptors, pharmaceutical residues, and other toxic pollutants in wastewater/sludge by radiation.

IAEA supports Recycling of Plastic Wastes



IAEA supports Recycling of Plastic Wastes

IAEA
International Atomic Energy Agency

The objective of NUTEC Plastics is to assist the IAEA Member States in integrating nuclear and nuclear derived techniques in their efforts to address challenges of plastic pollution. NUTEC Plastics builds on a portfolio of IAEA research and technical cooperation projects around plastic recycling using radiation technology and marine monitoring of microplastics using isotopic tracing techniques. NUTEC Plastics positions the IAEA on an important issue of global concern: plastic pollution.

On-going CRPs on Recycling of Plastic Wastes

- Recycling of polymer waste for structural and non-structural materials (2021~2025)

Objective: to modify polymer wastes to be used in structural and non-structural materials, providing the benefits of encapsulating plastic waste, and/or modifying the surface properties to obtain functionalized materials, enhancing material properties and reducing carbon emission.

Summary

It is becoming increasingly clear that humankind's environmental problems are no longer merely local or regional but have become continental in scope. Economically and technically feasible technologies for controlling pollution from gaseous emissions and liquid effluent streams are being sought by technologists working in a variety of areas, including radiation technologies.

Radiation technology is quite effective for remediation of contaminated environment. When irradiated with high energy radiation, practically all the energy absorbed initiate the ionization and excitation to result in formation of free radical and molecular species to destroy or to convert the harmful chemicals.

Over the last few decades, extensive work has been carried out on utilizing radiation technology for environmental remediation. This work includes the application of radiation technology for simultaneous removal of SOx and NOx from the flue gases, purification of drinking water, wastewater treatment and hygienization of sewage for use in agriculture.

The IAEA helps Member States strengthen their capacities in adopting radiation-based techniques that support cleaner and safer industrial processes. It also supports them in applying radiation technology for the management of industrial wastes and effluents and the recycling of plastics.


THANK YOU FOR YOUR ATTENTION!

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OPTIONEERING AND DESIGN OF SMALL-SCALE PILOT GREYWATER COLLECTION, TREATMENT AND REUSE SYSTEM, COLLEGE STREET GHAUT, ST KITTS.

Alphonsus Daniel, M.Sc. Managing Director of Daniel and Daniel Engineering Inc, Grenada
Email: altheus1@gmail.com, adaniel@dandplumbingsol.com

Agenda

- 1.0 Introduction
- 2.0 Grey Water Management Strategies
- 2.1 Grey water is not wastewater but a valuable resource
- 2.2 Grey Water Recycling
- 3.0 Centralized verses Decentralized Wastewater Treatment Systems
- 4.0 Greywater constituents
- 5.0 WHO Guidelines for Agricultural Use of Wastewater
- 6.0 The concept of Reuse/ Recycle and Green, and Circular Economies
- 7.0 Constructed Wetlands in treatment of wastewater
- 7.1 The role of Constructed Wetlands in the treatment of Greywater Use of Ornamental Flowering Plants in Constructed Wetlands for Wastewater Treatment
- 8.0 Costs
- 9.0 Summary of A Comparative Analysis of Suitability of Different Wastewater Systems
- 10.0 Conclusions
- 10.0 Q & A

Introduction

1.0 Introduction

- The Waterwise group (2021) defines greywater or sullage is the water that is created from activities such as showering, bathing, or doing laundry.
- It gets its name from its somewhat murky, cloudy appearance.
- While not nearly as dark as sewage, greywater is easily distinguishable from tap water.
- Greywater contains lower amounts of contaminants than black water and can therefore serve a variety of useful purposes in and around the home

2.0 Grey Water Management Strategies

- **2.1 Grey water is not wastewater but a valuable resource**
- *The choice of a greywater management strategy depends on the end use of the effluent.*
- *The planning of such management systems should be done with the reuse in mind and,*
- *should be adapted to a specified purpose:*

 - *such as agricultural reuse,*
 - *ground water recharge*
 - *or discharge into inland or coastal waters.*

- **Greywater reuse provides several benefits including:**
- Reducing potable water demand
- Reducing the amount of wastewater discharged into the environment
- A well-watered, healthy garden
- Reduces household water bills as well as the water footprint.

2.2 Grey Water Recycling

• The simplest and cheapest greywater recycling system is to capture shower and bath water in a bucket and use it to flush a toilet.

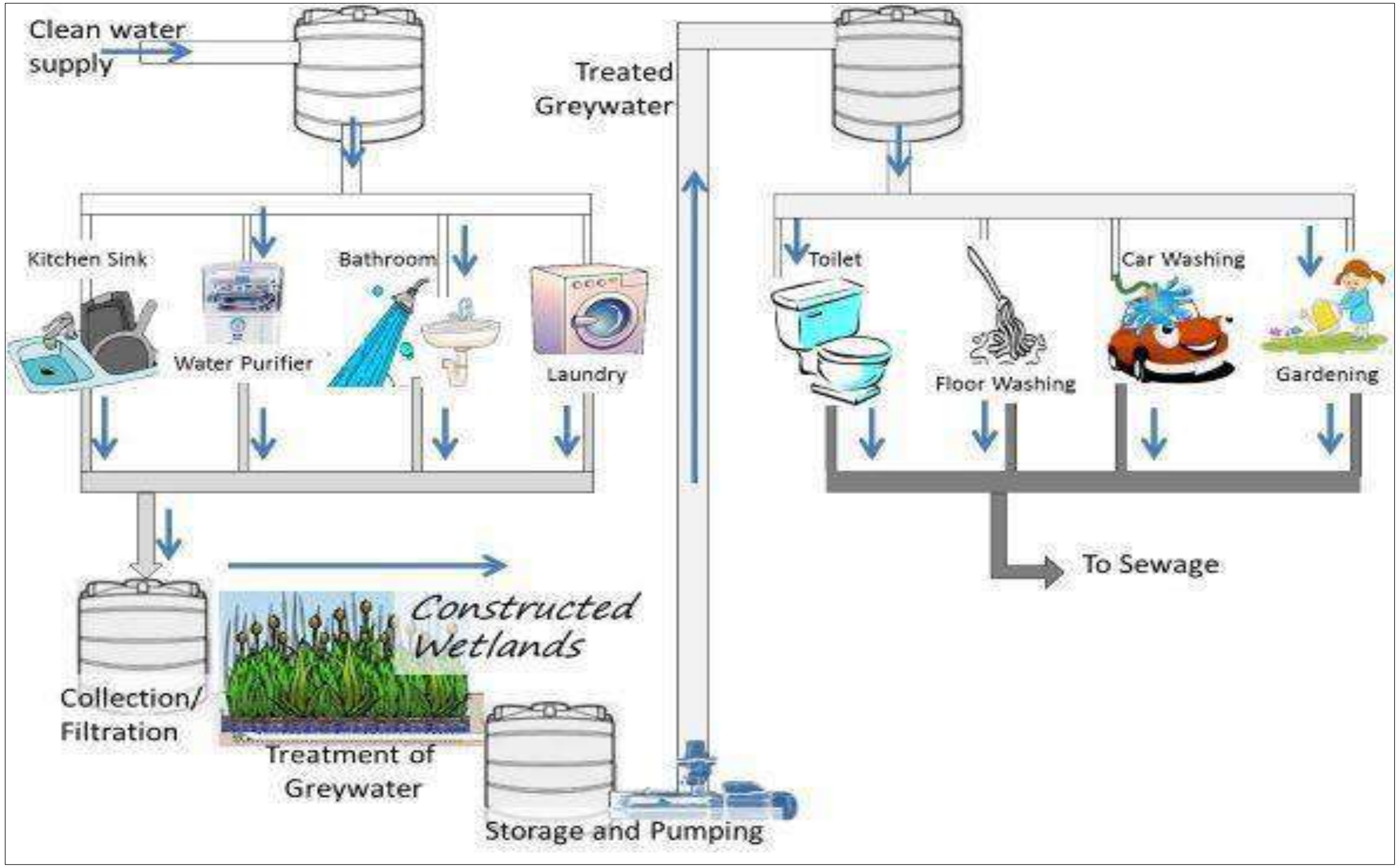
• Another simple way is to collect the water from a washing machine in a tub by connecting the outlet to the tub and using this water for irrigating a garden.

• Greywater can be used for other purposes like washing vehicles and driveways, mopping or cleaning sideways/staircases.

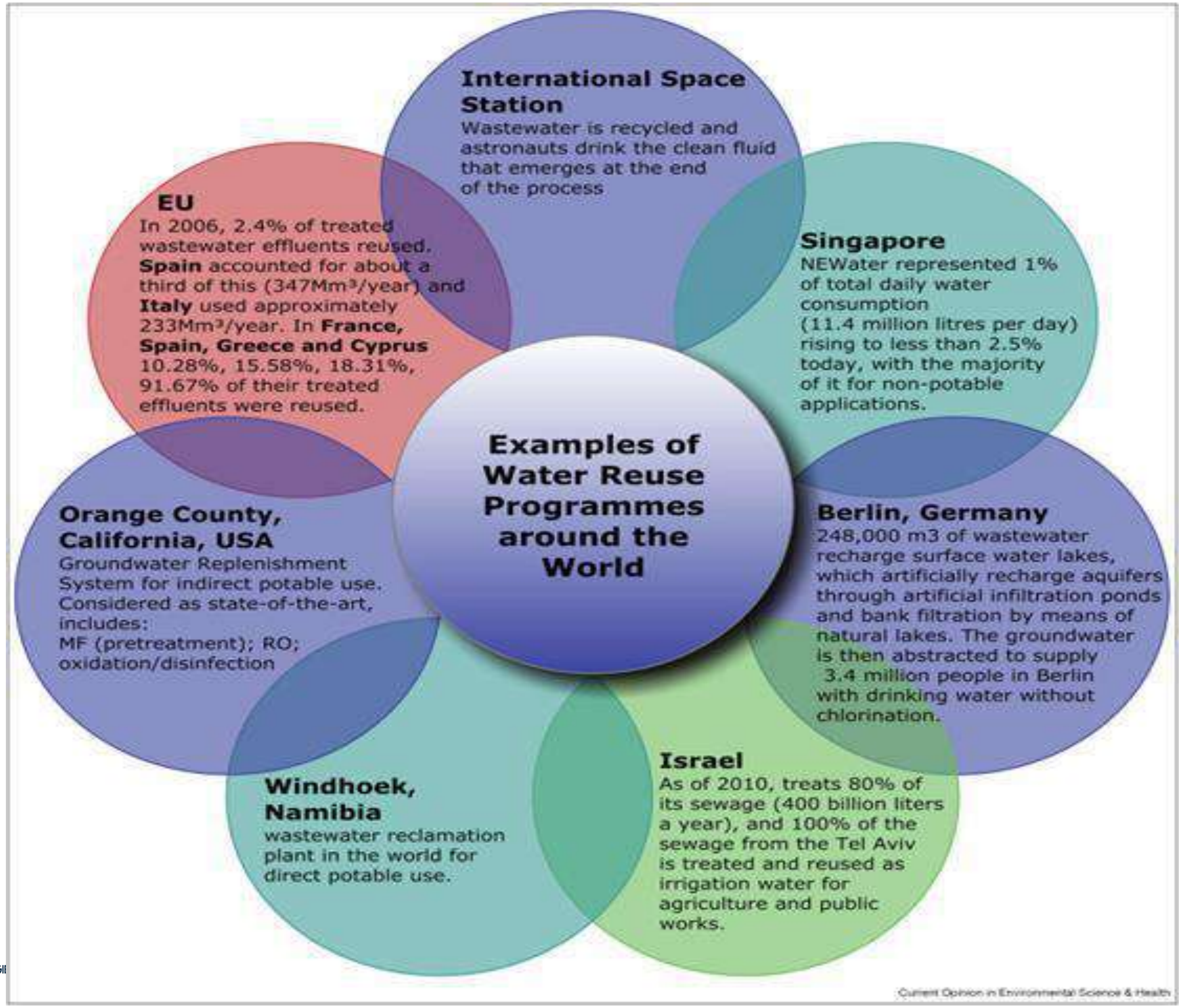
- The contaminant elements present in greywater are:
- soap, shampoo, toothpaste, shaving cream, food scraps, organic matters, and nutrients (e.g., nitrogen, potassium). These constituents do not necessarily harm the garden soils and plants if used for irrigation purposes.
- However, care must be taken to remove pollutants such as powdered laundry detergents which have high salt and phosphorus concentrations. These can stunt plants with low phosphorus tolerance if the greywater is used for irrigation purposes. (Marshall, 1996; Erguder *et al*.,2009

Schematic of the concept of greywater recycling

https://www.iamrenew.com/environment/grey-water-recycling-solution-catches-eyes-in-water-deficit-kerala/



Examples of Wastewater recycling around the world (Courtesy Environmental Source & Health, 2018)



3.0 Centralized verses Decentralized Wastewater Treatment Systems

- In reviewing the mandate given in the Terms of Reference of this project, it begs the questions, "Why does the city of Basseterre do not have a central sewerage system?"
- Why does the same situation exist in the neighboring St. John's in Antigua?
- Why was a central sewerage system built in the early 1930's in St. George's, Grenada but still serves less than 5 % of the population?
- Why does the central sewerage system in the Castries harbor, for the last 30 years, have a broken sea outfall that is yet to be repaired? The short answer to these questions is that centralized systems are too expensive!
- The traditional wastewater management concept, i.e., centralized system includes sewage collection and its treatment at the central treatment plant is difficult to adopt in developing countries mainly due to prohibitive costs.
- To overcome this limitation of the centralized system, decentralized wastewater management systems have evolved, with the wastewater treated close to where it is generated.

