

Commercial Scale RWH

Case Studies from the Barbados Experience

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RWH Knowledge Network Forum,
Bay Gardens,
St Lucia.
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Commercial Scale RWH – Case Studies from Barbados

Introduction

- GLOBAL WATER PERSPECTIVE
- BARBADOS WATER RESOURCES & INFRASTRUCTURE
- OPPORTUNITIES FOR CONSERVATION MEASURES
- RWH – REGULATORY INITIATIVES
- RWH – TECHNICAL ANALYSIS
- RWH – FIVE CASE STUDIES
- CONCLUSIONS

Commercial RWH – Case Studies from Barbados

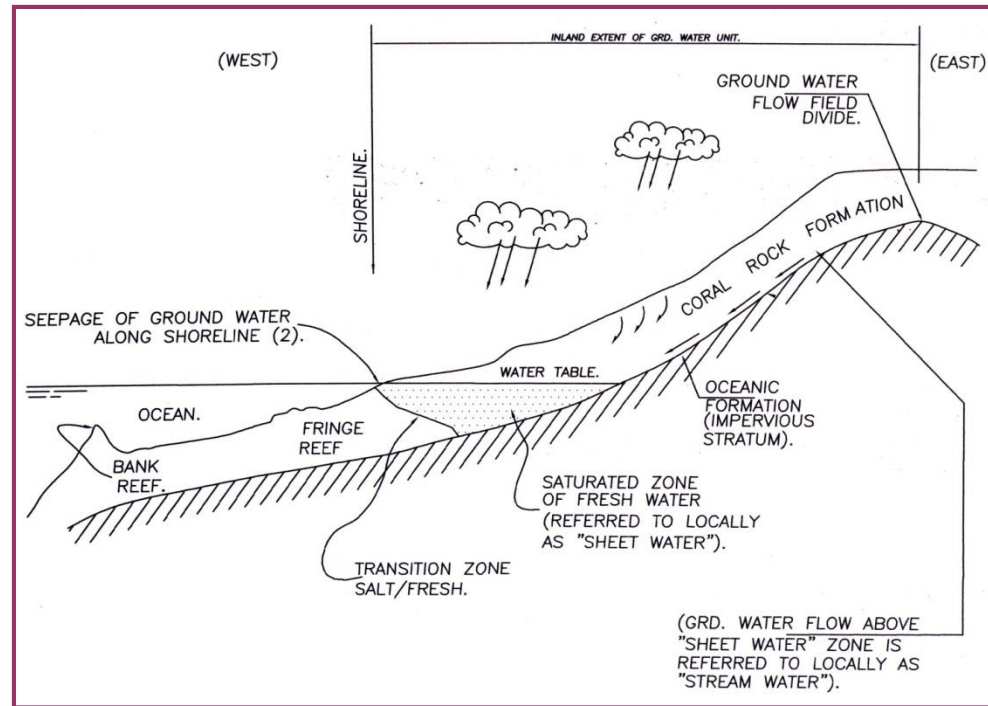
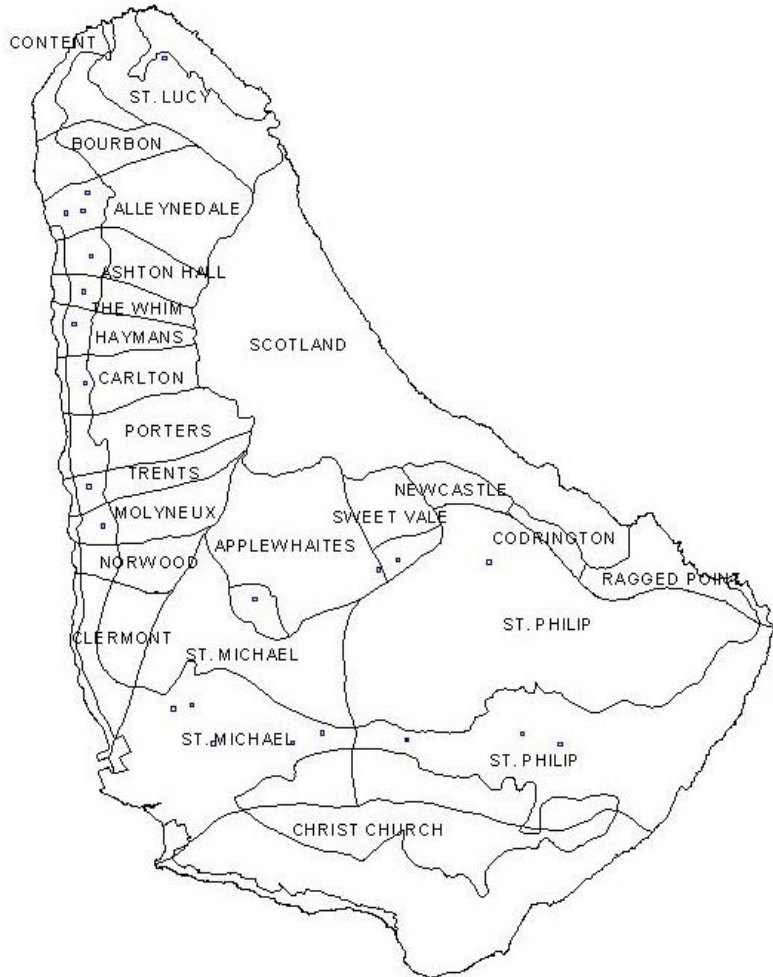
Global Water Perspective

