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Integrated Rainwater Harvesting

Using Weather Based Controls

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engineers | scientists | innovators

- Pre=Post Area for ET
- Depth of Storage for ET

Harvest and Use

Infiltration

- Soils
- Geotechnical
- Contamination
- Consequences of failed systems

Evaporation

- Demand high enough
- Irrigation use limited
- Competition with reclaimed/greywater use
- Sustainability/ Infrastructure

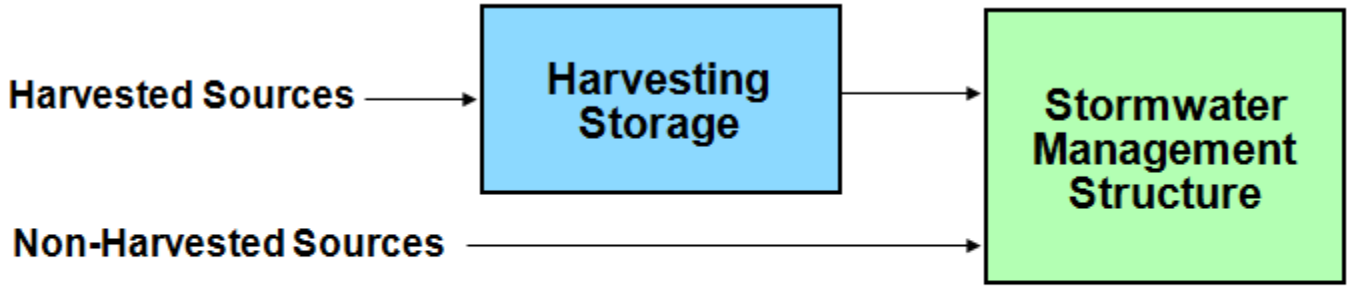
Capture and Use (Re-use)

- Key factors for conventional capture and use:
  - Having a use for the water: irrigation, toilet flushing, process water
  - Being able to use the water: Code issues/human health
  - Being able to use the water fast enough to recover storage (due to back-to-back storm events) so that subsequent storms are captured and overall capture meets goals
- Primary Benefits
  - Water conservation
  - Stormwater flow mitigation (CSO mitigation)
  - Public outreach and education

Rainwater Harvesting - Traditional

Harvesting Storage Inserted into Drainage Profile

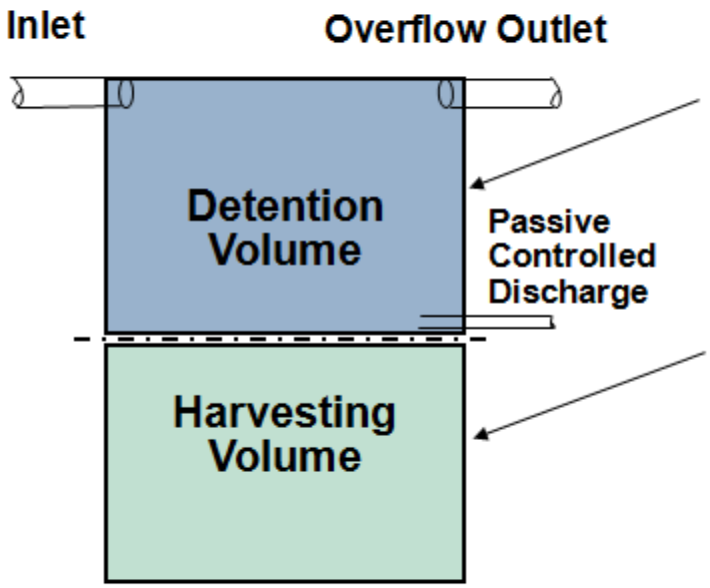
- "Bolt-On" Approach
- Harvesting Cost Fully Incremental
- Footprint and Profile Considerations



Rainwater Harvesting – Integrated / Passive

Integrating Detention Volume with Harvesting Volume – Cont.

Shared/Passive Storage Configuration



Detention volume and discharge determined by standard site stormwater analysis

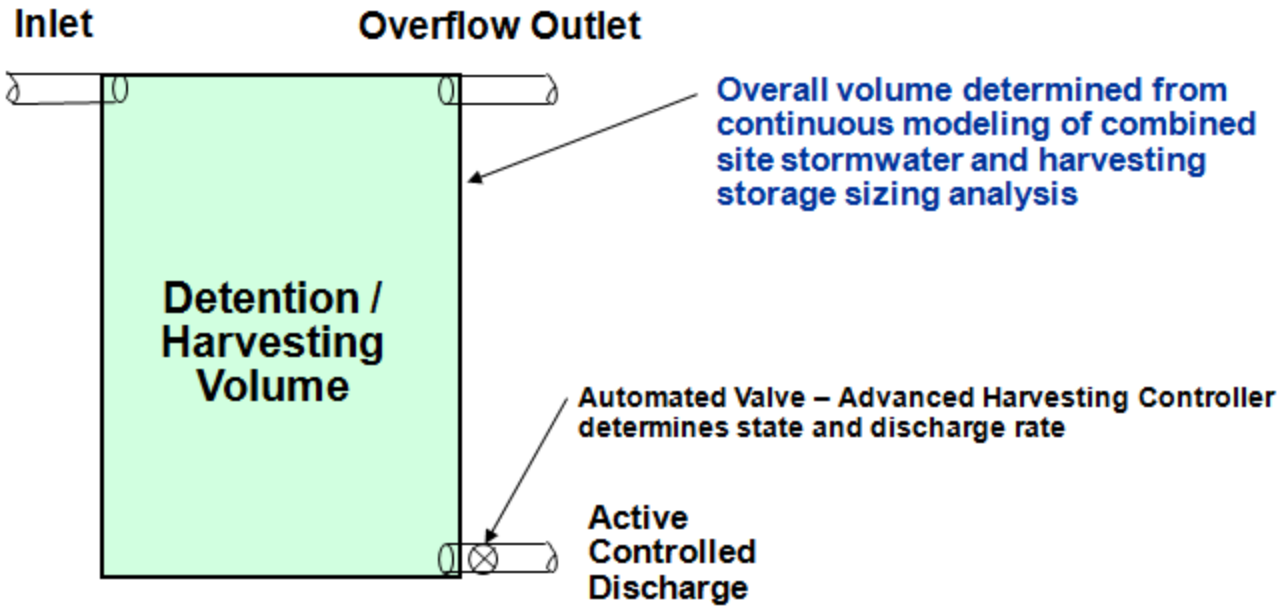
Harvested volume determined by WBA or Continuous Modeling