Successful decentralized treatment system should posses the following:

(1) Produce a good quality effluent for reuse

(2) Able to deal with high flow/load variations and is adaptable to different discharge requirements;

(3) Simple and easy operation and reduced risks associated with system failure;

(4) Low overall cost - i.e., capital, installation, and operating & maintenance cost;

(5) O & M must be accomplished by people who are specially trained for the job

(6) Minimal aesthetic impact;

(7) Small footprint treatment plant and allows incremental development

(8) Long useful life.

4.0 Greywater constituents

Chemical parameters & Nutrients in greywater

- General features of greywater are that it contains lower concentrations of organic matter, of some nutrients (e.g., nitrogen, potassium) and microorganisms than blackwater.
- The concentrations of phosphorus, heavy metals and xenobiotic organic pollutants are around the same levels.
- The main sources for these pollutants are chemical products such as laundry detergents, soap, shampoo, toothpaste, and solvents.
- The content of biological oxygen demand (BOD) and chemical oxygen demand (COD) in greywater indicate strength of the grey water, i.e., it indicates pollution potential of receiving bodies

Measured Values Of Nutrients In Greywater

Measured values of nutrients in greywater (Ledin et al., 2001a)

Nutrients [mg/l]	Laundry	Bathroom	Kitchen sink
Ammonia (NH_3-N)	< 0.1- 3.47	<0.1- 25	0.2 - 23.0
Nitrate and nitrite as N*	0.10 - 0.31	<0.05 - 0.20	-
Nitrate (NO_3-N)	0.4 - 0.6	0 - 4.9	-
Phosphorus as PO_4	4.0 - 15	4- 35	0.4 - 4.7
Nitrogen as total	1.0 - 40	4.6 - 20	15.4 - 42.8
Tot- N	6 - 21	0.6- 7.3	13 - 60
Tot- P	0.062- 57	0.11- 2.2	3.1 - 10

*** = per 100ml;**

Ground elements in greywater & Heavy metals in greywater

- Laundry wastewater was found to contain elevated sodium levels compared to other types of greywater. The sodium in the laundry wastewater may be caused by the use of sodium as a counter-ion to several anionic surfactants used in powder laundry detergent and the use of sodium chloride in ion-exchangers (Eriksson et al., 2002).

- Plastic and metal piping release compounds, such as Xenobiotic Organic Compounds (XOCs) and heavy metals, into the water supply and to greywater generated. Chemical products, resulting from water use, the type of pipes used for transmission and the quality of the water supply when it leaves the water works. Materials such as Arsenic, cadmium, iron, lead, mercury, etc. The Xenobiotic organic compounds (XOCs) that could be expected to be present in greywater constitute a heterogeneous group of compounds. They originate from the chemical products used in households such as detergents, soaps, shampoos, perfumes, preservatives, dyes, and cleaners. Kitchen wastewater contains lipids (fats and oils), tea, coffee, soluble starch, dairy products, and glucose, while the wastewater produced from laundry will contain different types of detergents, bleaches and perfumes (Eriksson et al., 2002).

TEMPERATURE AND PHYSICAL PROPERTIES

- Greywater temperatures are often higher than the temperature of the water supply due to hot tap water used for personal hygiene and laundry. High temperature favors microbial growth and leads to precipitation of e.g., calcite in supersaturated waters (Eriksson et al., 2002).

- The measurements of turbidity and suspended solids give information about the content of particles and colloids that could cause clogging of soil pores and installations. Generally highest values are found in greywater generated in kitchen sinks and washing machines as shown in Table 2.

PHYSICAL PROPERTIES

Physical properties [mg/l]	Laundry	Bathroom	Kitchen sink
Colour (Pt/Co units)	50 -70	60 - 100	
Suspended solids	79 - 280	48 - 120	134 - 1300
TDS		126 - 175	
Turbidity [NTU]	14 - 296	20 - 370	
Temperature [°C]	28 - 32	18 - 38	

5.0 WHO Guidelines for Agricultural Use of Wastewater

- Standards developed 40-50 years ago (1969-1979) tended to be very strict, as they were based on an evaluation of potential health risks associated with pathogen survival in wastewater, in soil and on crops, and on technical feasibility. The technology of choice for pathogen removal at that time was effluent chlorination.
- Evaluation of the credible epidemiological evidence; (an appraisal of the actual, as opposed to potential, health risks) – indicated that these standards were unjustifiably restrictive. As a result, a meeting of experts held in Engelberg, Switzerland, in July 1985, recommended the guidelines shown in table 4 (WHO, 1989b).

Tentative microbiological quality guidelines for treated wastewater reuse in agricultural irrigation (WHO, 2000b (adapted from WHO,1989b))

Reuse process	Intestinal nematodes (arithmetic mean no. of viable eggs per litre)	Faecal coliforms (geometric mean no. per 100 ml)
Restricted use: irrigation of trees, fodder crops, industrial crops, fruit trees and pasture	≤ 1	Not applicable
Unrestricted use: irrigation of edible crops, sport fields and public parks	≤ 1	≤ 1000

For developing countries, it is therefore more feasible to rely on the WHO guidelines for their own legislation than on USEPA or FAO guidelines.

6.0 The concept of Reuse/ Recycle and Green, and Circular Economies

The Water Supply and Sanitation Collaborative Council (WSSCC) in 1999 developed the Household Centered Environmental Sanitation Approach (HCES) which recommended among other things:

- People and their quality of life should be at the centre of any advanced Urban Environmental Sanitation System (UESS);

- Solutions of UESS problems should take place as close as possible to the place where they occur;

- “Waste”, whether solid or liquid, should be regarded as resources;

- UESS system should be “circular”- designed in such a way as to minimize inputs and reduce outputs.

- The HCES approach: (a) the household centered planning approach which deals with consultation with the stakeholders among the households, problems are solved as close as possible to their sources
(b) the circular system of resource management which seeks to minimize waste transfer across circle boundaries by minimizing waste-generating inputs and maximum recycling/reuse activities in each circle.

- The project consultants have pursued these concepts during the design of the grey water treatment system.

7.0 Constructed Wetlands In Greywater Treatment

- The Consultants were also mindful that the solution needed to be simple, i.e., easy to design, economical and sustainable operations and maintenance; should be nature-based; and that available land space is a limiting factor; hence the use of constructed wetlands in wastewater treatment was investigated thoroughly.
- Constructed wetlands (CWs) are systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and the associated microbial assemblages to assist in treating wastewaters.
- The first experiments aimed at the possibility of wastewater treatment by wetland plants were undertaken by Käthe Seidel in Germany in the early 1950s at the Max Planck Institute in Plön (Seidel, 1976).
- Danish Studies were carried out in 1960’s with emergent species such as: Phragmites australis (common reed), Typha latifolia (bulrush, common bulrush, common cattail).
- These systems known initially as reed beds gave excellent removal ratios for BOD5 (80 - 95%) & Total Dissolved Solids (TSS) (> 85%).

- The first fully constructed wetland was built with free water surface (FWS) in the Netherlands in 1967 (Kadlec and Tilton, 1979).

- However subsurface-flow type prevailed in the 1980s and 1990s (Vymazal and Kröpfelová ,2008).

- In North America, FWS CWs began with the ecological engineering of natural wetlands for wastewater treatment at the end of the 1960s.

- Subsurface-flow technology spread slowly in North America applicable to the treatment of various types of wastewater.

- At present, thousands of CWs of this type are in operation (Kadlec and Wallace, 2008).

- In Grenada there are three Horizontal Subsurface-Flow wetlands systems which were constructed since 2006.
- The first was a demonstration pilot Model Liquid Waste Wetland Treatment under the GEF-IWCAM Project in 2006. It was constructed to treat domestic wastewater from an office block/restaurant, events/theatre complex.
- The second was to serve a three-bedroom house in 2019. The third was constructed in 2020 to serve a three-bedroom dwelling & three single-bedroom apartment complex.
- These systems were planted with the following ornamental flowering plants: heliconia, ginger lily, ornamental banana and bird of paradise. They have been giving excellent effluent quality
- Molle *et al*., (2005) & (Seidel, 1976) in their study concluded that Vertical flow systems, if well designed, can achieve an effluent level that will meet the most stringent class, 95% removal of BOD, 90% removal of total-P and 90% nitrification.
- (Brix *et al., 2003 &* Arias *et al, 2003*) reported that these systems can give effluent quality of 60 mg/l COD, 15 mg/l SS, and 8 mg/l TKN with an area of 2 - 2.5 m^2/P.E.

Horizontal Subsurface- Flow CW serving a Three -Bedroom House, Grenada

7.1 The role of Constructed Wetlands in the treatment of Greywater

- Gorky,S.(2015), has proven through experiments that constructed wetland treatment systems is effective method for treatment grey water for recycling.
- In her research, the effectiveness of the wetland plant Colocasia esculenta in the treatment of grey water by vertical subsurface-flow constructed wetland system was studied.
- The results shown that the reed bed unit had reduced the concentrations of TSS, TDS, BOD, COD by 66%, 89%, 85%, 82% respectively on an average. These results indicated that this method of treatment is well suited for greywater.

7.2 Use of Ornamental Flowering Plants in CW for Wastewater Treatment

- Sandoval *et al*, (2019) reported after carrying out a review of the application of CWs in fifteen (15) countries (most in the Tropics), that the four most used flowering ornamental plants in CW were Canna, Iris, Heliconia and Zantedeschia. Canna spp. (Canna Lily or Indian Shot Plant) are commonly found in Asia, Zantedeschia spp. (Arum Lily, Calla Lily or Pig Lily) is frequent in Mexico, Iris has been most used in Asia, Europe and North America. Species of the Heliconia genus (Lobster Claw Plants) are commonly found in Asia and parts of the Americas (Mexico, Central and South America & the Caribbean).
- They reported removal efficiency of BOD (51–82%), COD (41–72%), TSS (62–86%), TN (48–72%), TP (49–66%), ammonium (NH4-N) (62–82%) & nitrates (NO3-N) (63–93%).
- Excellent removal efficiencies were also recorded for coliforms and some heavy metals (Cu, Zn, Ni and Al)

- In general, the mean TN and TP removal when using ornamental plants in CWs were less than the mean removal of the other pollutants (TSS, CDO, BOD, NH4-N or NO3-N).
- Such removal was influenced not only by the plants, but also by other parameters, such as filter media; or operational parameters, i.e., hydraulic and influent loading, which are related with the removal of pollutants in CWs and need to be considered in system designs (Yan et al., 2007).
- The use of Ornamental Flowering Plants (OFP) (especially species with different colours) in CWs provides an aesthetically pleasing appearance in the systems making it more probable for adoption and replication.
- In CWs with high plant production, OFP harvesting can be economical for operators/owners of CW, providing social and economic benefits.
- Such benefits include improvement of system landscapes, and improved environmental quality. The flowers could be sold as bouquets, as plants with attached roots for use in gardens, or for crafts made with parts of the plants.
- These were pertinent issues addressed for this project.

Typical Ornamental Flowering Plants

8.0 Costs

- (Vymazal and Kröpfelová, 2008) summarized available data from HF CWs in U.S., Czech Republic, Portugal, Spain and Portugal and found out that excavation costs varied between 7% and 27.4% of the total capital cost, while gravel varied between 27% and 53%, liner (13%–33%), plants (2%–12%), plumbing (6%–12%), control structures (3.1%–5.7%) and miscellaneous (1.8%–12%).
- The total investment costs vary even more, and the cost could be as low as 29 USD per m^2 in India (Billore et al., 1999) or 33 USD per m^2 in Costa Rica (Dallas et el., 2004), or as high as 257 EUR per m^2 in Belgium (Rousseau et al, 2004).
- In Grenada these systems were constructed with concrete envelops and were preceded with septic tanks and up flow filters. The cost of a system for a typical three-bedroom house is $4,780.00 US, i.e., $ 357 US per m^2. The media used was ¾” minus crushed stones and were planted with ornamental flowering plants.

