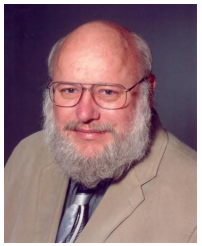
Robert Pitt, P.E., Ph.D., D.WRE



- Dr. Pitt is a professor in the Department of Civil and Environmental Engineering and the University of Alabama.
- Dr. Pitt specializes in the hydrology and water quality aspects of urban runoff.
- His research interests include the transport and control of contaminants in surface waters, the interaction between surface waters and groundwaters, and chemical behavior in contaminated stream sediments.

- Prior to his 24 years of teaching at UAB and UA, he spent 15 years as a senior engineer in industry and government.
- He was the Co-PI for WERF's *Innovative Metals Removal Technologies for Urban Stormwater* and was a project team member for WERF's project on *Benchmarking Decision Criteria for Urban Wet Weather Abatement*.

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Stormwater Non-Potable Uses and Impacts on Urban Infrastructure

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Long History of Stormwater Beneficial Uses (example from 7th Century B.C., Kamiros, Rhodes)

Cistern tank at temple

Temple and cistern at top of hill

Jug-filling area next to cistern

3

Objectives

- Study US and international practices of beneficial uses of urban stormwater runoff;
- Illustrate the range of technologies being used in developing and in developed countries;
- Identify different components of stormwater systems, treatment and recycling systems;
- Review possible uses of the harvested runoff for US conditions.

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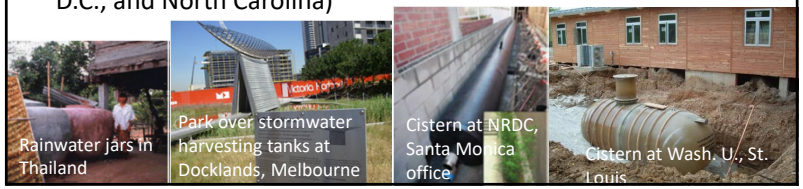
Representative Case Studies of Stormwater Beneficial Use Examined

- Asia (Singapore, Japan, Thailand, Indonesia, Philippines, Bangladesh, China, South Korea, and India)
- Africa (South Africa, Kenya, and Tanzania)
- Europe (Germany and Ireland)
- Australia (South Australia, Queensland, Victoria, and New South Wales)
- North America (US Virgin Islands, Florida, Hawaii, Washington, New York, Maryland, California, Missouri, Oregon, Washington, D.C., and North Carolina)



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		Treatment Method				Reuse Purpose			
		Sediment trap/sand filtration	Chlorination	Advanced Treatment	UV Disinfection	Irrigation	Toilet flushing	Fire fighting	Air conditioning
Washington	**Seattle, King Street Center**	✓	✓			✓	✓		
New York	**Battery Park City; Solaire**	✓	✓			✓	✓		✓
Maryland	**Annapolis; Philip Merrill Building**	✓	✓			✓	✓	✓	
California	**Santa Monica; SMURFF**			✓	✓	✓			

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Heavily Urbanized Developing Countries In Water Stressed Areas

- Most concerned with harvesting as much runoff as possible, with minimal concern related to water quality.
- Not only is roof runoff harvested, but also runoff from all urban areas, as maximum volumes are needed to augment the poor quality and poorly available local sources.
- The water is stored in large ponds, or injected to shallow aquifers. These improve the water quality to some extent, greatly depending on the storage conditions.

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Developing Countries with Large Rural Populations

- Most of the runoff harvesting schemes focus on collecting roof runoff for storage in tanks near homes.
- The water is used for all domestic purposes and for irrigation of food subsistence crops during dry weather.
- The storage tanks are therefore relatively large to provide seasonal storage.