- Pros: Passive; Simple implementation
- Cons: No volume savings; unlikely foot-print reduction

Rainwater Harvesting – Integrated / Active

Integrating Detention Volume with Harvesting Volume – Cont.

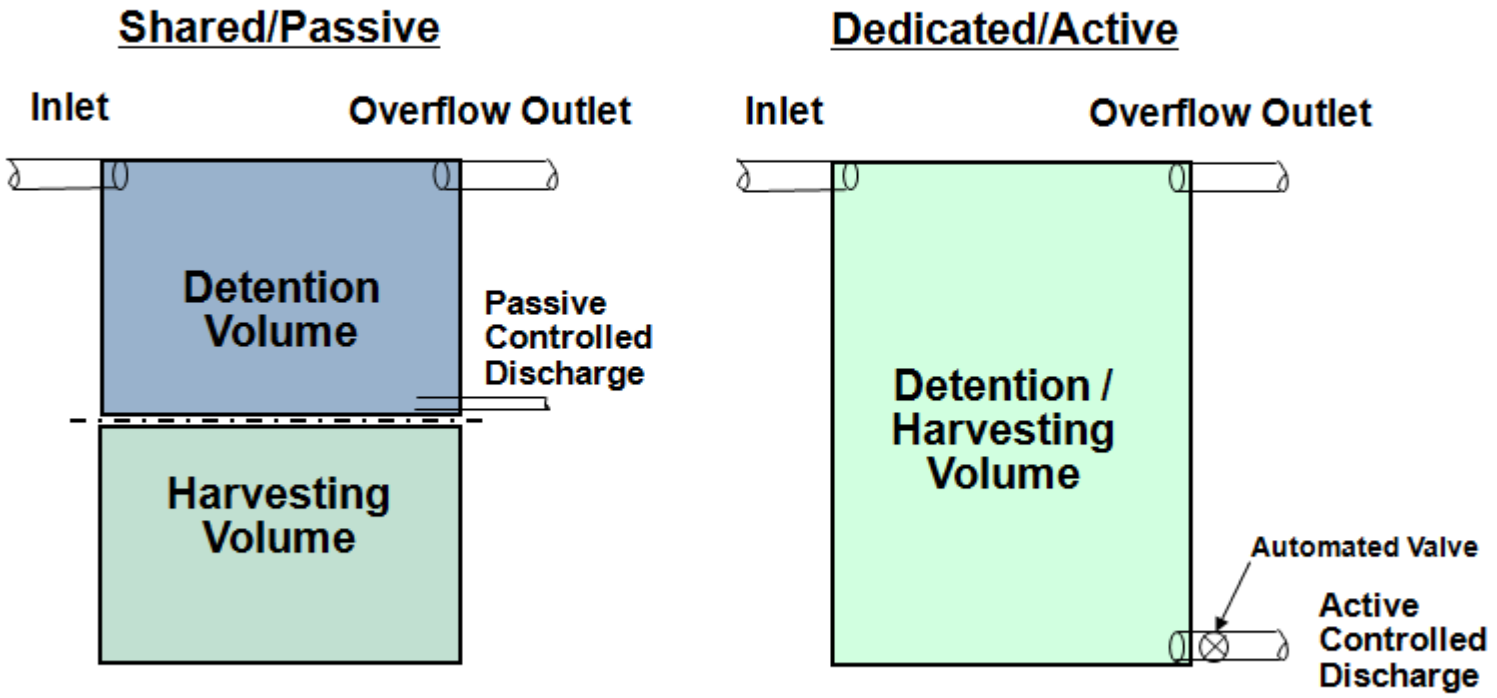
Dedicated/Active Storage Configuration



- Pros: Volume, footprint, cost savings
- Cons: Active controls, back-up power

Rainwater Harvesting - Integrated

Integrating Detention Volume with Harvesting Volume



Simple Definition

Providing storage in advance of predicted rainfall or other triggers.