8.0 Costs Continue

- Constructed wetlands have very low operation and maintenance costs, vegetation harvesting (if applicable).
- The basic costs are much lower than those for competing concrete and steel technologies, by a factor of 2–10 (Doherty et al., 2015) & (Kaldec and Wallace, 2008).
- In addition, because wetlands have a higher rate of biological activity than most ecosystems, they can transform many of the common pollutants that occur in conventional wastewaters into harmless byproducts or essential nutrients that can be used for additional biological productivity.
- These transformations are accomplished by virtue of the wetland´s land area, with the inherent natural environmental energies of sun, wind, soil, plants, and animals.
- Due to the natural environmental energies at work in constructed treatment wetlands, minimal fossil fuel energy and chemicals are typically needed to meet treatment objectives (Kaldec and Wallace, 2008).

9.0 Summary of A Comparative Analysis of Suitability of Different Wastewater Systems Applicable to the Treatment of Greywater in College Street Ghaut Based on Various Criteria

	TYPE OF WASTEWATER TREATMENT SYSTEM			
Criteria	Traditional septic tank and filtration	Typical package/ mechanical systems	Waste Stabilization Ponds	Settling Tank and Constructed Wetlands
General Considerations				
Decentralized	Yes	Yes	Yes	Yes
Appropriate	Yes, only if disinfection is added	Yes	Yes	Yes
Innovative	No (Traditional)	Yes	No	Yes
Nature-Based	No	No	Yes	Yes
Treatment Efficiencies	Moderate	Very good	Excellent	Excellent
Social Acceptance	Good	Yes, in developed countries where electricity is cheap	Yes, where cheap land is available	Yes, in the countries where they were constructed which includes Developing Countries
Land Availability	No. Septic Tank and filters take up too much land space. (Require.23 Sq M/5 P.E)	Yes (Require 2.5-3 Sq. M/5 P.E)	No (Require 30-40 Sq. M /5 P.E.)	Yes (Require up to 5 Sq. M/ 5 P.E)

Criteria	Traditional septic tank and filtration	Typical package/ mechanical systems	Waste Stabilization Ponds	Settling Tank and Constructed Wetlands
Environmental Criterion				
Nutrient Recycling (P, N)	No	yes	yes	yes
Organic matter recycling	no	no	yes	yes
Occupied area	protected	protected	Open and can attract birds and may emit offensive odours if overloaded	Open but the subsurface-flow ensure that the water level is below the media, hence no proliferation of mosquitos or attraction of birds
Energy Use	Nil	High	Moderate to nil. (Aerated ponds use up energy for aerators and pumps if gravity flow between the different ponds is not possible)	Nil
Quantity of Sludge and biosolids production	Medium to large after 4 to 5 years of operation	Small to medium	Large quantities after 3 to 4 years of operation	Nil
Sludge quality	stabilized	Partially stabilized	Stabilized	Not Applicable
Eutrophication potential of effluent	Medum to high	Low	Very low	Very low or nil if recycling for irrigation is considered
Disinfection Consumption of effluent	Medium to high	high	Very low since substantial die off of bacteria has been recorded	Very low since up to 96% removal of coliforms is reported

Criteria	Traditional septic tank and filtration	Typical package/ mechanical systems	Waste Stabilization Ponds	Settling Tank and Constructed Wetlands
Public Health				
Contact Risk	Medium to high	Low to medium	Very low	Very low
Treated Effluent Quality	Satisfactory to good	Good to very good	Very good to excellent	Excellent
Public Acceptance	Good	Very good to excellent	Very Good	Very good to excellent
Potential for reuse of treated effluent for irrigation and other uses	Median	Excellent	Excellent once they are not over loaded	Excellent
Financial				
Capital Cost	$3,680.00	$13,600.00	$10,200.00	$3,995.00
O&M Cost	$100.00	$1,000.00	$2,000.00	$450.00
Expected Lifetime	40 - 60 years	10 - 15 years	50 - 80 years	50 - 80 years
Operation and Maintenance Requirements	Low to medium. Medium because of the filtration	Very high, these are mechanical systems are energy intensive	Low to medium (especially if aerators are used for oxygenation. Desludging after years of operation can be time consuming and messy)	Maintenance activities are minimal. (The harvesting of plant material when they are overgrown. The system recommended will be planted with ornamental flowering plants that will have commercial value)

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Technological				
Ability to adapt to hydraulic fluctuation	Good	Low to medium	Low to medium	Very good
Ability to adapt to changes in organic load	Good	Good	Low to medium	Very Good
Vulnerability to natural disasters and climate change	Medium since the system will be covered and generally the envelop will be made of reinforced concrete	High	High	High

10.0 Conclusions

- Based on general considerations, public health, environmental, financial, and technological criteria the varying treatment trains all present some disadvantages. the main of which are as follows:

1. not enough available land space to accommodate these systems on residential lots along the College Street Ghaut,
2. the necessary skills set to operate and maintain these systems may not be found among householders,
3. the commercial systems are energy intensive and moving parts may render them not sustainable,
4. These commercial systems are not nature-based so they were not considered as sustainable solutions.

- Stakeholder consultations were a critical component of this review. Residents and commercial interests in the study area, operators of motor vehicles, pedestrians and government organisations were interviewed. Interviews were conducted face to face, via telephone and social media. A consultation of government organisations was conducted virtually via zoom.

- The consensus from individuals, businesses and government organisations was that the greywater flowing down College Street Ghaut posed a threat to human health, was not aesthetically pleasing, had the potential to impact the near shore marine environment and negatively affected both vehicular and pedestrian traffic through College Street. There was also consensus that the government should make control and or treatment of greywater a priority, but interviewees offered varied solutions to the problem.

Preliminary Design of constructed wetland system for treatment of greywater in the College Street Ghaut

- The Initial conditions are as follows:
- Greywater: 50% - 80% of total domestic water use
- The per capita water consumption of SKN: Q = 50 Imp. Gallons/day, water consumption = Q water avg.
- Considering a single household of 5 P.E (5 persons)
- Wastewater generated = Q waste avg. = (0.8 – 0.9) of water consumption
- = (0.8 – 0.9) Q water avg.
- =0.9 (50 gpcpd) x 5 persons
- =225 gallons/d
- From this figure, (50% - 60%) is greywater.
- Therefore, Q greywater = 0.6 * 225 Imp. gallons/d
- =135 Imp. gallons/d * 4.5
- =613.7 litres/d
- =614 l/d

- The hydraulic loading rate of VFCWs is much higher than HFCWs.
- Experiments in France/ Europe show that a total area of 1.2m^2 per P.E is adequate.

 (Min – max): (0.1 – 4.7m^2/P. E)

- Literature reports suggest that the area needed per capita or P.E:

- 1.5 – 2m^2/PE
- 2 – 2.5m^2/PE
- 2.5 – 3m^2/PE, depending on the strength of the wastewater.

- VFCW is very appropriate for small communities because treatment is extremely efficient >90% for COD (Chemical Oxygen Demand), 95% for SS (Suspended solids) and 85% for nitrification.

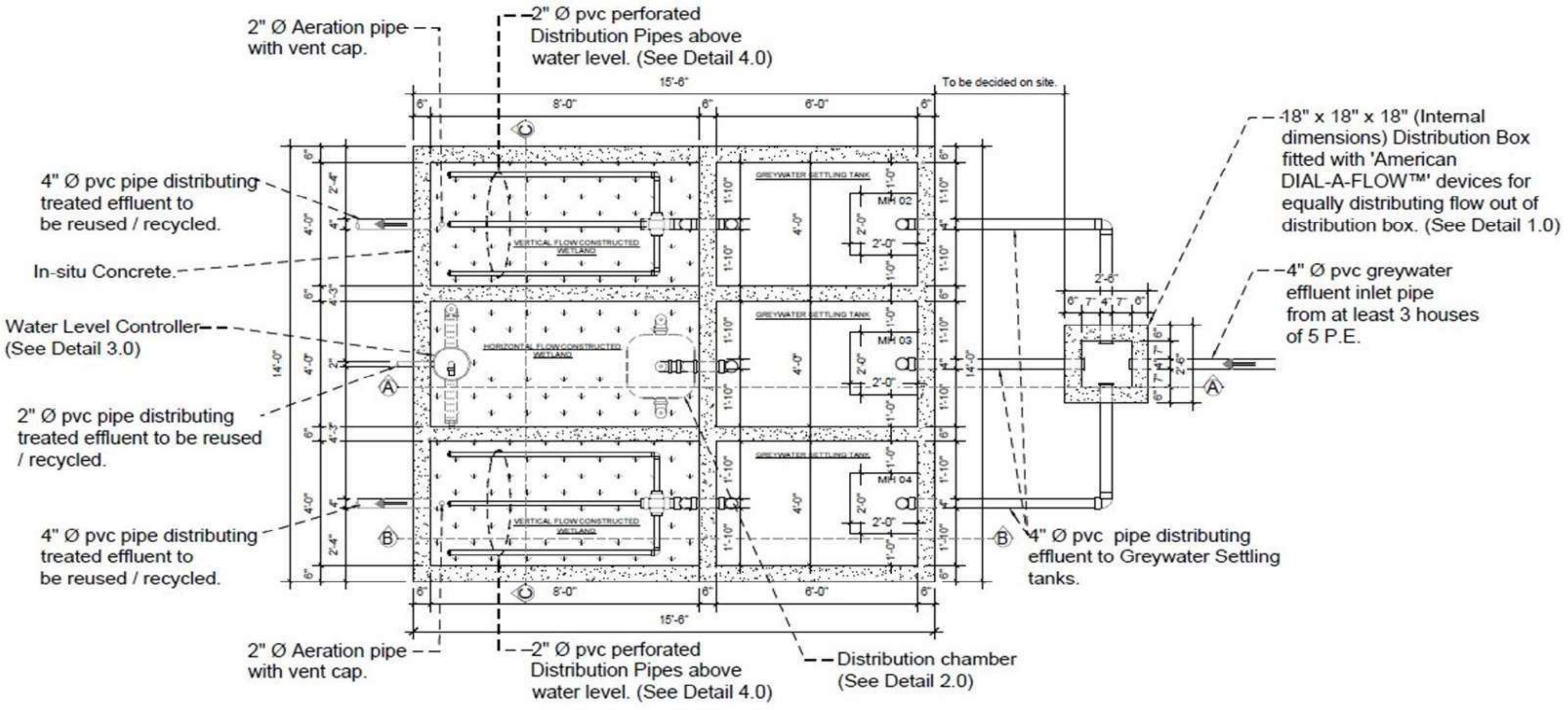
- There are various methods of approach for the design of constructed wetlands, using the approach with common hydraulic loading rate (HLR), typically 50 – 130 l/m^2/d and up to max 200 l/m^2/d,

HLR = Q/A, where Q = $Q_{greywater}$ = 614 litres/day, A= area required.

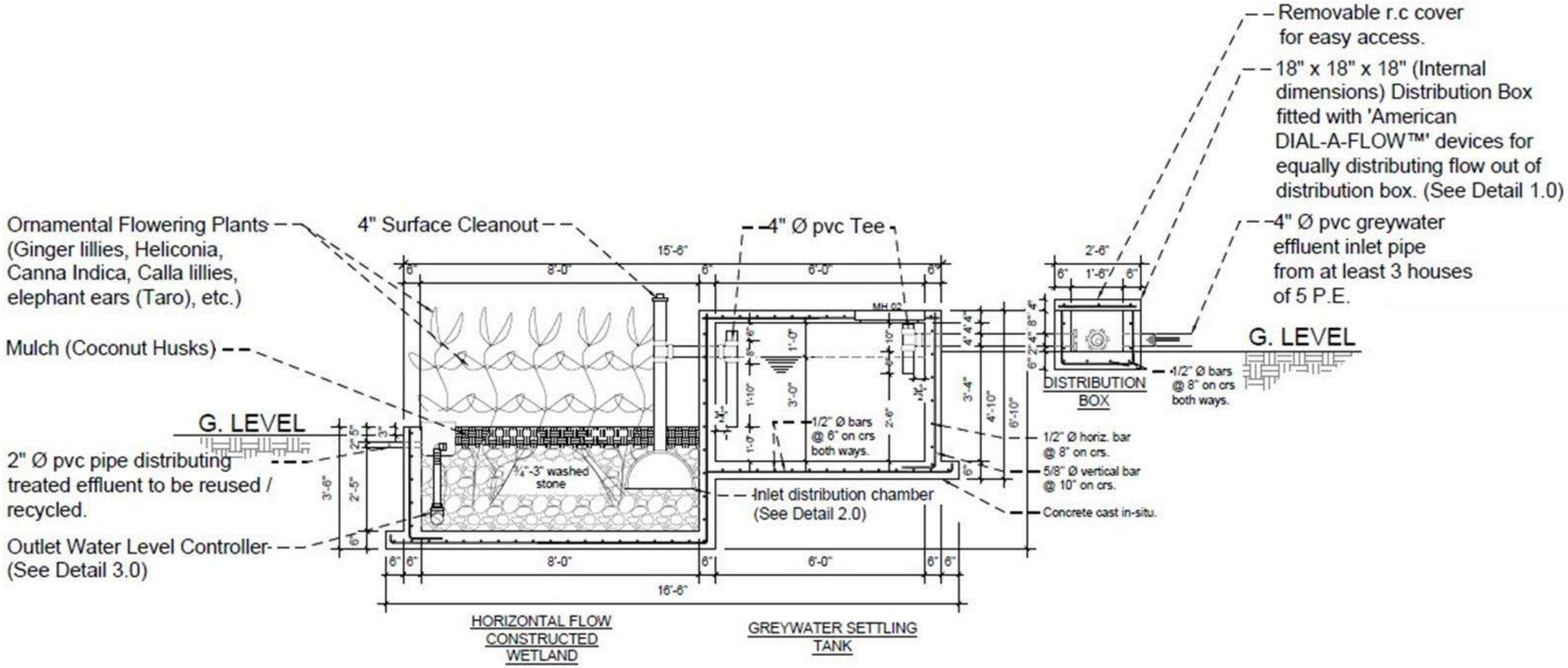
Therefore A = 614 l/d ÷ 200 l/m^2/d = 3m^2 or 33 sq. ft