- **Global Water** – 97% Seawater – 2% Polar Icecaps – 1% Useable
- **“Water Stressed”** Regions – 2.0 billion people (<1,700 cm/p/yr)
- **“Water Scarce”** Regions – 1.2 billion people (<1,000 cm/p/yr)

- No access to water for sanitation – 2.4 billion people
- Annual Deaths from Waterborne Diseases – 2.2 million people; mostly children < 5 years age (2007 UN World Water Day)
- World Population – 2.5 billion (1950) to 6 billion (2000) - up 150%
- Urban Population – from 29% to 47% in 50 years (1950-2000)
- US Bottled Water Industry value now US\$12 billion (The Economist)
- Privatized Water in USA now US\$400 billion (Worldwide business)
- Investment in US Water & Wastewater Technologies rose 433% (2006-2007) – (Forbes)

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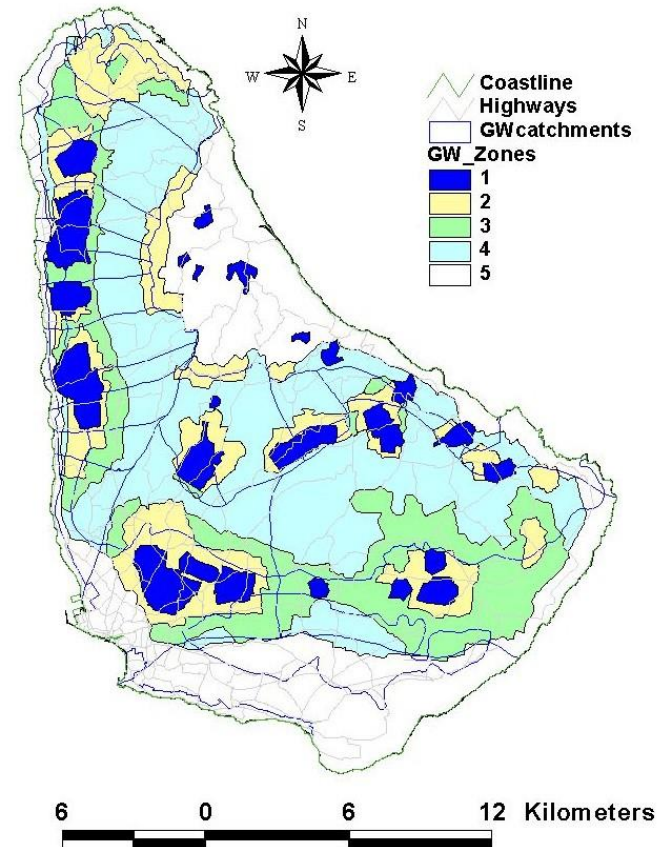
Geology & Ground Water Units



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Ground Water Protection Zones

- H. Tullstrom introduced Protection Zones in 1963.
- **Zone 1:** 300 days travel time; 9% or 3,927Ha (9,700 acres); no development allowed.
- **Zone 2:** 600 days travel time; 13% or 5,590Ha (13,807 acres); dev. with Septic Tanks + suck well.
- **Zone 3:** 5-6 years travel
- **Zone 4:** All highland areas.
- **Zone 5:** Coastal areas.



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Water Scarcity or Poor Resource Use?