Advanced Rainwater Harvesting

- Simple Definition:
  - Providing storage in advance of predicted rainfall or other trigger
- Explore Applications:
  - Ability to integrate detention and harvesting volume (maximize use of storage)
  - Provide runoff volume reduction
  - Provide wet weather flow reduction (CSO mitigation)

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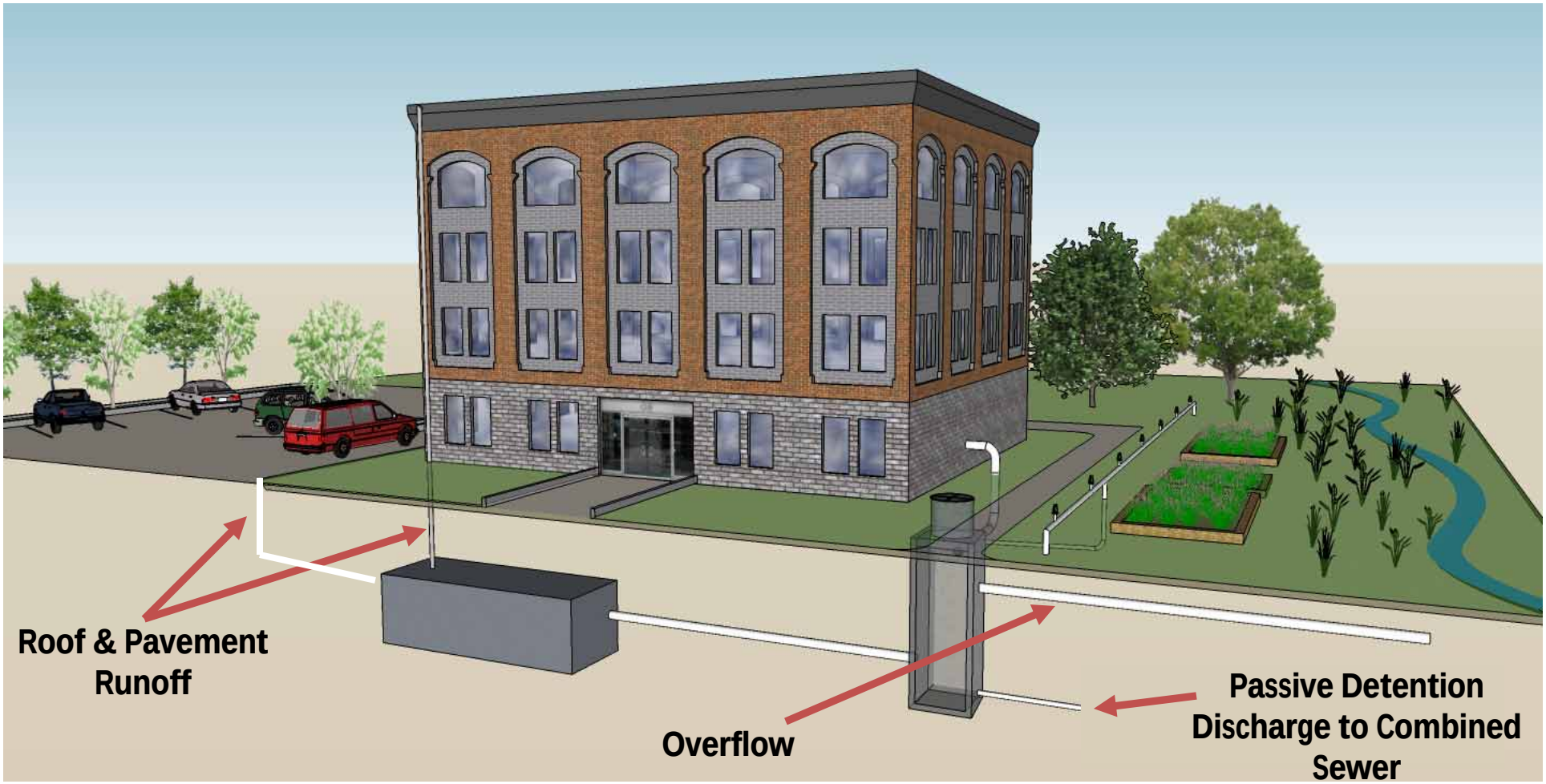
Conventional Underground Detention System



- Compulsory, distributed storage widespread
- Substantial aggregate discharges during storms