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Developed Countries with Large Urban Populations in Water Stressed Areas

- In most cases, the runoff is collected from roofs and stored in large tanks adjacent to buildings where the water is used for non-potable uses.
- In some rural cases, the water is used for all domestic water uses. In large development water harvesting projects, runoff is collected from all areas and undergoes some pretreatment before storage in large (usually underground) storage tanks.
- The water then undergoes very sophisticated water treatment before use. In many cases, this highly treated harvested runoff is still restricted to non-potable uses.

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Example Regulations for Stormwater Beneficial Uses

		Coliform Bacteria	Chlorine	Turbidity
WHO	Roof water harvesting	*E. coli.* <10 cfu/100 mL	>0.2 and <5 mg/L	Not relevant
	Surface Runoff	*E. coli.*<10 cfu/100 mL	>0.2 and <5 mg/L	<15 NTU
New South Wales (Australia)	Non-potable residential uses	<1 cfu/100 mL	1 mg/L Cl_2 residual after 30 minutes	≤ 2 NTU
	Public access public uses	<10 cfu/100 mL	1 mg/L Cl_2 residual after 30 minutes,	≤ 2 NTU

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Current Stormwater Beneficial Uses in the U.S.

- Many of the U.S. stormwater harvesting projects are either part of a LEED® certified project, and/or to help reduce stormwater discharges to combined sewer systems.
- The collected water is not used for potable uses, but mostly for irrigation uses, and sometimes for toilet flushing or for fire suppression.

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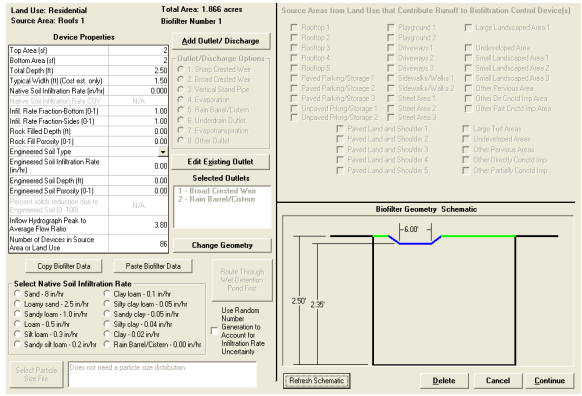
Continuous Simulations using Long-Term Rain Records to Develop Performance Curves for Roof Runoff Storage in Tanks for Later Irrigation

Calculation of irrigation opportunities of landscaping around the homes using WinSLAMM. The following is a typical input screen for a water tank (this example screen is for a 35 gallon rain barrel).



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Comparison of East Coast vs. Central US Roof Runoff Harvesting Potential for Medium Density Residential Areas (about 17% roof areas and 60% landscaping areas)

Region	annual rain fall (in)	maximum roof runoff control (%)	storage tank size for max roof runoff control (ft^3 storage/ft^2 roof area)
Central	33.5	90.6	0.72
East Coast	53.0	60.1	2.00

✓The Central US area has a higher potential level of control compared to the East Coast because the evapotranspiration (ET) demands better match the rain fall pattern.

✓The Southwest U.S. area is challenging due to large mismatches in timing of ET/irrigation requirements and availability of rains (would need very large tanks for long-term storage).

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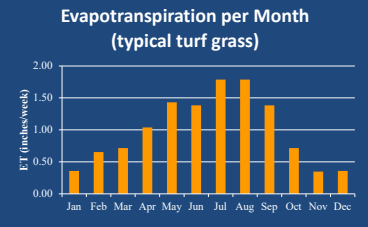
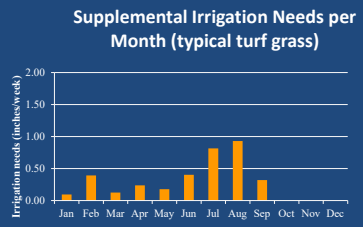
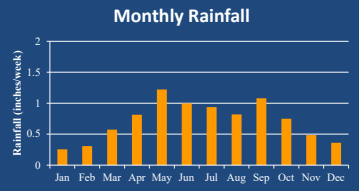
Kansas City Green Infrastructure Demonstration Project: Calculations of Water Harvesting Potential of Roof Runoff







Irrigation needs for the landscaped areas surrounding the homes were calculated by subtracting long-term monthly rainfall from the regional evapotranspiration demands for turf grass.