Area required = 33 sq.ft

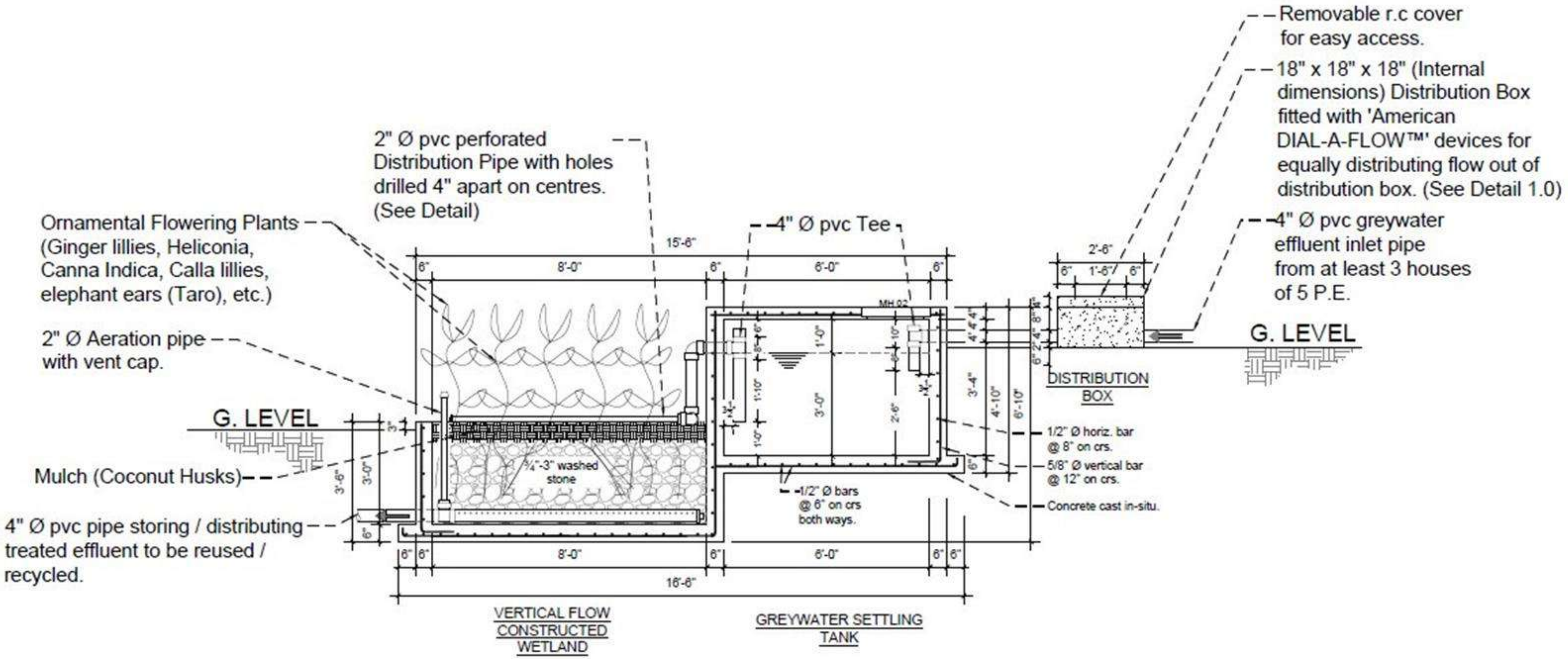
Layout of Pilot Greywater Treatment Plant- Vertical and Horizonal Constructed Wetlands with OFP



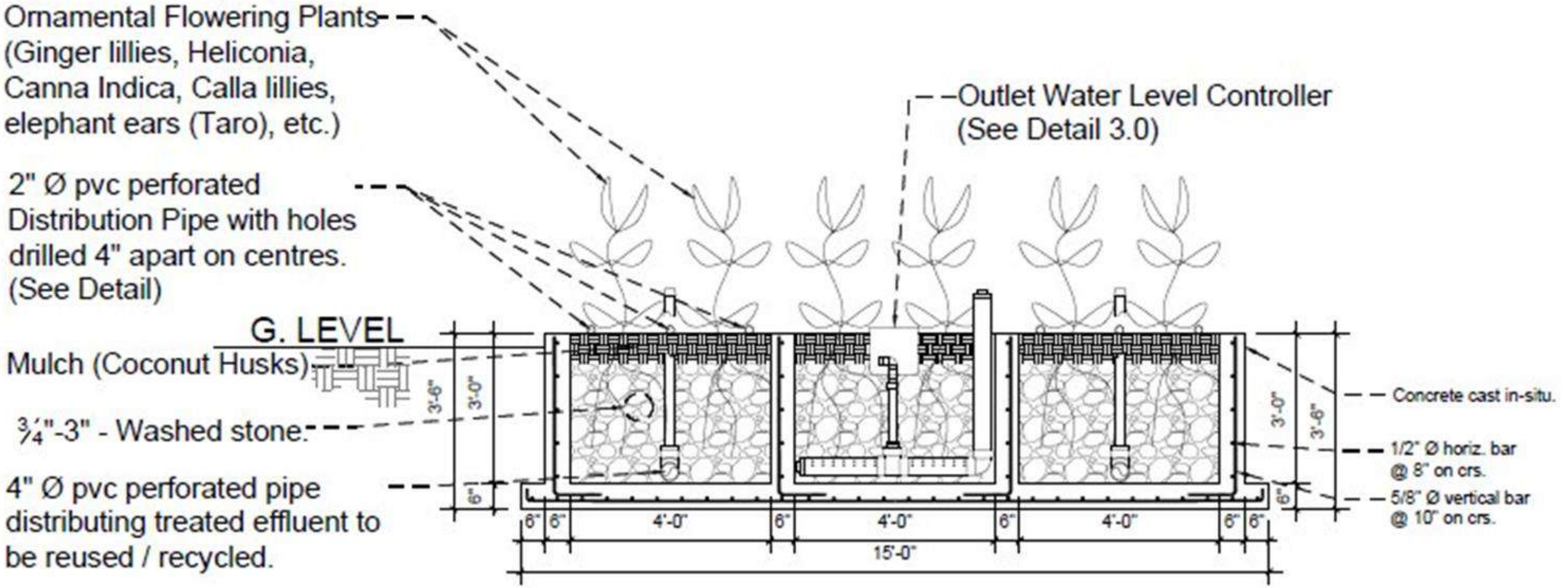
PLAN VIEW OF GREYWATER SETTLING TANK / VERTICAL & HORIZONTAL SUBSURFACE-FLOW CONSTRUCTED WETLANDS



SECTION A-A - VIEW OF GREYWATER SETTLING TANK / HORIZONTAL SUBSURFACE-FLOW CONSTRUCTED WETLAND



SECTION B-B - VIEW OF GREYWATER SETTLING TANK / VERTICAL SUBSURFACE-FLOW CONSTRUCTED WETLAND



SECTION C-C - VIEW OF GREYWATER SETTLING TANK / VERTICAL & HORIZONTAL SUBSURFACE-FLOW CONSTRUCTED WETLANDS

INNOVATION & SMART TECHNOLOGIES
BUILDING RESILIENCE IN THE WATER & WASTE INDUSTRIES
CWWA CARIBBEAN WATER AND WASTEWATER ASSOCIATION
30th Annual Conference and Exhibition
THE CAYMAN ISLANDS
3-8 OCTOBER 2021

Using a Water Security Index (WSI) approach to drive targeted projects: the Tobago Experience

Presented by Candice Santana

October 2021

Agenda

Why Water Security?

Defining Water Security

Overview Of The Water Security Index

The Tobago Experience

Why Water Security?

The UN's SDGs and Caribbean SIDs

The SDGs recognizes that development and economic prosperity depend on the sustainable management of freshwater resources and ecosystems

All SDGs are interconnected and interrelated, SDG 6 is no exception

Water is needed for agriculture, energy, domestic purposes, tourism and industrial production

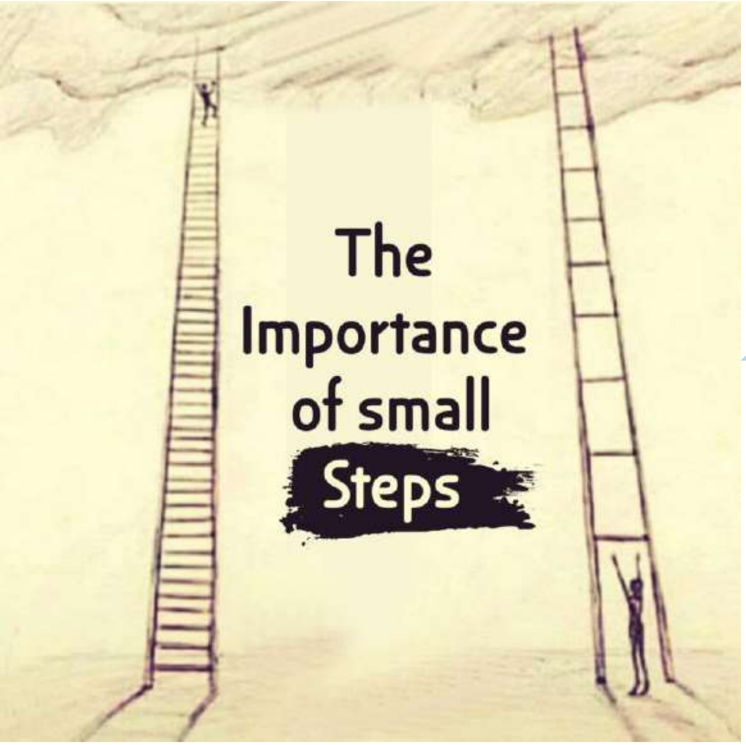
In the Caribbean, the intensity and frequency of both extremes of rainfall have increased in the last decade

Dry seasons have been littered with periods of extreme drought

Rainy seasons have had torrential rainfall resulting in both flash and riverine flooding

Water resources are commonly developed and managed by different government agencies and within different sectors which can foster a lack of coordination and a fractional perspective of the state of the resource

Most Caribbean SIDs also cope with fragile economies, limited finance and human capital as well as limited land use



Water
Security
Milestones
=
Measurable
Milestones

Caribbean SIDs and the UN's Sustainable Development Goals

Defining Water Security?