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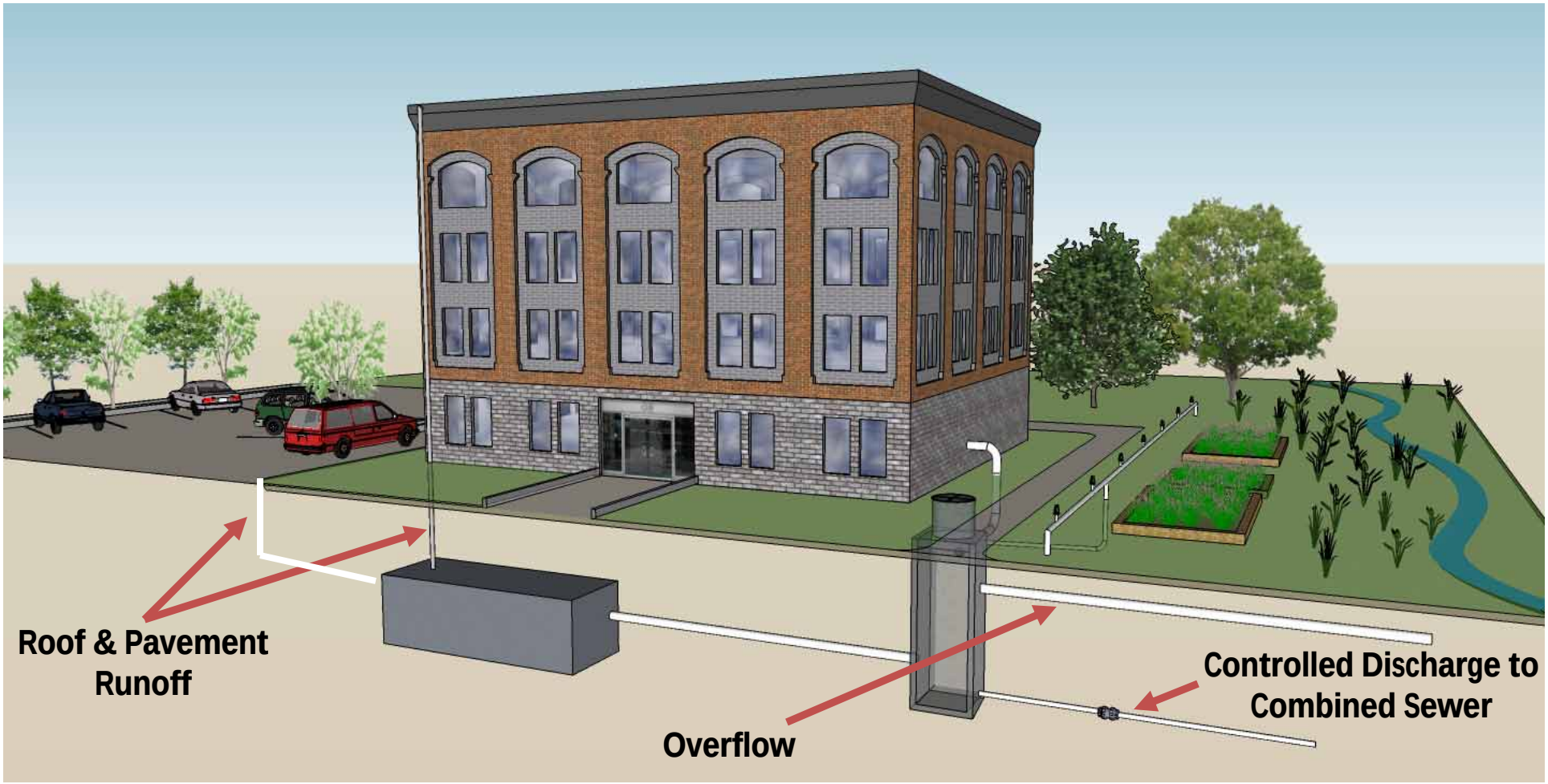
Forecast-Controlled Distributed Detention Systems



- Installed Cost $3 - $4 per gallon
- Cheaper, compelling retrofit opportunities

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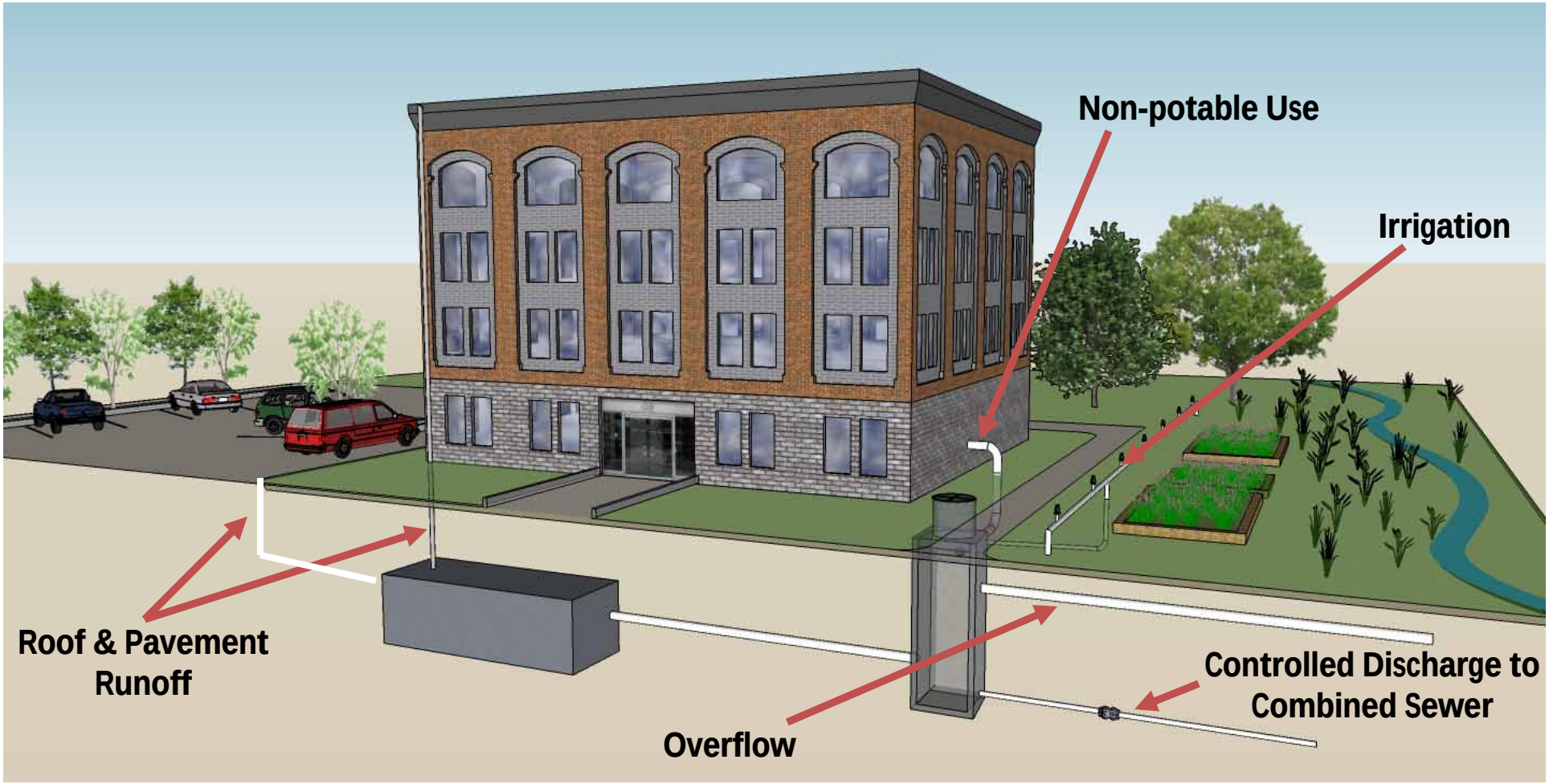
Intelligent Distributed Detention with Integrated Harvesting Systems