- **“Water Scarce Country”** - renewable water resource <1000 cm / person / year (UN 1990's)
- Barbados ~ 210 cm /person/year (2009)
- St. Lucia ~ 5,500 cm /person/year (2000)
- Trinidad ~ 4,200 cm /person/year (2000)
- BWA Average Daily supply 159k cm/d ~ 58M cm/yr.
- 1016mm Rainfall ~ 435M cm/yr (BWA utilization = 13.3%)
- **1270mm Rainfall ~ 549M cm/yr (BWA utilization = 10.5%)**
- 1524mm Rainfall ~ 655M cm/yr (BWA utilization = 8.8%)
- Evapotranspiration Rates ~ 1,220mm to 1,829mm /year

- **Question – Are we really water scarce or just complacent ???**

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Barbados Water Infrastructure

- **WWD started 1861** – Benn Spring + Standpipes, Cod. College.
- **BWA Statuary Authority** - since Oct 1980 for Water + Wastewater; Since April 1, 1981 BWA supplies 98% population with tap water
- **Water Mains** – 2,600 km (1,600 miles).
- **GW Sources** – 2 Springs + 17 Sheet Water Wells + 5 Stream Water Wells + 7 Boreholes – 159k cm/d (42M USGPD) + 120 Private Wells – 36.4k cm/d (9.6M USGPD)
- **RO Desalination Plant** (2001) - 30,000 cm/d (7.9M USGPD)
- **Bridgetown WTP** (1980) ~ 2.5M USGPD + 4 Sewage PS + 1 Sea Water PS + 500mm diameter x 300m marine outfall 15m water depth.
- **Graeme Hall WTP** (1997) ~ 6.0 M USGPD + 5 Sewage PS +1.2km marine outfall in 36m depth.

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Opportunities for Efficiency Gains

- **Reduce UFW** – 60% lower to 40%, save 32,196 cm/d.
- **Meters Replacement & Maintenance** – 105,000 meters; most >15 Years old & under recording flows.
- **Hydraulic Model** - to optimize pipe sizes in network – identify weak links.
- **Mains Replacement** – after identifying deficiencies in system.
- **Restructure Employment & Industrial Practices** – excessive overtime, billing irregularities, absenteeism.



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Consumers Role – “Respect for Water”

- **Conservation** – through water saving fixtures; spring loaded taps, monitor meters for leaks.
- **Rain Water Harvesting** – irrigation, car washing, WC flushing, laundry, mopping, swimming pool; 429M cm/yr lost in 50” Rainfall Year.
- **Respect Value of Water** – Domestic = 0.25/0.77cent/Liter; Commercial = 0.466 cent / Liter; Cruise Ships = 0.81 cent / Liter.
- **Water Toilet** – John Harrington (1596); J.F. Brondel (1738) with valve; J. G Jennings (1852) patented pan with water trap.
- **WC’s** – 110k BWA customer connections; 350k WC’s on line 24/7
- **WC Flushing** – 26% to 30% domestic use; 18,940 cm/d or 12% BWA supply.
- **Overflowing WC Cisterns** – faulty flapper valve; 1% WC’s waste >20,000 cm/.d

Commercial RWH – Case Studies from Barbados Town & Country Planning Policy Initiative

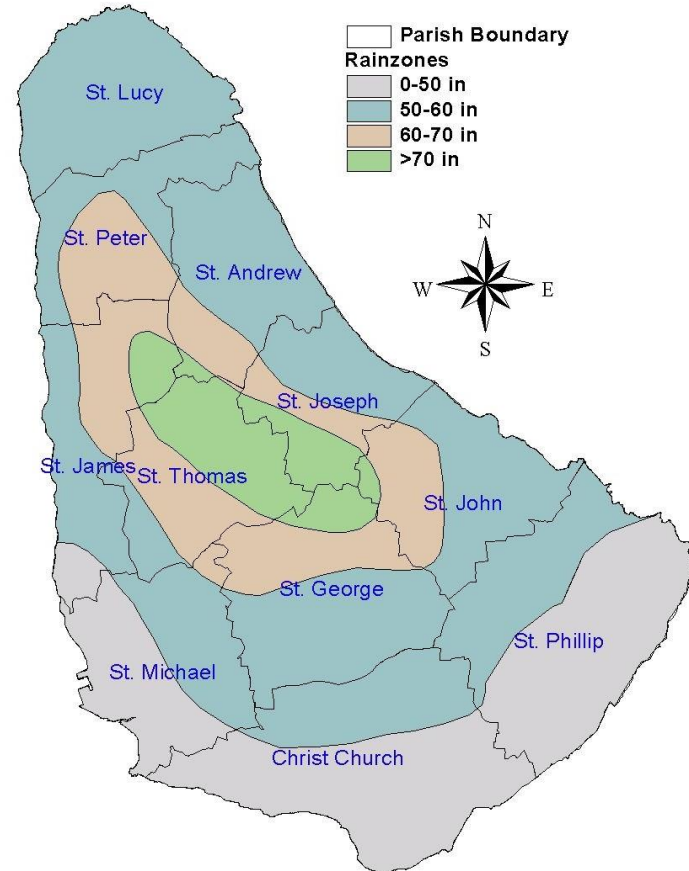
- **Jan. 1996** – Planning applications; Rain Water Tanks
- **Aug. 1997** – Planning requirement revised (roof area ?)
- **Domestic:** 1,500 – 3,000 SF floor (tank 3,000 Imp gals)
- **Domestic:** >3,000 SF floor (tank 6,000 Imp gals)
- **Commercial:** 4.0 Imp gals per SF of roof area.
- **Enforcement:** No Tank / No Permit Approval ??
- **Policy Success:** Tanks built, not all used effectively !!!