Defining Water Security

- “The capacity of a population to safeguard access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water related disasters, and for preserving ecosystems in a climate of peace and political stability.” - ***UNESCO-IHP Intergovernmental Council 2012***

Defining Water Security

- Cashman (2014) posited that by looking at different definitions offered by varying organizations, stakeholders, and academics, four (4) common elements of water security are identified, within which water security in the Caribbean can be assessed
- These are Adequacy, Accessibility, Assurance, and Affordability
- Each of these four elements has specific drivers which, Cashman posits, affect water security. For instance, water resource availability may affect adequacy, service coverage indicates accessibility, water management practices affect assurance, and tariff structures indicate affordability

Adequacy

- Addresses conditions governing water resource availability and the nature of water demands

Accessibility

- How much water is available when and where it is needed

Affordability

- How water services are paid for, as well as financial position of state agencies and businesses

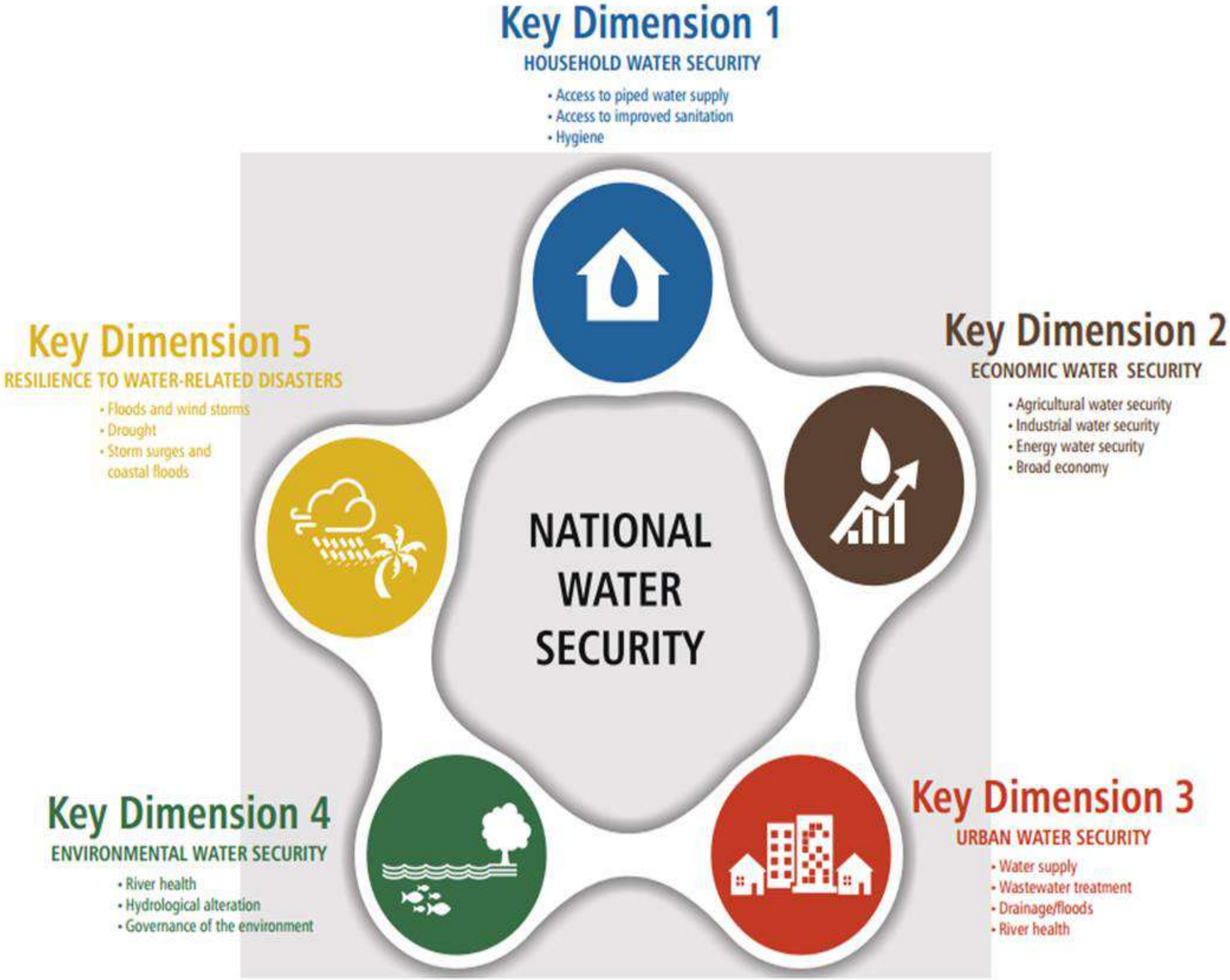
Assurance

- Ability to secure safe and sufficient water resources to deal with system shocks

Overview of the Water Security Index

Water Security Index

Adopted from the Asian Development Bank



The Tobago Experience

In 2018/2019 COLE Engineering Group Limited was contracted by WRA, WASA to completed the Development of an Integrated Water Security Programme for Tobago

Water Security Index – Tobago Experience

Domestic Water Security	The extent to which Tobago is supplied with safe and reliable water	Access to piped water Provision of 24/7 supply Access to improved sanitation
Urban Water Security	How well Tobago manages its urban water services and assets	Non-Revenue Water as a Percentage of System Percent of Wastewater Treatment Drainage coverage
Economic Water Security	How water is being used to support economic growth and development	Water use in agriculture Water use for tourism
Environmental Water Security	How well Tobago is able to manage its water resources	Water Resource Development Watershed Disturbances
Water Related Disaster Resilience	Tobago's capacity to cope with water related disasters, in this case floods, storm surges, and droughts	Drought Resilience Flood and Storm Surge Resilience

Domestic Water Security: The Tobago Experience

Access to Piped Water (%)	Score
<60	1
60-70	2
70-80	3
80-90	4
>90	5

Access to 24/7 Supply (%)	Score
<60	1
60-70	2
70-80	3
80-90	4
>90	5

Access to Improved Sanitation (%)	Score
<60	1
60-70	2
70-80	3
80-90	4
>90	5

Access to Piped Water	24/7 Supply	Improved Sanitation	Domestic Water Security Score
4	1	4	3

Urban Water Security: The Tobago Experience

NRW (% of System Input)	Score
>60	1
50-60	2
40-50	3
30-40	4
<30	5

Wastewater Collection (Central Sewerage) (%)	Score
<40	1
40-50	2
50-60	3
60-70	4
>70	5

Drainage Coverage	
A suggested indicator which can be utilized upon the collection of required data	

NRW	Wastewater Collection (Central Sewerage)	Urban Water Security Score
3	1	2

Economic Water Security: The Tobago Experience

Agricultural productivity data is sparse so far → A mid-range score of 3 has been assigned

Currently, tourism data for Tobago is being reviewed → A mid-range score of 3 has been assigned.

Water Use in Agriculture	Water Use in Tourism	Economic Water Security Score
3	3	3

Environmental Water Security: The Tobago Experience

Water Stress Indicator	Score
>1	1
0.6 - 1	2
0.3 - 0.6	3
0.3 - 0.1	4
<0.1	5

Watershed Disturbance	Score
Review of environmental policies, testing criteria, and previous consultations	3

Water Resource Development	Watershed Disturbance	Environmental Water Security Score
4	3	3.5

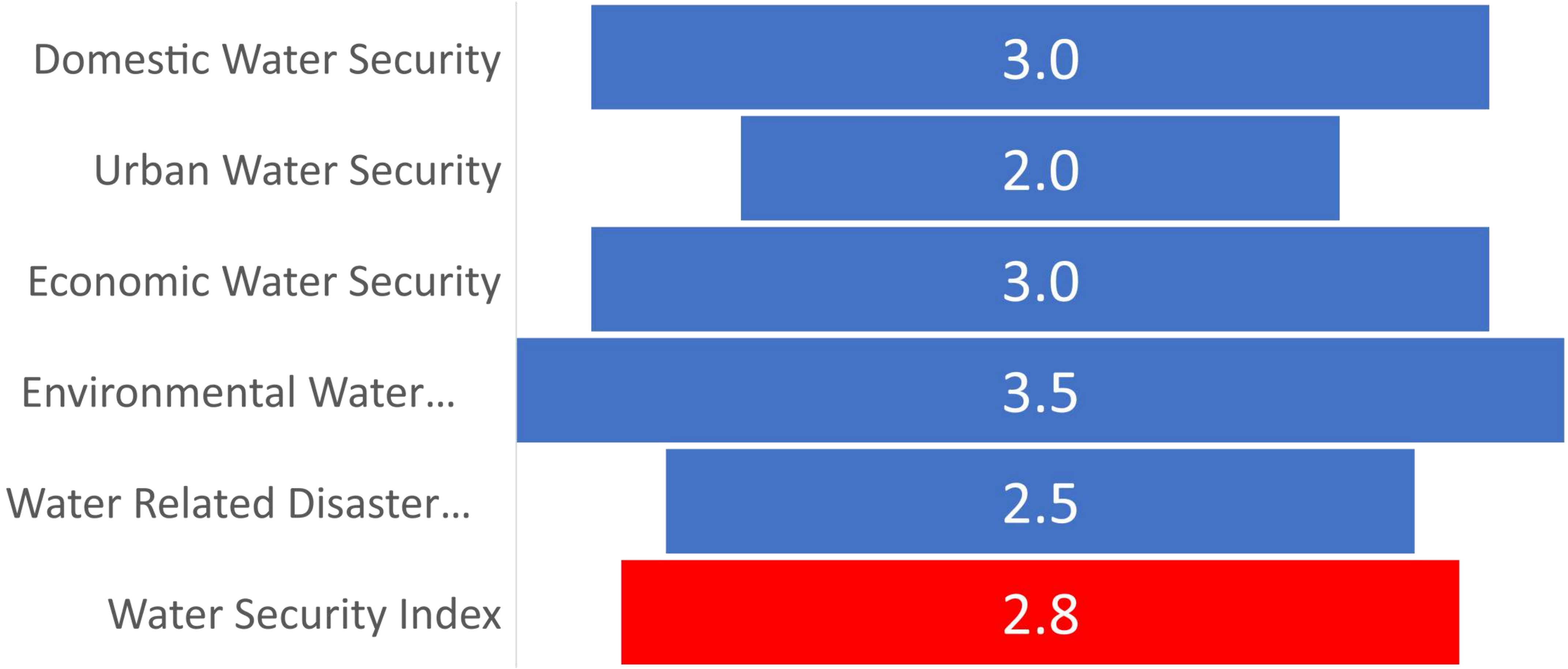
Water Related Disaster Resilience

Drought Resilience	Score
Reservoir Storage and Trucking Volume	2.5

Flood and Storm Surge Resilience	Score
A suggested indicator which can be utilized upon the collection of required data	

Drought Resilience	Flood and Storm Surge Resilience	Water Related Disaster Resilience Score
2.5	-	2.5

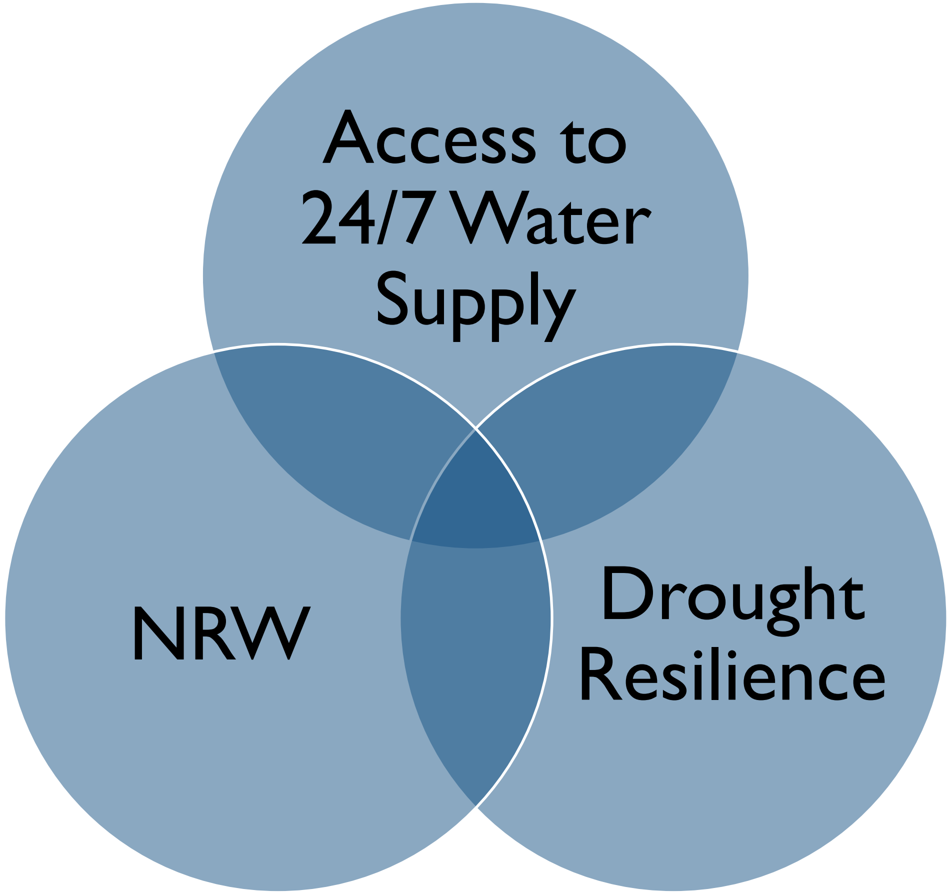
Water Security Index: The Tobago Experience