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The expected per household water use (gallons/day) from cisterns for toilet flushing and outside irrigation (ET deficit only) for the Kansas City study area (6 homes per acre) is:

January	113 gal/day/house	July	428
February	243	August	479
March	126	September	211
April	175	October	71
May	149	November	71
June	248	December	71

Examples of water harvesting storage tanks in New Zealand and Australia (where they are experts in modern roof runoff harvesting):

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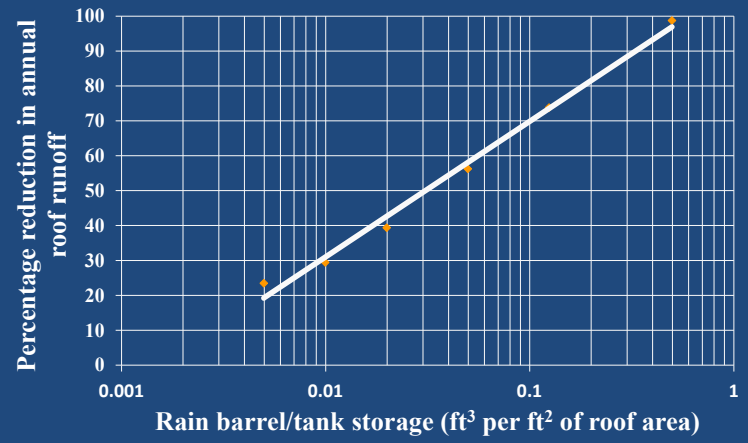
Reductions in Annual Flow Quantity from Directly Connected Roofs with the use of Rain Barrels and Water Tanks (Kansas City CSO Study Area)



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Cistern/Storage Tank Sizing vs. Performance

Storage per house (ft^3 per ft^2 of roof area)	Reduction in annual roof runoff (%)	Number of 35 gallon rain barrels for 945 ft^2 roof	Tank height size required if 5 ft D (ft)	Tank height size required if 10 ft D (ft)
0.005	24	1	0.24	0.060
0.010	29	2	0.45	0.12
0.020	39	4	0.96	0.24
0.050	56	10	2.4	0.60
0.12	74	25	6.0	1.5
0.50	99	100	24	6.0

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Millburn, NJ

Dry well disposal of stormwater for groundwater recharge in conjunction with irrigation beneficial use

- For the past several years, the city of Millburn has required dry wells to infiltrate increased flows from newly developed areas.
- There are some underground water storage tanks now being installed to use stormwater for irrigation.
- Project supported by the U.S. EPA is investigating performance of this shallow groundwater recharge, including groundwater contamination potential, in conjunction with irrigation beneficial uses of the stormwater.

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This major home restoration project included the installation of underground water storage tanks instead of dry wells. Homes in this neighborhood have summer water bills approaching $1k/month for landscape irrigation, so the economic benefits of irrigation using stormwater are very good.

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Conclusions

- The range of approaches being used for stormwater beneficial uses is vast, ranging from:
  - capturing any available runoff possible to augment scarce local supplies,
  - To conserve already abundant water supplies.
- The methods used for storage and treatment vary greatly, from local clay jars to vast underground reservoirs.
- The uses of the harvested runoff also vary from irrigation and toilet flushing only, to all domestic water uses.

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Conclusions (cont.)

- The safest beneficial uses of stormwater are mainly for purposes having low potentials for human contact, such as irrigation.
- Treatment varies from virtually none to very sophisticated water treatment systems
- Beneficial uses of stormwater are not effectively regulated at this time (most reuse regulations are based on beneficial uses of treated sanitary wastewaters, for example).
- Given the potential for beneficial uses of stormwater in many areas of the U.S., higher priority should be given to development of specific guidelines.

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Acknowledgments

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