Watearth, Inc. Presents: Engineered Rainwater Collection and Case Studies for Sustainable Water Management

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Course Instructor

• Jennifer J. Walker, P.E., D.WRE, CFM
  – President, Watearth, Inc.
  – jwalker@watearth.com
  – 832.444.0663
  – www.watearth.com
Chat with Attendees

• What Part of Country Are You in?
• How Do You or Your Clients Use or Plan to Use Harvested Rainwater?

Average Monthly Precipitation

- Dallas-Ft. Worth - 35 in
- Houston - 47 in
- San Antonio - 33 in
- Austin - 34 in
- Longview - 49 in
Topics

• **Residential Case Studies: Small-Scale Cistern Applications**
• **Commercial Case Studies: Larger-Scale Applications**
• **Park/Public Land Case Studies: Cisterns on Public Lands**

Topics

• **Site Layout, Selection, and Sizing: Locating and Selecting Cisterns Materials and Sizes**
• **Practical Advice and Recommendations: Design and Construction Tips**
Growing Vine Street

• Seattle’s Belltown Neighborhood
• Neighborhood and Artistic Response to Gentrification
• Green Street Project
• Annual Rainfall = 36”

Growing Vine Street

• 2,100 gallon Painted Aluminum and Stainless Steel Tank
• Used for Local Landscaping
• Overflow Cascades Through Rock Filter Pools and Discharges to City’s Storm Sewer System
• Downspout is “Vertical Garden” Sculpture
Urban Organic Farming

- Minimal Irrigation for Perennials
- Partial Irrigation for Fruit Trees
- Full Irrigation for Vegetables
- Demand Varies Seasonally
- Average Demand = 3,300 gallons/month
Location Options
Available Footprint

- Maximum Height = 6 ft
- Maximum Diameter = 8 ft
- Maximum Storage = 5,000 gallons
  - Two 2,500 gallon Cisterns
- Evaluate Multiple Scenarios with 2,500 gallons and 5,000 gallons
Basic Calculations

• 600 gal/1,000 ft² Roof/ in Rain
• Average Annual Rainfall = 48 in.
• Average Annual Landscape Demand = 40,000 gal.
  − 3,300 gal/month
• 1,935 ft² Roof Catchment Area

• 1,935 ft² Roof Meets Average Annual Landscape Demand of in Average Rainfall Year
  − 600 x 48 x 1,935/1,000 = 55,728 gal
  − 41,800 gal @ 75% Efficiency
• 50% of Roof is Not Adequate
How Much Can You Collect?

- **Houston** = 29 gal/ft²/yr
  - 43,500 gallons on 1,500 ft² home
- **Seattle** = 21 gal/ft²/yr
  - 31,500 gallons on 1,500 ft² home
- **Anchorage** = 10 gal/ft²/yr
  - 15,000 gallons on 1,500 ft² home

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**Average Monthly Precipitation**

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Monthly Water Balance Calculations

- Used Average Rainfall Each Month
- Used Median Rainfall Each Month
- Used Average Monthly Irrigation
- Used Actual Historical Monthly Irrigation

Results

- Results Vary for 1 vs. 2 Cisterns
- System Efficiency Affects Results Significantly, Depending on Scenario
- Maximize Gutter Capacity for Intense Rainfall Events
  - Oversized with Low Headloss
Median Rainfall + Avg. Irrigation

- Cisterns remained empty or < 1/2 full during entire year until efficiency increased to 85%
- Rainfall inadequate to fill cistern throughout year regardless of size
- Efficiency/Gutter capacity important

Avg. Rainfall + Avg. Irrigation

- Cistern(s) held significant volume once filled early in year
- Efficiency more important for 5,000 gal. than 2,500 gal. cistern
- 2nd tank only utilized if gutter capacity adequate
  - 85% efficiency required to fill 2nd tank
Avg. Rainfall + Actual Irrigation

- Stored Significant Volume Through Year
- Efficiency, Gutters, and Tank Capacity Did Not Affect Results Significantly
- Low/Consistent Irrigation Demand
  - Spike in Demand for 3 Months
- Met Monthly Irrigation Demand
  - Except 13,000 gal Demand in August

5,000 Gal. Cistern @ 75% Efficiency

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<th>Month</th>
<th>Monthly Use (gal/mo)</th>
<th>Average Rain (in)</th>
<th>Rainfall Volume (gallons)</th>
<th>End of Mo. Storage (gallons)</th>
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<th>Rainfall Collected (gallons)</th>
<th>End of Mo. 25 (gallons)</th>
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Totals 47.31 42,797 40.40 36,546
Median Rainfall + Actual Irrigation