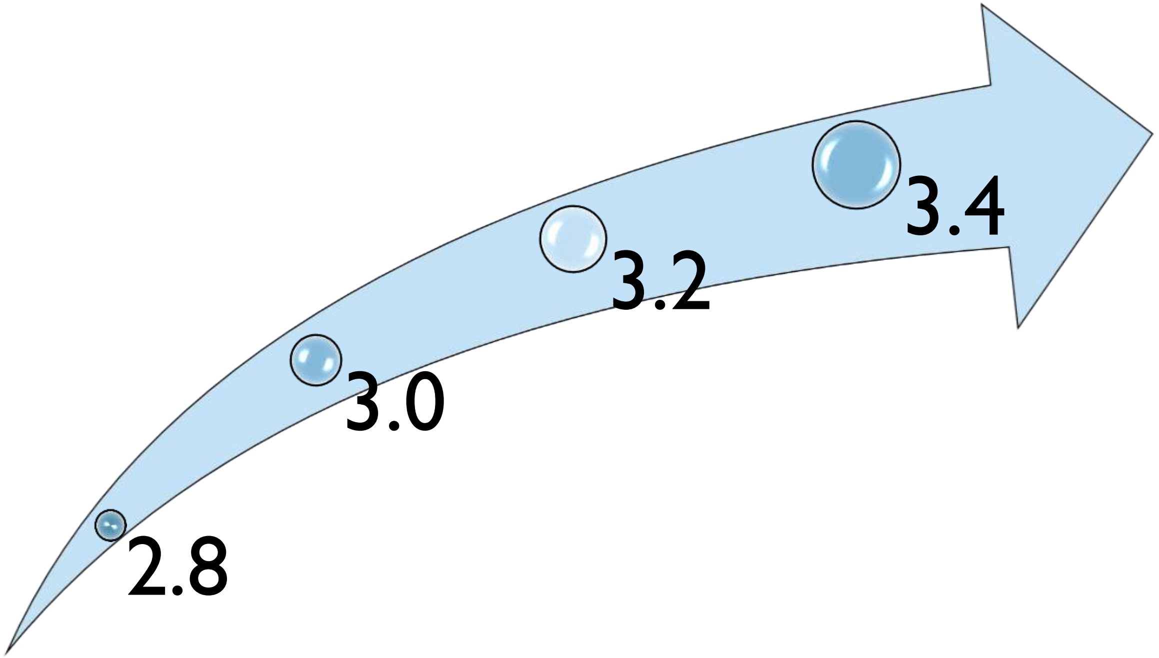


Targeted Projects

Domestic Water Security	• Access to 24/7 Water Supply
Urban Water Security	• NRW • Wastewater Collection
Water Related Disaster Resilience	• Drought Resilience • Climate Change

Targeted Projects





Possible Projects

- Demand Management Programme
- Leak Repair Programme
- Universal Metering
- Increasing Water Storage Capacity
- Exploring New Water Sources
- Water Information Management System

Acknowledgement

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Staff at Water Resources Agency, WASA

Thank You

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INNOVATION & SMART TECHNOLOGIES
BUILDING RESILIENCE IN THE WATER & WASTE INDUSTRIES
CWWA 30th Annual Conference and Exhibition
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CLIMATE CHANGE AND RAINWATER HARVESTING FOR DOMESTIC PURPOSES IN THE CARIBBEAN: THE CASE OF HARMONY VALE AND DRUMILLY DISTRICTS, ST ANN, JAMAICA

Lilly Loe

Presentation outline

- Introduction
- Research problem and objectives
- Conceptual framework of the Research Problem
- Methodology
- Literature review
- Findings
- Recommendations
- Conclusion

Introduction

- *"Water is life. It is essential for our survival. The future of the world also depends on water. Indeed, we cannot dream of a peaceful and prosperous world without water. But we must not forget that water is a finite resource. If we fail to manage this resource properly, it can cause a lot of human sufferings. Let us all work together for a world where everybody would have equal rights and access to safe water." (The Prime Minister of Bangladesh, Sheikh Hasina)*
- *Water a medium that links everything on this planet*
- *SIDS are more vulnerable to the climate change*
- *RWH is dependent on the rainfall.*
- *RWH Small island nations will be affected by the change in rainfall*

Study Area

JAMAICA HIGHLIGHTING ST. ANN PARISH
CARIBBEAN SEA
CARIBBEAN SEA
CARIBBEAN SEA
Hanover
St. James
Trelawny
St. Ann
St. Mary
Westmoreland
St. Elizabeth
Manchester
Clarendon
St. Catherine
Kingston & St. Andrew
Portland
St. Thomas
THE CARIBBEAN
Data Sources
Urban Areas: Urban Development Corporation
Parish: NSDMD
Map Datum: JAD2001
Date: June 2021
Created by: Luke Buchanan
0 20 40 80 Kilometers
0 20 40 80 Miles
Bensonton Community
St. Ann Parish
Urban Areas
Jamaica Parishes

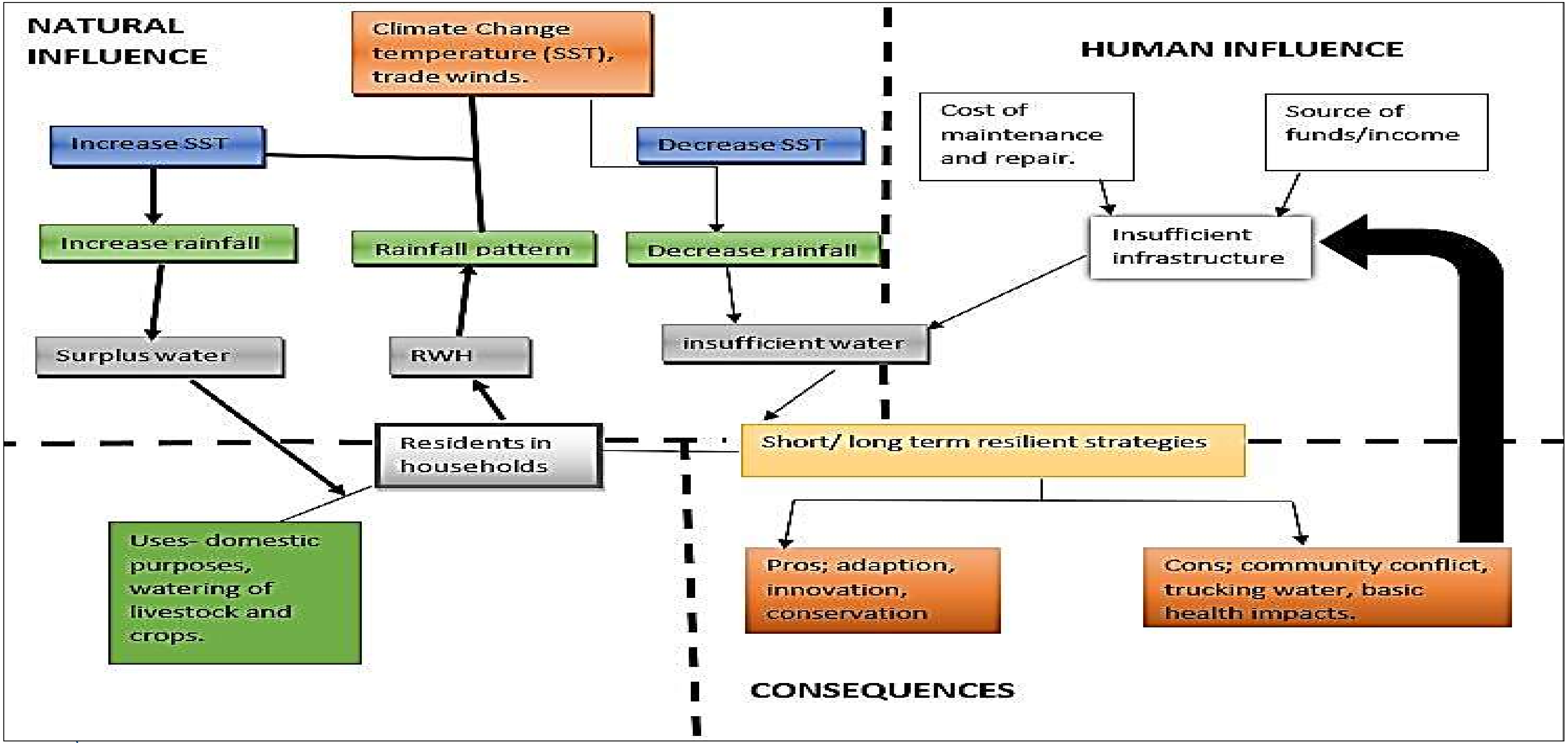
Research problem:

- Lester 2018 states that rainfall variability has change in the region.
- Aladenola et al (2016) mentioned that RWH has been practiced in the region to augment water and sanitation needs, however is exacerbated by climate change. climate change presented a challenge for those who rely on rainwater as their main source of potable water and are not connected to the centralized water system.
- The communities of Harmony Vale and Drumilly however have been innovative in adapting to the situation. (Emmanuel,2011)

Main objectives:

1) To examine the impacts of swift in rainfall change to the people's rainwater harvesting livelihood
2) To assess the adaptive strategies, they have been utilizing

Conceptual framework of the Research Problem



Methodology

- Data collected was based on survey questionnaires and interviews.
- **Mixed method**, where both qualitative and quantity are utilized equally 50/50.
- Survey questionnaires were close-ended for the quantitative part. And open ended for the qualitative. It was done in using a convenient method based on the availability of people.
- Interview is all qualitative.

- **Quantitative data** were entered to SPSS and integrate graphs
- **Qualitative data** were transcribed, memo, develop emerging themes

Literature review

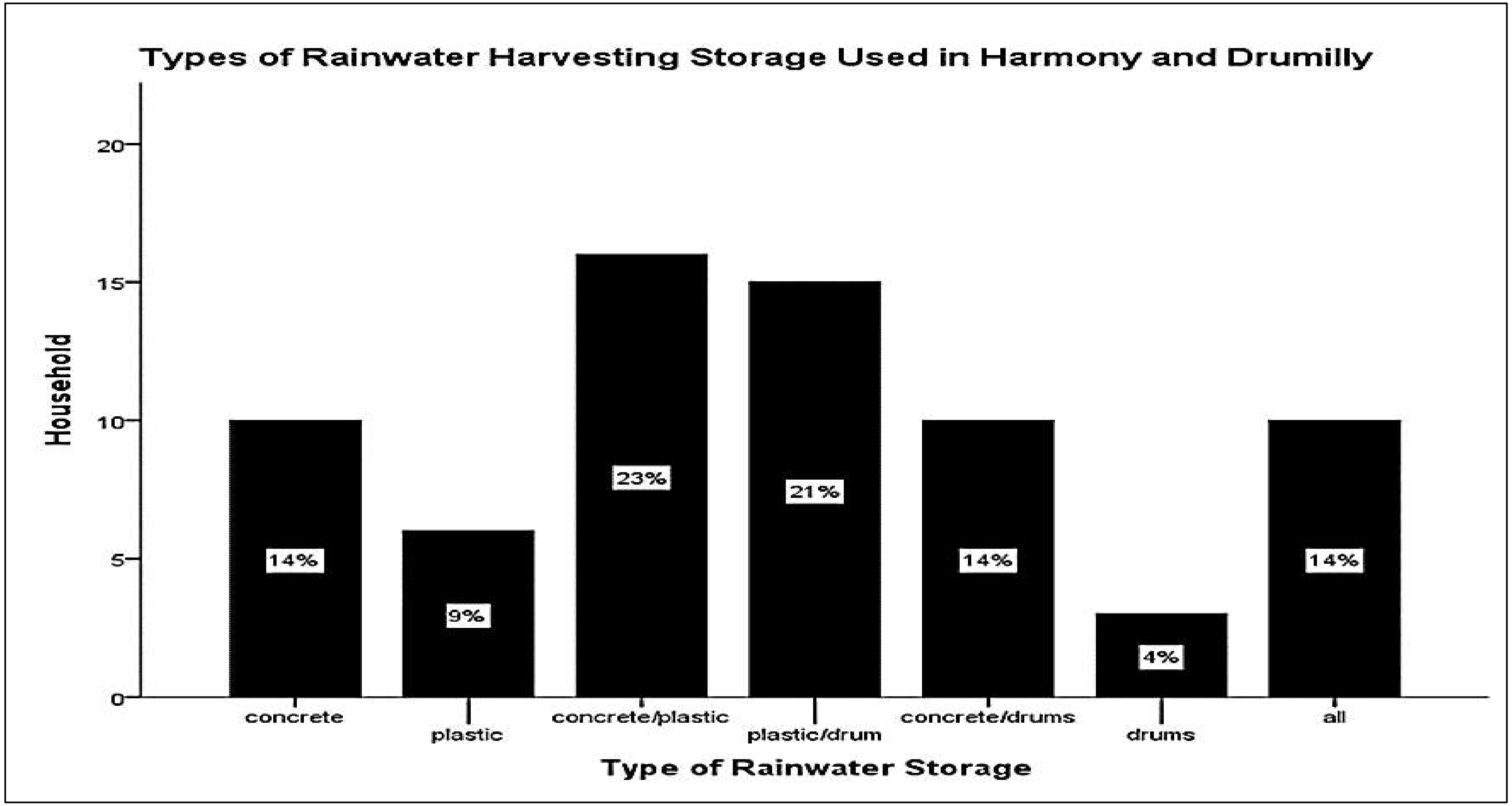
- Waite 2012 emphasizes a further research on the impacts of climate change to water resources in Jamaica.
- Lester (2012) highlighted a change in the rainfall variability for the Region.
- Aladenola et al (2016) RWH an important augmented measure for meeting the water and sanitation needs but exacerbated by climate change and disasters.