- Water savings benefit at low incremental cost
- Mitigates total flows to Combined Sewers

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Rainwater Harvesting Components

Pretreatment Options: Pavement

- Filterra System
  - Precast concrete
  - Small footprint
  - Filtration of bacteria, metals, nutrients, TSS
  - Vegetative uptake through plant
- Bioretention Cells
  - Infiltration, evapotranspiration, and SW storage
  - Reduce peak discharge & downstream flow rates
  - Physical, biological, chemical treatment through plants, soil, and mulch

Pretreatment Options: Roof Runoff

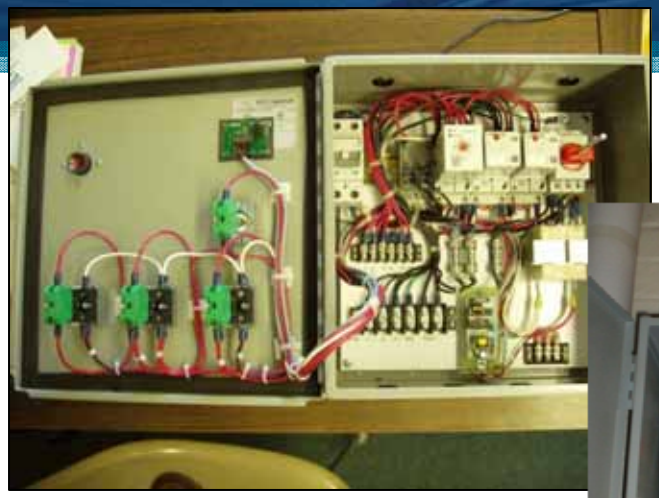
- Drain Line Filters
  - Designed for filtering collected roof runoff
  - Below ground installation
  - Fine filtration through removable filter
  - High water-collection efficiency: 90%
- Down Spout Filters
  - Designed for small roof areas
  - Inline filtration
  - Installed at each down spout

Cistern Types

- Cast-in-Place Concrete
- Pre-Cast Concrete
- Fiberglass Reinforced Plastic (FRP)
- Modular Plastic Vaults
- Plastic Tanks

Technology Developments
Controller Technology

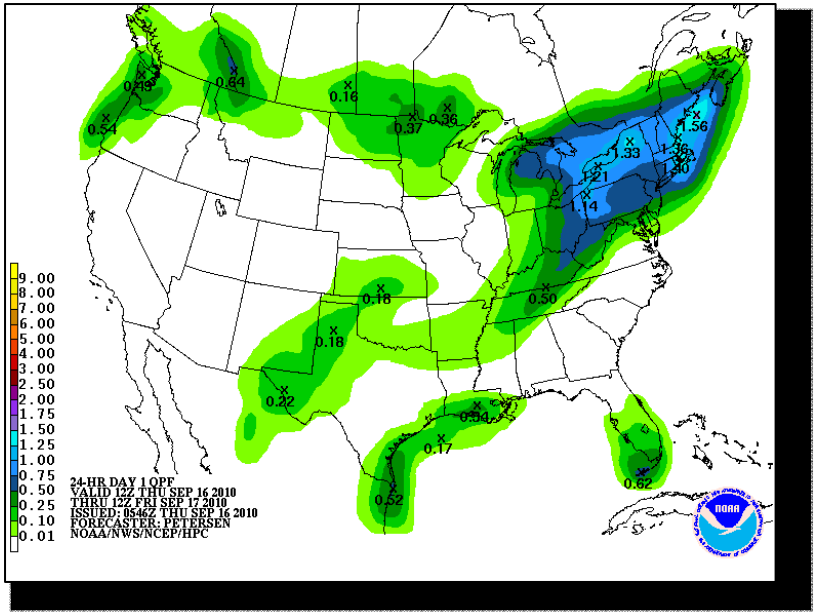
- Traditional Controls
  - Limited functionality
  - Abundant input and control relay devices
  - Size and form-factor issues