POLICY INITIATIVE: Mandatory rain water tanks for flushing toilets on commercial projects; industry, hotels, offices etc.; + fiscal incentives for hardware.

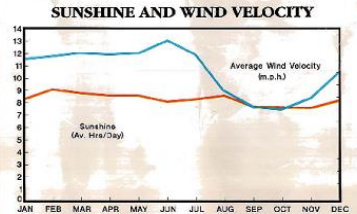
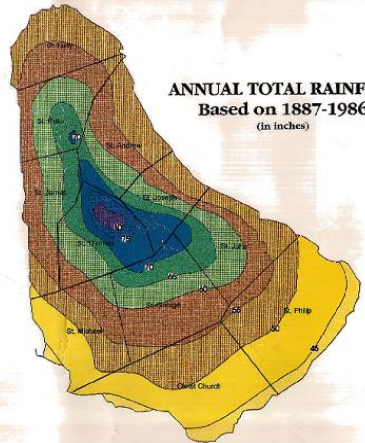
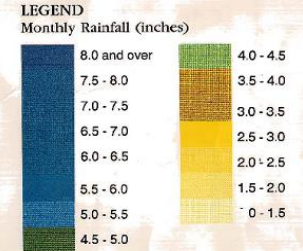
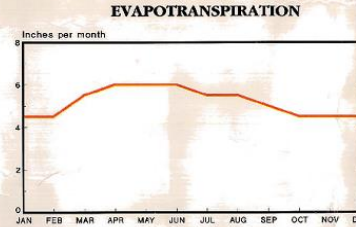
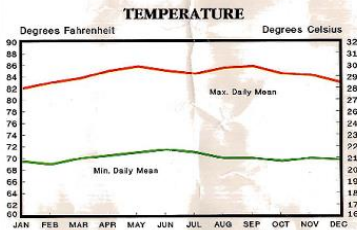
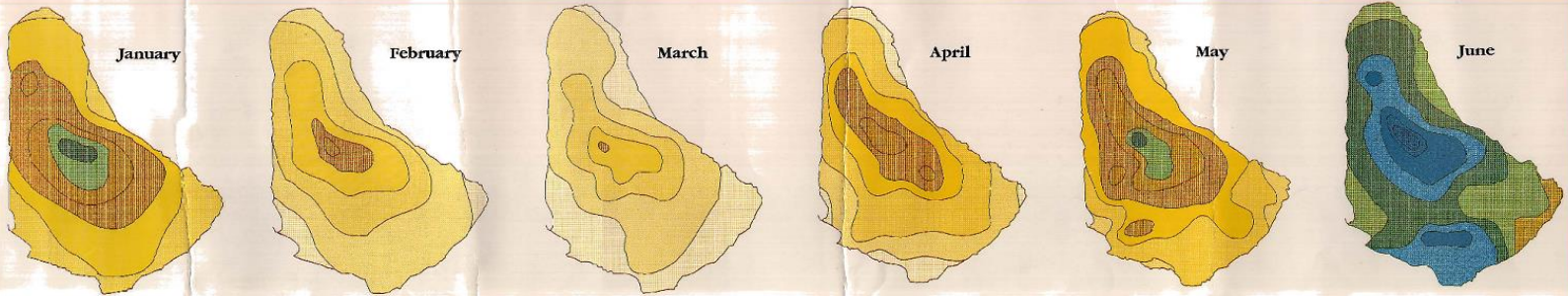
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Available Data for Rain Water Harvesting