Results

Types of Rainwater harvesting designs in the two communities

Types of rooftop methods

RWH storages



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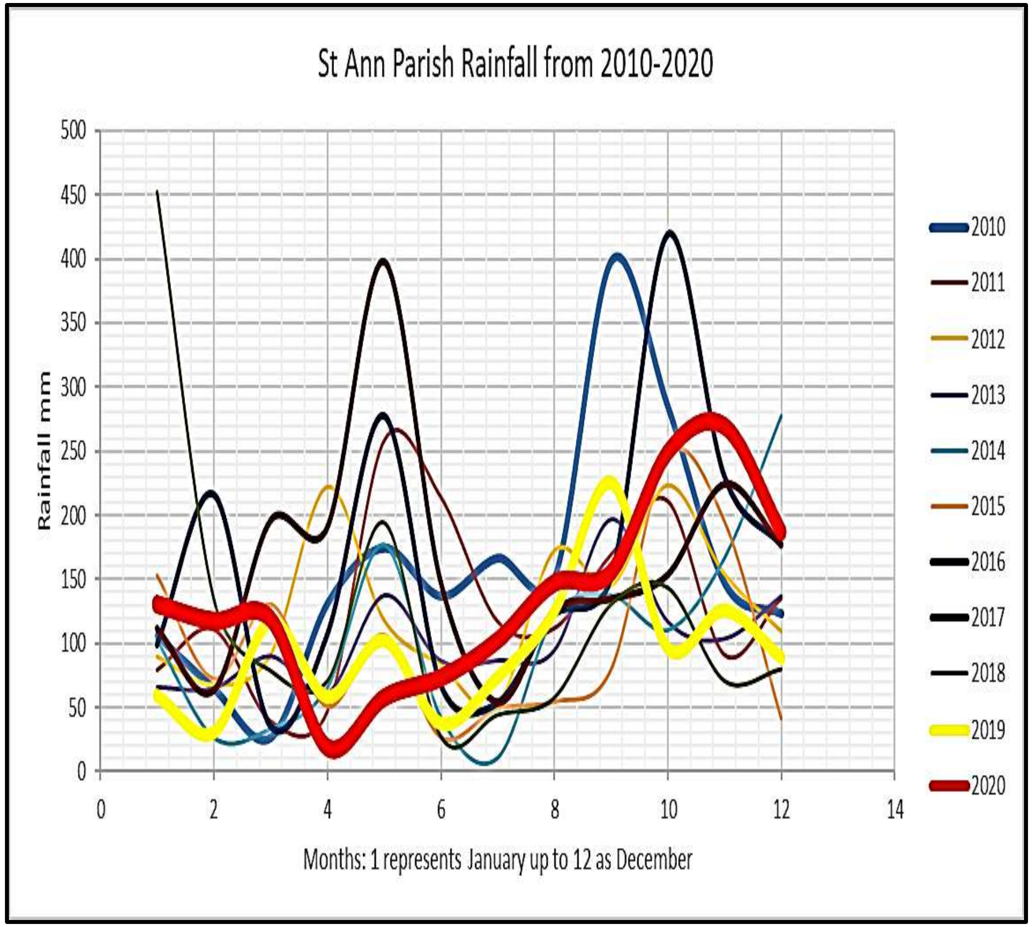
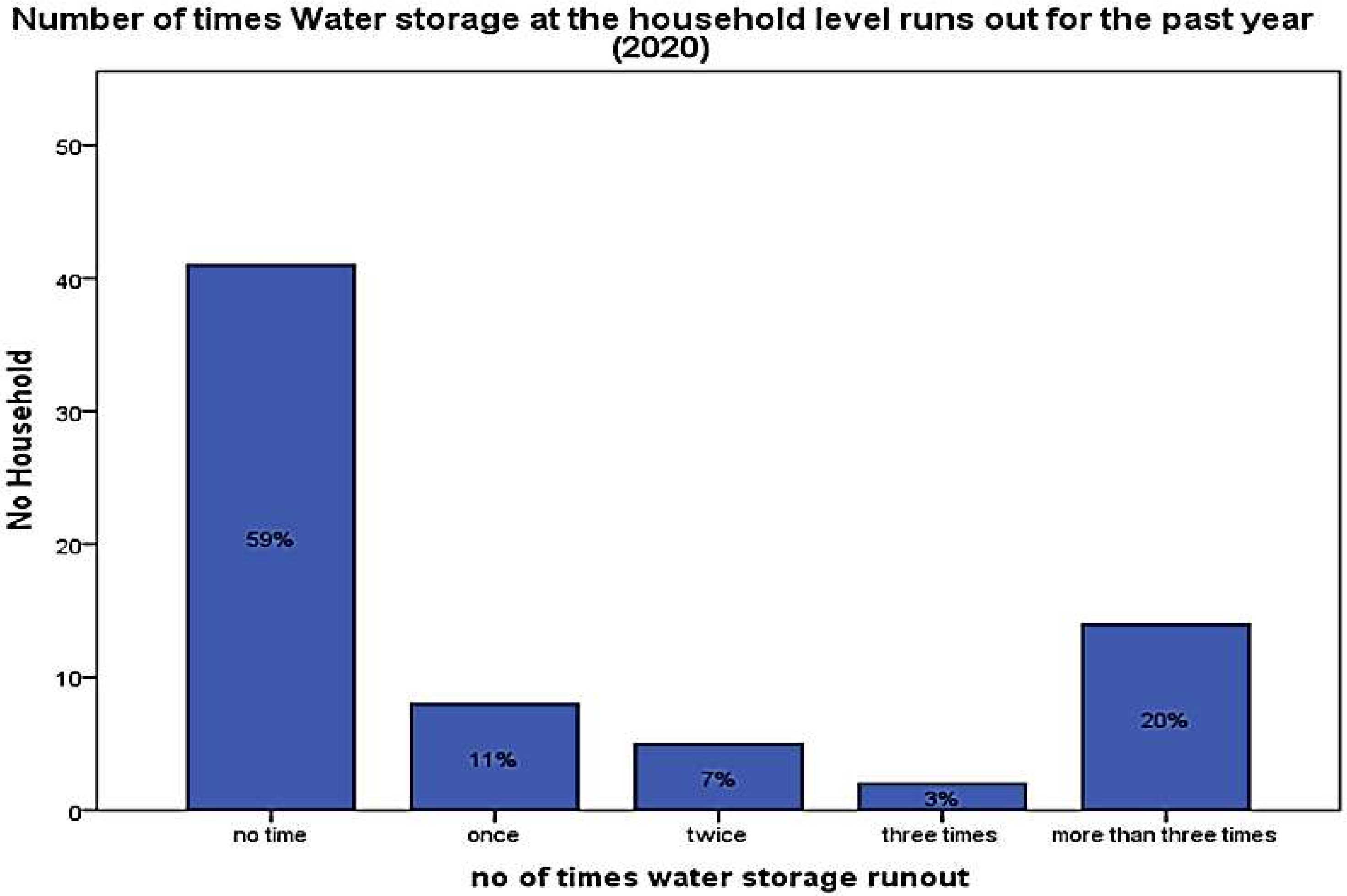
Rainfall change (Observation vs met data)

Observation from the HV/D residents

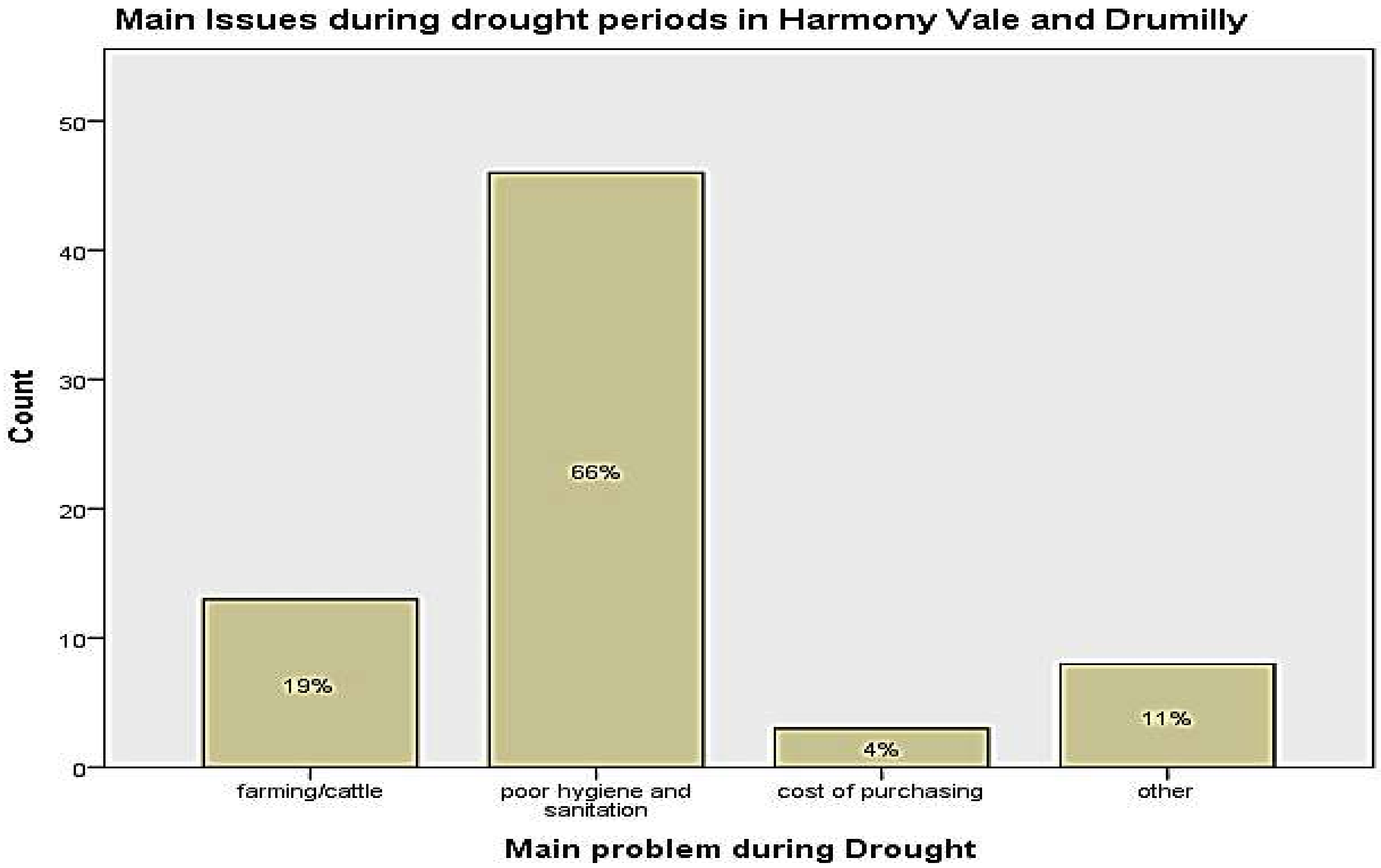
- Rainfall vary over the years, last year was worst
- Drought months for 2020 lasted 3 months (April, May and June)
- Rainfall has decreased-with evidence of about 41% of the population's water storage had runout.