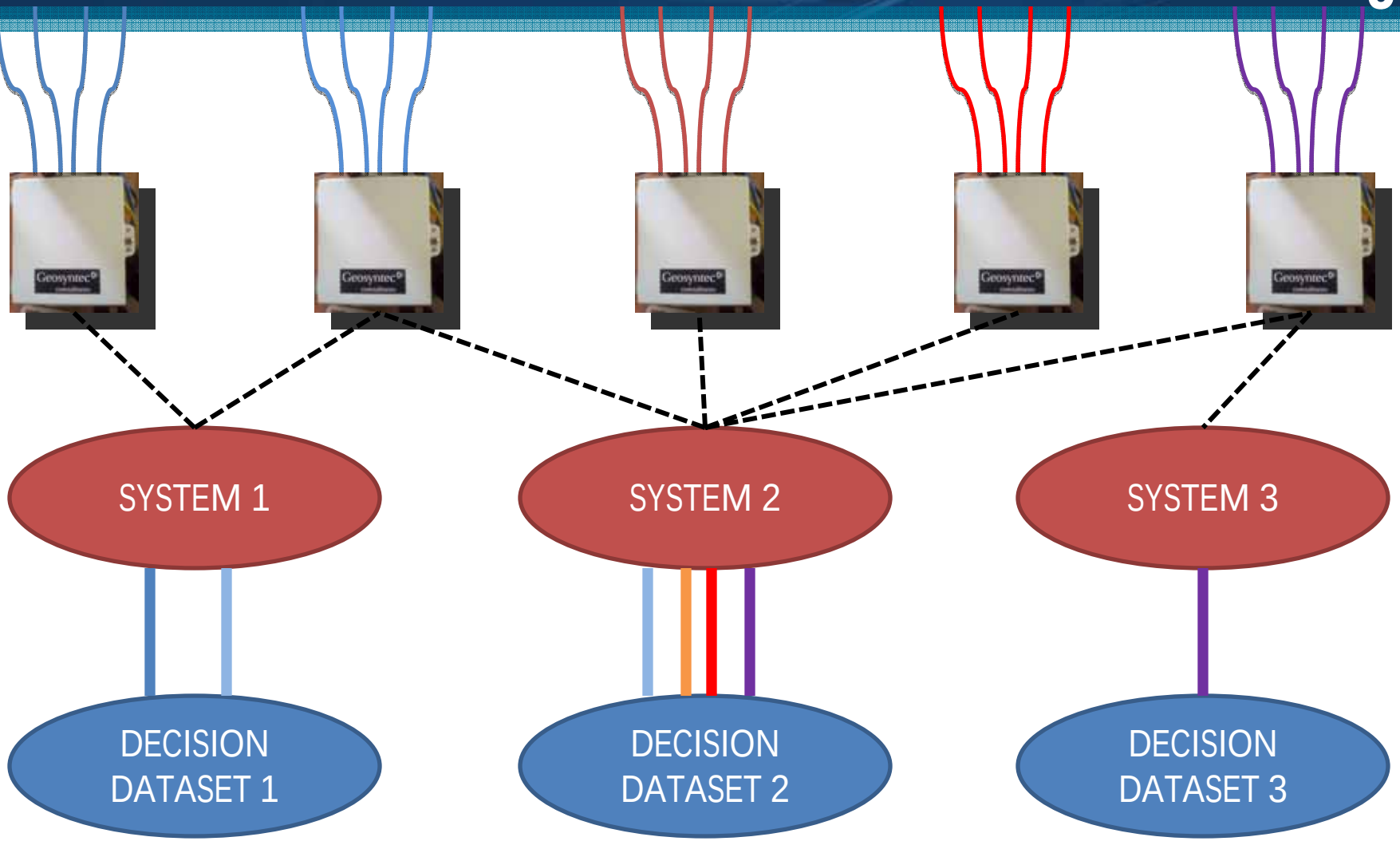
- Advanced RTC
  - Wide-ranging, customizable functionality
  - Access to web-based information streams
  - Integrate modeling software
  - Ubiquitous remote access and control

Advanced RTC Solutions

- Uses Internet feeds (e.g., NWS Quantitative Precipitation Forecasts and POP) and real-time sensors to control detention function of water storage
- Operate autonomously or as integrated system via server-side solution
- Web interfaces can be independent of server-side solution.



Possibilities in Integration and Decision-Making



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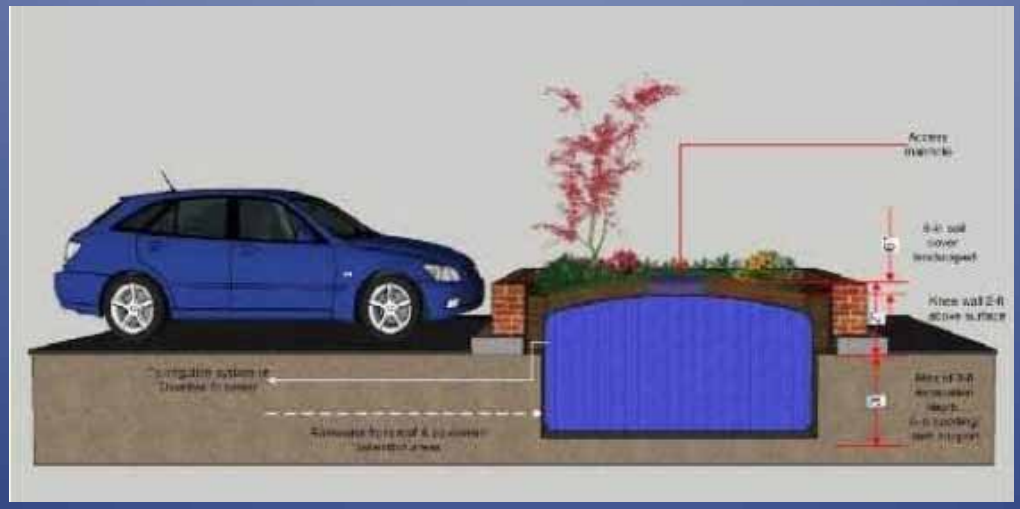
Case Study

Integrated Rainwater Harvesting: Design and Construction St. Louis, MO



Project Overview

- American Recovery and Reinvestment Act (ARRA) Funding
  - Solar Panel Installation (Sunwheel)
  - Rainwater Harvesting (Geosyntec)
- Rainwater Harvesting
  - Irrigation use & optimization
  - Irrigation retrofit at seven locations
  - Community rain gardens
  - $1.3 M (design & construction)
  - Annual water savings of over 34 M gal
  - Annual cost savings over $65 k