- Rainfall Data – monthly average since 1847.
- Rainfall I/D/F Maps (J.F. Lirios, Nov. 1971)
- Topo / Watershed Maps – 1:10,000 scale
- B'dos Geology Map
- Evapotranspiration data – Met Office.
- Rainfall Stats – CIMH, Husbands, St. James



THE BARBADOS WEATHER MAP



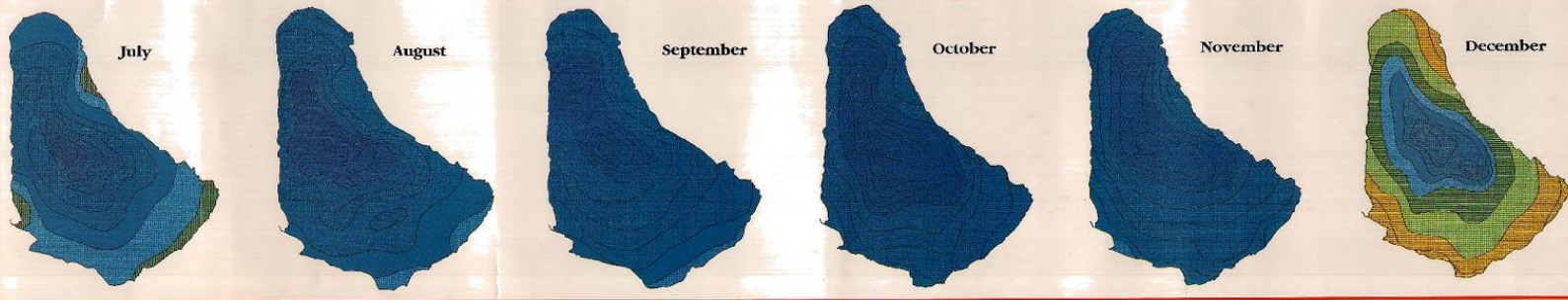
SOME SEASONAL CROPS AND FOODS

	J	F	M	A	M	J	J	A	S	O	N	D
Flying fish/dolphin (surface fish)	●	●	●	●	●	●	●	●	●	●	●	●
Sea snapper, snapper, fish (Bottom fish)	○	○	○	○	○	○	○	○	○	○	○	○
Sea eggs	●	●	●	●	●	●	●	●	●	●	●	●
Redfish (fish belly fish)	○	○	○	○	○	○	○	○	○	○	○	○
Sugar cane harvest	●	●	●	●	●	●	●	●	●	●	●	●
West Indian Sea Island Cotton harvest	○	○	○	○	○	○	○	○	○	○	○	○
Yams	●	●	●	●	●	●	●	●	●	●	●	●
Green potatoes	●	●	●	●	●	●	●	●	●	●	●	●
Mango	●	●	●	●	●	●	●	●	●	●	●	●
Bananas	●	●	●	●	●	●	●	●	●	●	●	●
Avocado pears	●	●	●	●	●	●	●	●	●	●	●	●
Red grape (grape), lime	●	●	●	●	●	●	●	●	●	●	●	●
Barbados Cherry, guava	●	●	●	●	●	●	●	●	●	●	●	●
Four-eyes, golden apple	●	●	●	●	●	●	●	●	●	●	●	●
Barrel	●	●	●	●	●	●	●	●	●	●	●	●

● = plentiful ● = less plentiful ○ = almost absent

CHANCE OF LESS THAN 'X' INCHES OF RAIN

'X' inches	1	2	3	4	5	6	7	8	9	10	11	15	20
January	8	28	59	79	89	92	97	98	98	99	100	100	100
February	15	65	86	92	97	98	99	99	99	99	100	100	100
March	29	67	88	96	97	100	100	100	100	100	100	100	100
April	31	58	78	89	91	94	97	99	99	100	100	100	100
May	19	65	86	77	86	88	95	97	97	98	100	100	100
June	1	14	29	41	59	72	80	86	90	94	99	100	100
July	0	1	11	26	39	59	71	83	88	94	99	100	100
August	0	0	6	16	29	37	52	70	74	81	89	100	100
September	0	1	5	12	25	42	62	76	81	87	95	100	100
October	1	2	6	9	23	39	47	66	72	83	95	98	100
November	1	2	7	17	31	45	65	74	81	87	98	100	100
December	2	9	27	51	64	79	85	90	94	96	100	100	100



RAINFALL DATA BY TRANSENERGY CONSULTANTS LTD.
GRAPHICS BY PROFESSIONAL COMPUTING SERVICES

COMPILED BY
BARBADOS SOCIETY OF TECHNOLOGISTS IN AGRICULTURE

DISTRIBUTED BY THE AGRICULTURAL DEPARTMENT OF
Plantations Ltd. (Trading Company Limited)



Commercial RWH – Case Studies from Barbados

Water Balance Analysis

- **Irrigation Requirement** = water to make up soil moisture deficit.
- **Identify Watersheds** for Harvesting – compute runoff.
- **Select Rainfall Event** – 45"Yr; 51"Yr, 60"Yr etc.
- **Model computes monthly Water Balance.**
- **Select pond volume** needed to sustain system – trial & error.