Impacts of the changing rainfall



Impacts of the changing rainfall



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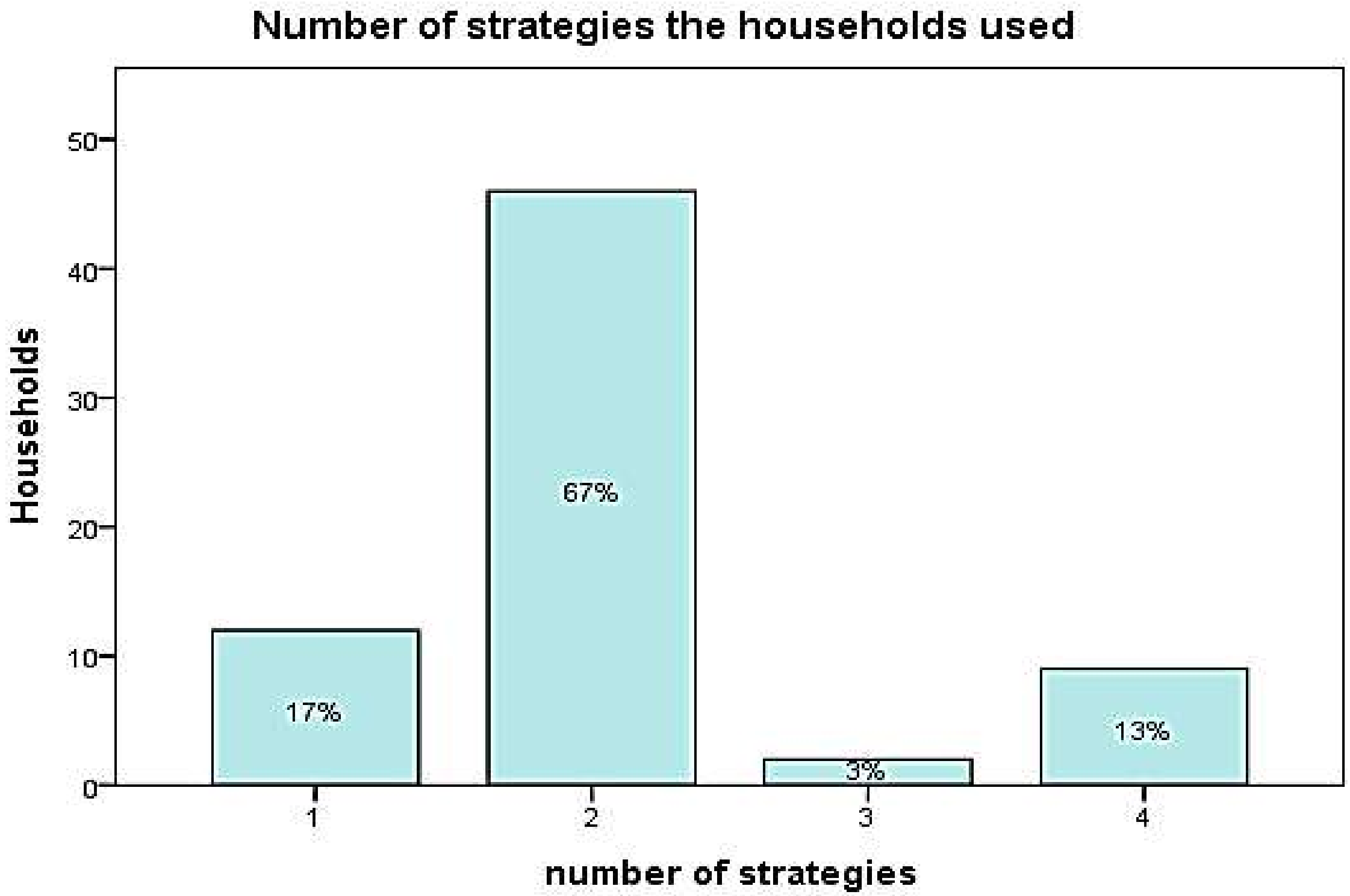
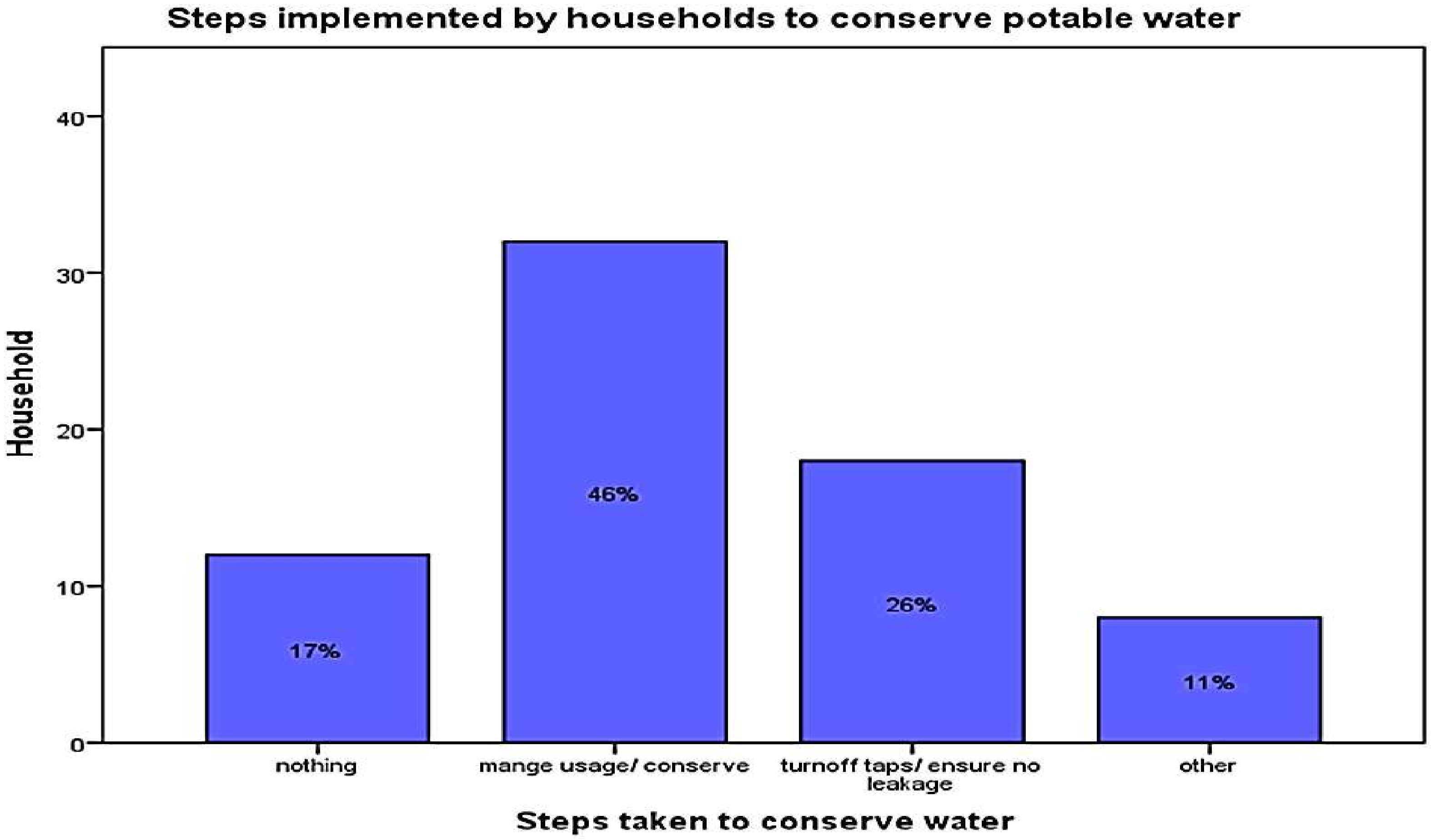
Strategies employed in response to the changing climate.

Strategies	Supply	Demand
Coping (short term)	1) Purchase bottled water 2) Buy trucked water 3) Water from neighbors 4) Purchase water from NWC in Claremont	
Adaptation (Long term)	Community tank	Practice conservation

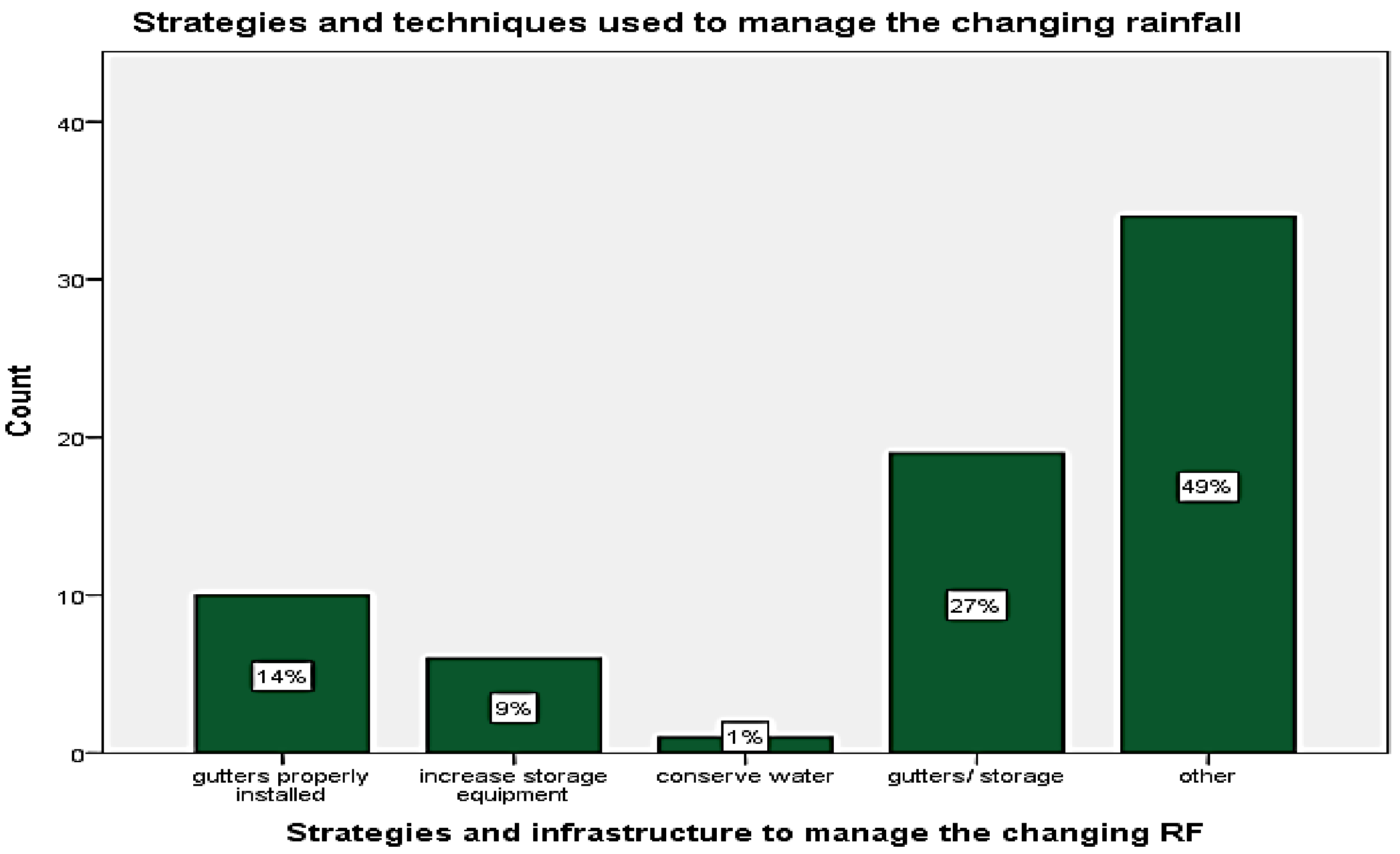
Strategies Cont'



Resilient techniques used

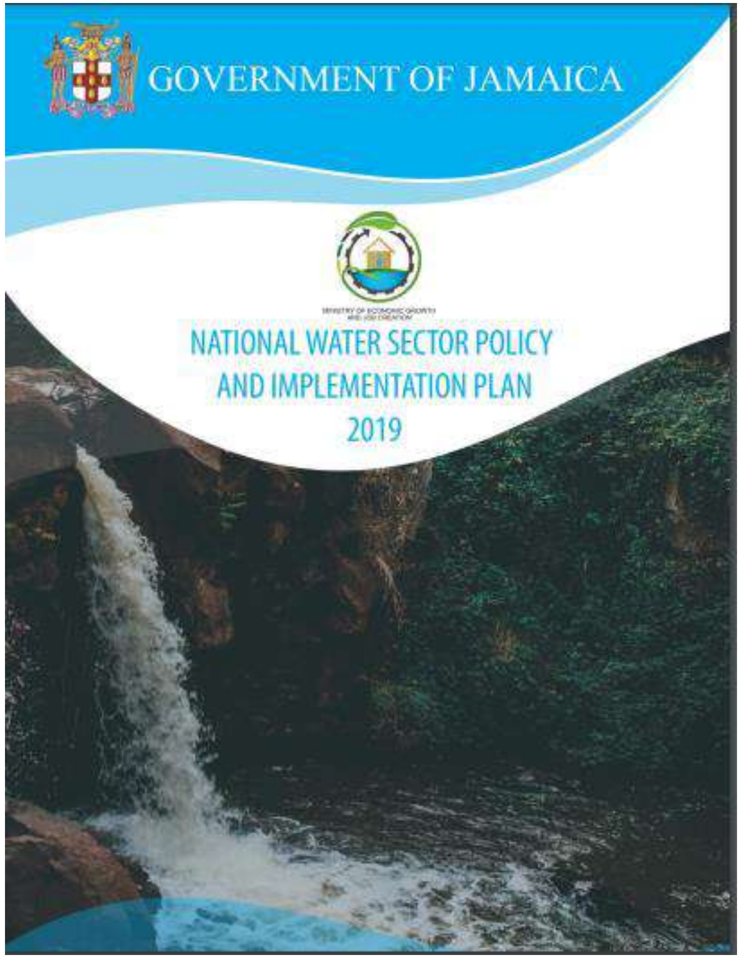


Combined resilient measures and techniques to the changing rainfall



Jamaica's National water policy and implementation plan 2019.

- RWH is incorporated in the policy
- Govt encouraged RWH as an augmented water supply
- Implementation phases varies based on the institution



Recommendations for RWH in the study Area

Household level

- Individuals to observe and estimate the volume of usage and estimate their use during the drought months to avoid water storages runout.
- Extra guttering needed to harness to the maximum capacity
- Use low flush design toilets
- possible to use solar powered water pumps for those that use them

Local govt and national govt level.

- Parish council (local govt) to work with the Rural water supply limited.
- Identify those that need more water storages and provide.
- Connect to the centralized water system

Conclusion

- Change in rainfall impacts RWH
- Main issue is the accessibility to water when there is the need.
- Reliable water supply connections, would be the best alternative on a long- term basis.