- System Performed Similarly to Average Rainfall + Actual Irrigation

Additional Considerations

- Rainwater Typically Underutilized in Southeastern U.S.
- Economical to Install Entire System
- Served by City Water Supply
  - Quality may Decrease with Conversion to Surface Water
- Option to Add Second Tank Later
Additional Considerations

- Consider Drought & Climate Change
- Second Tank = Back-Up Supply
  - Hurricane
  - Climate Change: Drought
  - Factor of Safety for Failure
  - Allows “Off-line Tank” to Perform Cleaning and Repairs

Additional Considerations

- Second Tank May Be Less Utilized than First Tank
  - Smaller Incremental Economic Benefit
- Irrigation Demand May Be Higher than Estimated, Since Based on Water Bills + Description of Use
Additional Modeling Options

- Model Historical Monthly Rainfall Data During Time-Frame Covered by Water Bills
- Perform Multi-Year Simulation

Other Sizing Options

- Popular Sizing for Professional Installers is to Meet Quarterly Demand without Rain
- Tends to Oversize System
- Size = 3,300 gal/month x 3 = 9,900 gal vs. 2,500 gal!
Discussion Question?

- Is Rainwater Harvesting Capacity Recognized as Detention Storage in Your Region?
Rainwater Collection for Flood Control

Flood Control + Water Supply

• 900 ft\(^2\) Roof Catchment Area
  – 50\% of Roof
• Size for Design Storm Event or Desired Level of Protection
• Gutters + Cistern
  – 80\% Efficiency
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<th>80% Runoff Volume (gal)</th>
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**Flood Control + Water Supply**

- **Operate for Flood Control + Water Supply for Landscape Irrigation**
- **Yields 21,000 gal/yr**
- **Adequate Supply for Backyard**
- **Combine with Swale to Rain Garden or Gully**
HEB Pantry - Austin

• Storage Capacity = 28,200 gallons
• Two 8,225 gallon and Two 5,875 gallon Welded Steel Tanks
• Used with Automated Sprinklers to Irrigate Landscape Areas
• Overflow into Storm Sewer
• Annual Rainfall = 32”

HEB Pantry - Austin

• Rainwater from Parking Lot Filtered Through Re-Irrigation Pond
• Vegetation Removes Pollutants Prior to Reuse
• Excess Stormwater Drains to City System
• Located at 6900 Brodie Lane
24” Supply Line

Roof Area and Connected Tanks

6” PVC Pipes & Valves

50,000 ft² Roof
Other Opportunities

- Turn Parking Medians into Depressed Bioretention (Rain Gardens)
- Rain Gardens Behind Cisterns
- Permeable Pavement
- Use Rainwater for Toilet Flushing
Commercial Vehicle Washing

- Average Monthly Use = 62,000 gallons
- Inadequate Roof Area to Meet Demand
  - Requests maximum storage at minimum cost
- Monthly Water Balance Calculations
- Tank empty at end of every month
  - Assume entire volume available for detention credit

<table>
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<tr>
<th>Size (gallons)</th>
<th>Collected Volume (gal)</th>
<th>Incremental Volume (gal)</th>
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<td>35,000</td>
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The Presidio Army Base
Monterey, CA

• New Design Uses Rainwater Harvesting for Toilet Flushing
• 50 Buildings/Barracks with High Occupancy

Photo Source: http://www.monterey.army.mil

The Presidio

• Required by City to Harvest Rainwater
• Potable Water as Back-Up Supply Bypasses Cisterns
• Irrigation Demand Not Adequate for Volume Captured
The Presidio

- **Average Annual Rainfall = 20 in.**
- **Average Annual Collection**
  - $600 \text{ gal/1,000 ft}^2 \times 20 \text{ in} =$
  - $12,000 \text{ gal/1,000 ft}^2$
  - $10,800 \text{ gal @ 90% Efficiency}$
  - $32,400 \text{ gal/yr for 3,000 ft}^2$
The Presidio

- **Ultra Low Flow Toilets (ULFT)**
  - 1.6 gal/flush
  - 6 flushes/occupant/day
  - 3,500 gal/yr/occupant
  - 35,000 gal/yr/100 occupants