MODEL OF IRRIGATION WATER REQUIREMENTS



Stansac Consulting Caribbean Ltd
Black Rock, St. Michael,
Barbados, W.I.

Project: Apes Hill Golf Course Dev.
Sector: Irrigation Water Budget
Rain: 51" Rainfall / Yr
Eng: A. P. Hutchinson, P.Eng.

Job No: 0518
Date: 9/17/05
Shk No: 1

Irrigated Area (acres)	Irrigation Zones	IRRIGATION WATER REQUIREMENTS												
		Dry Season						Wet Season						
		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	
	Evap. Transp. Rate (inch / mth)	>>>>	4.80	4.40	6.08	6.20	6.28	5.78	6.00	5.88	4.92	4.60	4.64	4.96
	Irrigation Rate (inch /mth)	>>>>	2.15	2.80	4.58	4.60	3.78	1.16	1.00	1.00	1.00	1.00	1.00	1.06
200.0	Apes Hill 18 Hole GC	84.0	4.9	6.4	10.5	10.5	8.6	2.7	2.3	2.3	2.3	2.3	2.3	2.4
10.0	Apes Hill Driving Range	10.0	0.6	0.8	1.2	1.3	1.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3
			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total Irrigation Volume / mth	MGM	5.5	7.2	11.7	11.8	9.7	3.0	2.6	2.6	2.6	2.6	2.6	2.7
	Average Irrigation Volume / day	MGD	0.18	0.24	0.39	0.39	0.32	0.10	0.09	0.09	0.09	0.09	0.09	0.09

Runoff Factor (%)	Watershed Zones	Watershed Area (acres)	STORMWATER RUNOFF (51" Yr - 50% chance of exceedance)											
			Dry Season						Wet Season					
			Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Rainfall (inch/mth)	>>>>	2.65	1.60	1.50	1.60	2.50	4.60	5.50	6.30	6.60	7.25	6.75	3.90
1.00	Apes Hill GC Storage Lake	2.00	0.14	0.09	0.08	0.09	0.14	0.25	0.30	0.34	0.36	0.39	0.37	0.21
0.20	Apes Hill GC Watershed	156.00	2.25	1.36	1.27	1.36	2.12	3.91	4.67	5.35	5.61	6.16	5.73	3.31
0.25	Farmers Watershed	246.00	4.44	2.68	2.51	2.68	4.19	7.70	9.21	10.55	11.05	12.14	11.30	6.53
1.00	Farmers Water Impoundment	18.00	1.30	0.78	0.74	0.78	1.23	2.25	2.70	3.09	3.23	3.55	3.31	1.91
0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Runoff Volume / mth	MGM	8.1	4.9	4.6	4.9	7.7	14.1	16.9	19.3	20.3	22.2	20.7	12.0

Water Balance by Month			Dry Season						Wet Season					
Irrigation Vs Storage			Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	GC lake volume at start of mth.	MG	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
2	Add: GC stormwater runoff /mth	MG	2.4	1.4	1.4	1.4	2.3	4.2	5.0	5.7	6.0	6.6	6.1	3.5
3	Less: GC lake losses (6.5"/mth)	MG	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)
4	Less: GC Irrigation vol /mth	MG	(5.5)	(7.2)	(11.7)	(11.8)	(9.7)	(3.0)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.7)
5	Net GC lake storage at month end	MG	11.5	8.9	4.3	4.3	7.2	15.8	17.1	17.8	18.1	18.6	18.2	15.5
6	Farmers Lake volume at start mth	MG	60.0	59.1	53.3	42.6	32.2	26.7	33.5	42.2	52.6	60.0	60.0	60.0
7	Add: Farmers watershed runoff/mth	MG	5.7	3.5	3.2	3.5	5.4	10.0	11.9	13.6	14.3	15.7	14.6	8.4
8	Less: Lake Evaporation (6.5"/mth)	MG	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)	(3.2)
9	Less: Vol transfer to GC Lake/mth	MG	(3.5)	(6.1)	(10.7)	(10.7)	(7.8)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	Net Farmers Lake vol at mth end	MG	59.1	53.3	42.6	32.2	26.7	33.5	42.2	52.6	63.7	72.5	71.4	65.3