Project Overview

- St. Louis Housing Authority (SLHA)
  - Formed in 1939
  - 87 Employees
  - Operation budget: $60 M
  - Public Housing & Sec. 8 Voucher program
  - 18,000 clients

- McCormack Baron Salazar
  - Leading developer of economically integrated urban neighborhoods
  - 137 projects in 33 cities
  - Hope VI financing pioneer
  - Built 15,260 units
  - Services: Design &, development, finance, and management

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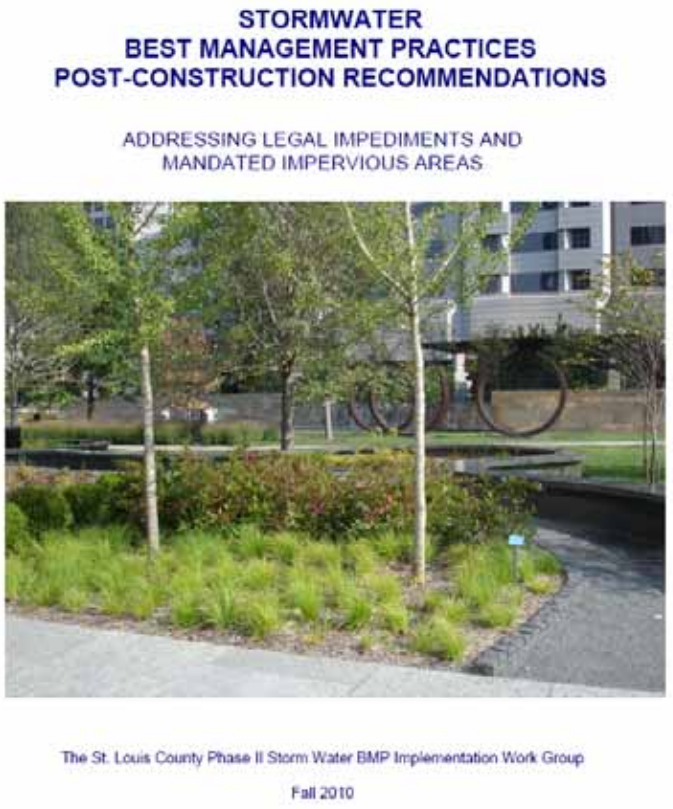
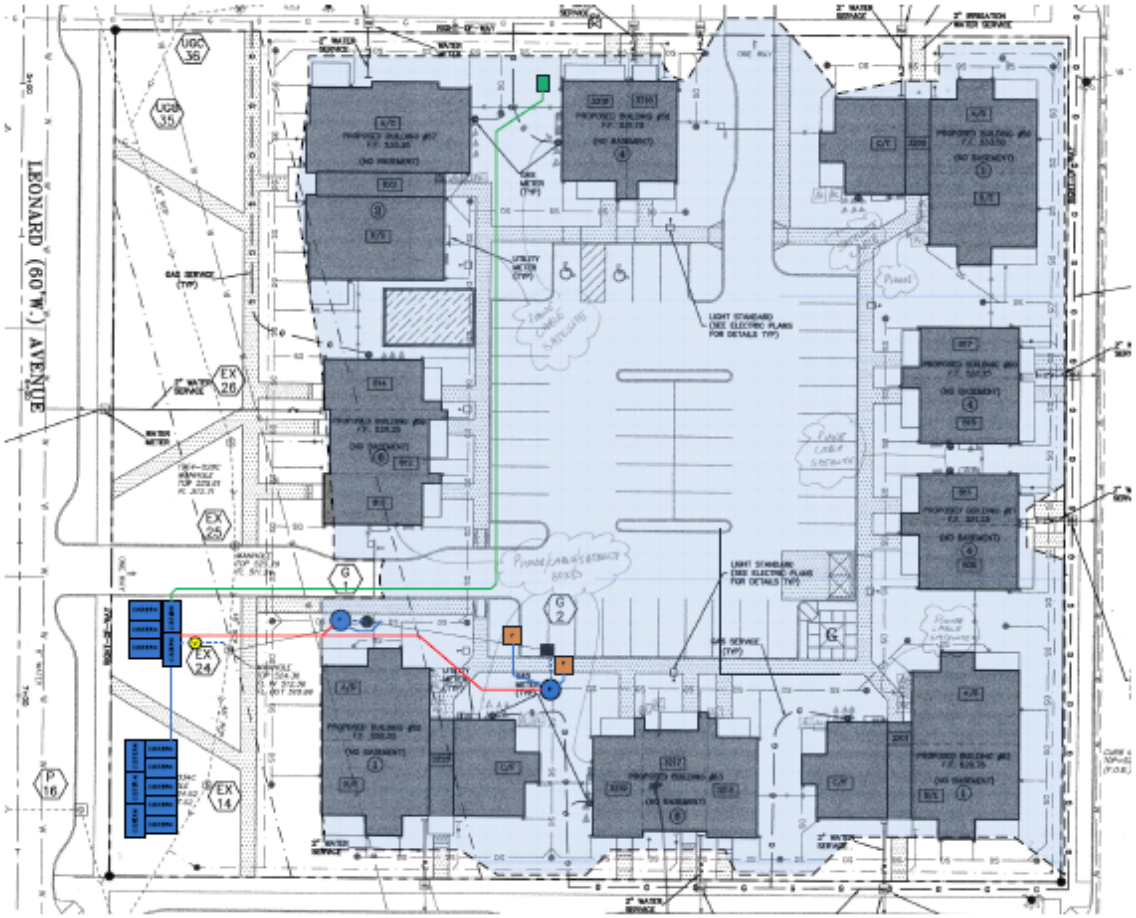
Rainwater Harvesting Site Locations