Cascade People’s Center

- **Located at Cascade Adopt-A-Park in Seattle**
- **Site Includes Community Center, Gardens, and Park**
Cascade People’s Center

- Rainwater from Roof Flows into Storage Pond Below Pergola
- Includes Partially Buried Cistern
- Pumped into Small Tank for Gravity Feed Irrigation
- Filters Water and Supplies Water in Lake Union Watershed

Downspouts & First Flush Clean-Out
Cascade Gardens Water Collection

• 2,640 gallons of Storage
  - 48, 55-gallon rain barrels

• Filter Barrel with Sand and Charcoal and Limestone to Balance pH

• Runs Through Garden and Filtered by Vegetation

• Saves 26% of Potable Water Use
Lady Bird Johnson Wildflower Center

- Rainwater Harvesting System
- Demonstration Gardens
- Stormwater Management Facilities
- Pioneered Sustainable Sites Initiative for USGBC and LEED Green Buildings
- Extensive Database on Native North American Plants

Lady Bird Johnson

- Catchment Area = 17,000 ft²
- Cistern Capacity = 70,000 gallons
- Collects 300,000 gallons in Average Rainfall Year
- Supplies 10% to 15% Irrigation Needs
Entry Cistern

5,000 gallons

Aqueduct to Cistern

Collects Water from 1,200 ft² Roof
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NCSU – Dept. BAE

- Studied 3 Rainwater Harvesting Systems in North Carolina
- Annual Rainfall = 44"
- Found Systems Underutilized
  - Less Ability to Capture Runoff Volume
- Highest Use from Toilet Flushing
- Education Needed on Use of Captured Rainwater
Toilet Flushing

- Maintained Adequate Supply During Drought
- Dropped Below 80% Capacity Only Once in 30 months
- Added Irrigation Faucets to Increase Utilization

Vehicle Washing

- Harvested Rainwater Pumped to Vehicle Washing Station
- Used Infrequently
- Maintained 80% of Capacity
- Workers Used Pressure Washers with Municipal Supply
- Education Increased Utilization Slightly
Irrigation

- No Formal Irrigation Schedule
- Used for Hand Watering Only
- Located on Opposite Side of Building from Gardens Due to Aesthetics Concerns
- Municipal Water Connections Available

Irrigation

- Only 7 Major Uses in 30 Months
- Used Substantial Volumes
- Largest Depleted 70% of Capacity
- May Have Been Intentionally Drained
- Required Months to Refill due to First Flush Diverter
NCSU – Dept. BAE

- Found Rain Barrel Inadequate Storage
  - Even for Small Events
- Minimum Volume of 550 gallons for Southeastern U.S.
- Challenge is to Use Harvested Water

Zilker Botanical Gardens

- System Completed in 2005
- Roof Area = 5,000 ft² of Garden Center
- Funded by City of Austin Water Utility Water Conservation Programs
Zilker Park Botanical Gardens

- **Storage Capacity = 7,000 gallons**
  - Three Connected Tanks
  - 2,000 gallon Gray Fiberglass
  - Two 2,500 High Density Polyethylene Tanks
- **Collects 3,000 gallons from 1” of Rain**

Zilker Botanical Gardens

- **Gutters with Leaf Guards & PVC Pipe**
- **Electric Pump Used with Drip Irrigation**
  - Acid loving azaleas and ferns
- **Overflow to Water Garden & Ponds**
- **Includes Potable Water Attachment**
  - Backflow Preventer
Intakes, Overflows, and First Flush Filter

Austin Rainbarrels

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“Private” System

Inlet & Overflow
Downhill
Pump and Tank Connection

Site Layout, Selection, and Sizing

- Locating Cisterns
- Selecting Cistern Material
- Selecting Cistern Size

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Locating Cisterns

- Consider Gravity, but Pump Typically Required
- Consider Downspout Locations
- Consider Overflow Connection and Use
- Locate Underground Systems 50’+ Away From Septic Fields or Wastewater Application Area

Locating Cisterns

- Locate Close to Water Use
  - More Likely to Use Water
  - Reduce Pumping Costs and Head Loss
  - Automate System
- Consider Community Regulations, Deed Restrictions, or Homeowner’s Associations Rules
Locating Cisterns

- Locate in Area Easy to Grade Flat
- Water is 62.4 lb/ft³ or 8.3 lb/gal
- Map Underground Utilities
- Do Not Place Over Buried Pipes, Septic Tanks, or Drain Fields
- Maintain Separation Between Underground Cistern & Structures