Commercial RWH – Case Studies from Barbados

Millennium Heights Complex, St. Thomas

- Residential Sub-division 45 Acres (built in 2000)
- Phase 1 – 78 Condos & Villas
- Phase 2 - 20 Duplex + 16 Condos + 64 free hold Lots.
- Existing Sinkhole converted to 1.5 acre, 5.5 M gal. lined pond.
- Improved aesthetics and property values + irrigation
- Exceeds TCDPO regulatory requirements for Rain Water Storage.

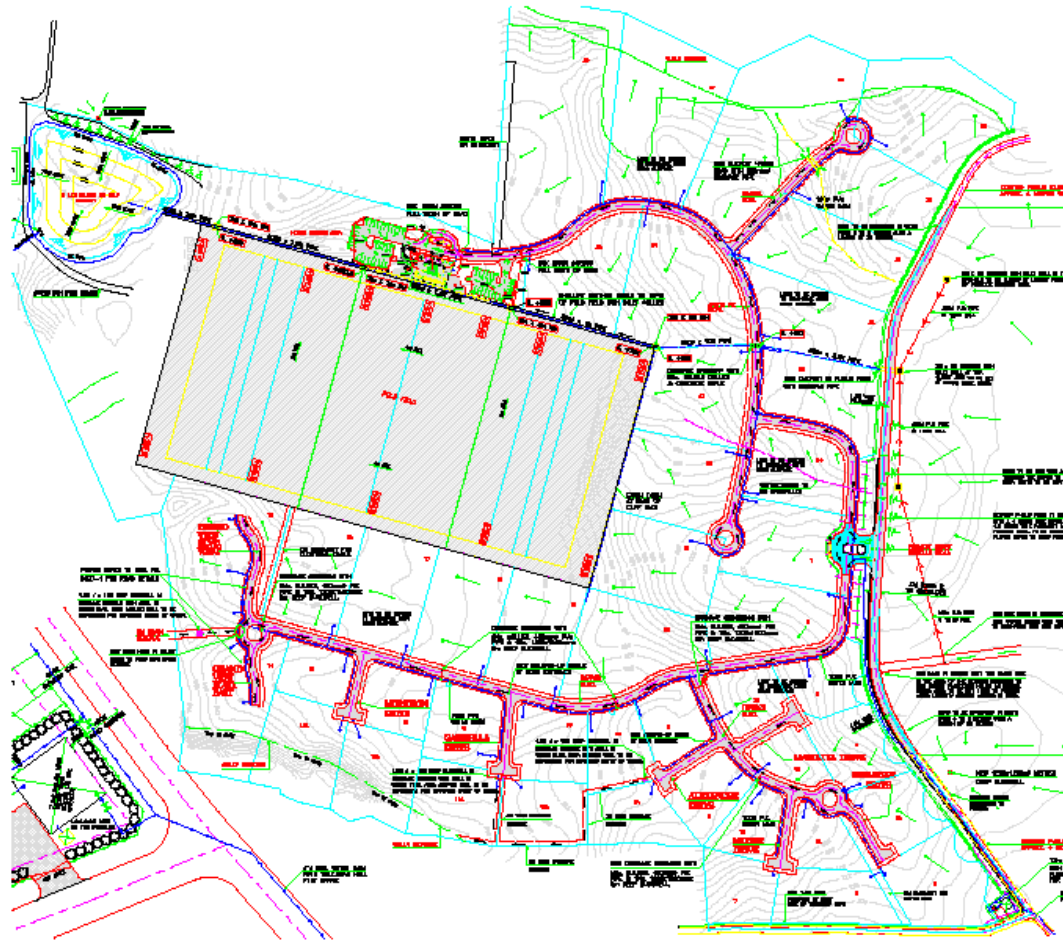


Commercial RWH – Case Studies from Barbados Lion Castle Polo Estate, St. Thomas

- 64 Acres Residential 2003 Sub-division + Polo Field.
- Required non-potable water for irrigation of 12 acre polo field Jan – May.
- Existing Sinkhole converted to 6.0 M gal. lined pond with overflow to Suck Well.
- Harvested Watershed ~ 40 Acres = polo field + roads + paddock + home sites.