Selecting Type of Cistern

- Anticipate Current and Future Water Needs
- Are Aesthetics a Concern?
- Size of Cistern
- Budget Constraints
- Time for Maintenance
- Consider Local Plumbing Codes
Selecting Cistern Size

• **Water Demand**
  - Landscape Area and Plants to be Watered
  - Other Calculated Demand
• **Type of Conveyance System**
• **Commitment to Using Harvested Water**

Selecting Cistern Size

• **Systems < 550 gallons are Less Efficient and Effective**
• **Smaller Cisterns Cost More per gallon**
• **3,000 gallons Irrigates Typical Landscape with 1” of Water**
Selecting Cistern Size

- **Space Available for Tanks**
  - Multiple Shapes and Sizes
- **Need for Back-Up Tank**
  - Use 2 Smaller Tanks

Rain Water H₂OGs
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Water Wall from Tank Town

Rain Tank Supplier/Installer: Construction EcoServices

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Selecting Cistern Size

- Water Balance Calculations, Analysis, or Modeling for Large Systems
  - May not capture all of runoff
  - Stop where incremental benefit declines

Practical Advice/Recommendations

- Think about existing drainage problems
- Plan ahead to use rainwater
- Place system in convenient and accessible location
- Knowledge of water usage imperative
Practical Advice/Recommendations

• Educate Users of System
• Consider Changes in Facility Use and Public Perception
• Incorporate Signage on Public Systems
• “Advertise” System for Commercial Systems
Practical Advise/Recommendations

• Consider On-Demand Pump to Eliminate Pressure Tank
• Check with Drip Irrigation Manufacturer for Sediment Filtration Requirements

Practical Advise/Recommendations

• Requires significant teamwork
  - Architect, MEP, civil, structural, LA, irrigation consultant
• View Introduction and Case Studies on DVD for system components
What About Permits?

Discussion Question?

• Do Non-Potable Uses Need Treatment?
• Does Irrigation Water Need Treatment?
• What About Toilet Flushing Water?
• Concerns About Pathogens and Bacteria?
Building Codes

• Ohio, Kentucky, Hawaii, Arizona, New Mexico, Washington, West Virginia, Texas, Portland, and U.S. Virgin Islands Have or Are Developing Rules

• Texas, Oregon, and Others Do Not Require Treatment for Non-Potable Use

References - Websites

• Lady Bird Johnson
  - www.wildflower.org

• Zilker Park Botanical Gardens
  - www.zilkergardens.org

• Growing Vine Street
  - www.inthefield.info/growing_vine_street.pdf

• Cascade People’s Center
  - wwwCASCADEPeoplescenter.org
References - Websites

- Texas A&M University
  - http://rainwaterharvesting.tamu.edu

- North Carolina State University
  Department of Biological and Agricultural Engineering
  - http://www.bae.ncsu.edu

References - Websites

- American Rainwater Catchment Systems Association
  - http://www.arcsa.org

References - Papers


References - Papers

Upcoming Webinars

- **Sustainable Water Management**
  Rainwater Collection Systems and Analysis
- **Stormwater BMPs:** What Works, What Doesn’t, and What About Maintenance

New Webinars

- **Fundamentals of Grey Water Systems for Sustainable and Integrated Water Management**
- **Engineered Rain Gardens and Bioretention Facilities for Sustainable Stormwater Management**
- **Sustainable Sites Stormwater Design and Water Efficiency Points for LEED Projects**
Follow-Up DVD

- Engineered Rainwater Collection
  - Lecture + Outdoor Site Evaluation
  - Self-Document 3.5 PDH
- 1 Free per Registered Site included with Registration

Engineered Rainwater DVD

- Name______________________________
- Company Name_____________________
- Address___________________________
- City, State, Zip_____________________
- Phone #___________________________
- Email Address_____________________
- Name on Credit Card________________
- Credit Card #_____________________
- Security Code_____________________
- Exp. Date_________________________

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Requests Must be Received by 3/22/2010 – Allow 2 to 4 Weeks to Process
DVD Ordering Information

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  – Use Offer: ASCE-Rain-2.3010 in Subject Line
• Watearth, Inc.
• P.O. Box 10194
• Houston, TX 77206-0194

Follow-Up Questions or Contact

• Jennifer J. Walker, P.E., D.WRE, CFM
  – President, Watearth, Inc.
  – jwalker@watearth.com
  – 832.444.0663
  – www.watearth.com