Commercial RWH – Case Studies from Barbados Lion Castle Polo Estate, St. Thomas



Commercial RWH – Case Studies from Barbados Mount Gay Distilleries, St. Lucy

- Rum Ageing & Blending Facility on 12 acre site.
- Completed 2005
- Four buildings + paved areas
- Existing Sinkhole converted to 3.0 MG. lined pond for irrigation + fire fighting reserve.
- Overflow to Suck Well.
- Exceeds TCDPO rain water storage requirements.



Commercial RWH – Case Studies from Barbados

Farmers Water Impoundment, St. Thomas

- 220m L Dam; crest +250m, Invert +243m, TWL +248m
- Watershed area 246 acres.
- 68 M gal. pond; flooded area 15 acres.
- Overflow 5m x 5m + 2.4m x 2.4m outlet culvert.
- Pump capacity 1.0 MGD via 1.3 miles of 250mm pipe to Apes Hill to irrigate 18 hole golf course.
- Completed May 2006.



Commercial RWH – Case Studies from Barbados Farmers Impoundment – Before Construction



Commercial RWH – Case Studies from Barbados Farmers Impoundment – After Construction



Commercial RWH – Case Studies from Barbados Kensington Cricket Oval, St. Michael

- Cricket Stadium since 1895
- Reconstructed for CWC2007
- Integrated Drainage & Irrigation Solution.
- Watershed ~ 7.5 acres.
- Field + Roofs drainage in perimeter “French Drain” with 230 Storm Chambers in 418m L x 3.0m W x 1.5m D trench.
- On site ground water well provides brackish water for irrigation.



Commercial RWH – Case Studies from Barbados

Other Projects in Progress

- River Plantation – 500 acres, irrigation/drainage control for farming.
- Lancaster Golf Course – irrigation + water reuse.
- Lears Impoundment – irrigation/drainage control.
- Industrial Facilities – non potable water uses.
- Development of East Coast Watersheds – non potable for farming use etc.



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Unused East Coast Watersheds – More Water

- Haggatts, St. Andrew ~ 3,469 acres
- Joes River Plantation, St. Joseph ~ 1,015 acres
- Greenland, St. Andrew ~ 1,110 acres
- **Turners Hall/Swan's, St. Andrew ~ 1280 acres**
- **Bawden's North, St Andrew ~ 356 acres**
- All East Coast Watersheds, high rainfall areas in Scotland District area – impermeable clay & shales, high runoff.

POLICY INITIATIVE: Initiate planning for development of East Coast Watersheds; farming benefits; water augmentation.

Commercial RWH – Case Studies from Barbados

Water Conservation Measures ??

- Reduce WC Cistern Leakage ~ 7.5 MGD (save 17.8%)
- Reduce “Unaccounted for Water” from 55% to 35% - (Save 8.0 M USGPD or 19% of current daily pump rate)
- Update Operations - flow controls systems at pump stations.
- Establish National Pressure Zones – hydraulic model.
- Tariff Review - implement water tariffs that reward conservation.
- Reward Rain Water Harvesting - for secondary use, toilet flushing, landscape irrigation, gardening, pools etc..

POLICY INITIATIVE: Mandatory retrofitting of flapper valves on American water toilets + fiscal incentives for rain water harvesting.

Commercial RWH – Case Studies from Barbados

Recommended Regulatory Policy Initiatives

- FTC - Set targets to reduce “UFW” 62% to 35% - save 8M USGPD.
- FTC – Accountability for reliability of meters in system,
- Provide incentives for Low Flow water use fixtures and retrofitting of Toilet Cisterns Valves, save ~ 7.5M USGPD.
- Implement Water Tariffs that Reward Conservation,
- Incentives for RWH – for all non potable uses + mandatory commercial toilet flushing ~ 4M USGPD.
- Fiscal Incentives for development of East Coast Watersheds – farming benefits, water augmentation, etc..
- Public Education – leak management, conservation, RWH.

Commercial RWH – Case Studies from Barbados
Who will rescue our Civilization ?

*“The person that solves the water problem
deserves **two Nobel Prizes** for their
contribution to improved health and food
production”*

By John F. Kennedy

This is still true in 2014 – 50 years later

Commercial RWH – Case Studies from Barbados

The Engineer's Responsibility

“Engineers must use their knowledge of Mathematics and Natural Sciences to develop ways to **Economically** utilize with **Judgment** the **Materials** and **Forces of Nature** for the **Benefit of Mankind.**”

Commercial RWH – Case Studies from Barbados Expand Rain Water Harvesting for Non Potable Uses



THANK YOU FOR LISTENING

QUESTIONS ?