Geosyntec's Role

- Leading Innovator
  - Design Charrette
  - Advanced harvesting controllers
  - Irrigation evaluation & optimization
- Design Engineer
  - Final design & permits
  - St. Louis green demonstration project
- Construction management
  - Special waste permitting & disposal
  - Contractor coordination
- O&M training & manual preparation



Original Design Concept



- Minimized footprint
- Buried Tanks
- Located within open space
- Gravity feed system

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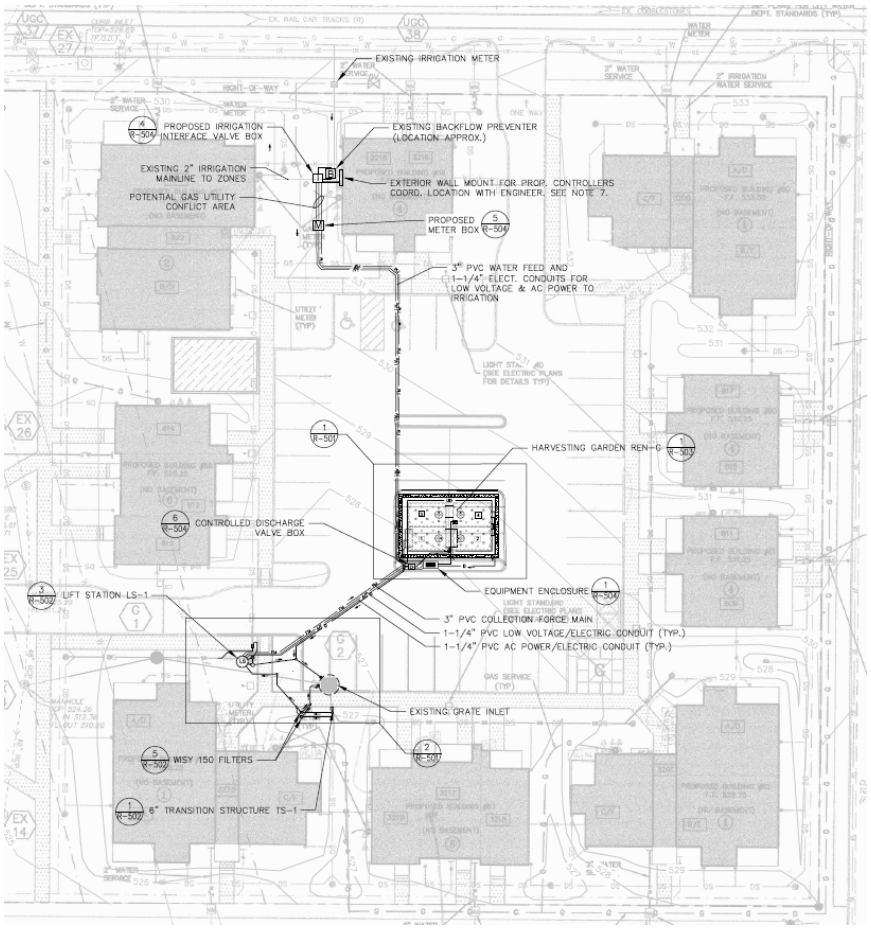
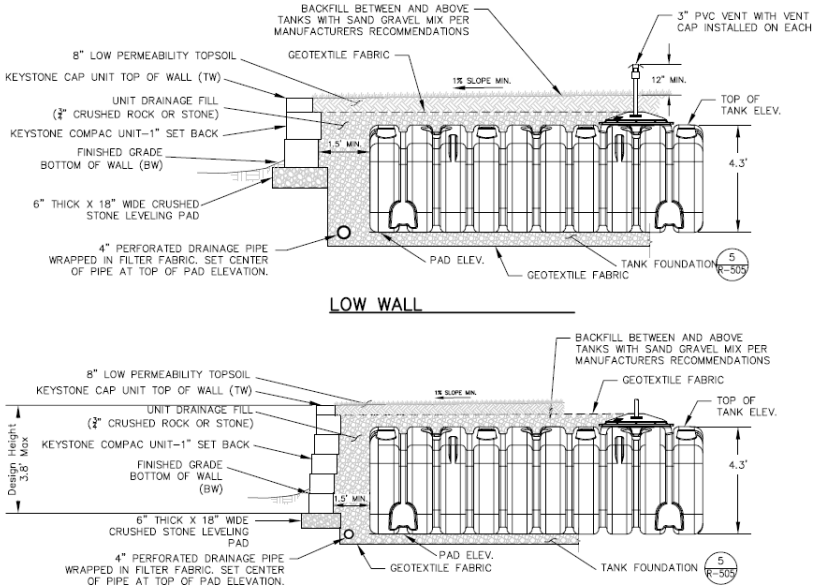
Final Design Concept





- Flexible, urban site design
- Focused on customer's needs
  - Footprint
  - Aesthetics
  - Operability

Pre-construction

Geo-fabric placement

Pad compaction

Initial excavation

Cistern placement (10,000 gal)

Tie into existing roof drains: minimized disturbance

Harvesting system piping

Harvesting system cisterns

Controlled discharge valve

Lift Station & WISY Filter

Concealed harvesting cisterns

Performance Monitoring

Parameter	Monitoring Equipment
Flow rate from cisterns (volume provided by cisterns)	Water meter with data feed to controller
Water level (volume) in cisterns	Pressure transducer in cistern
Precipitation/Weather Conditions	Weather based controller with local data feed

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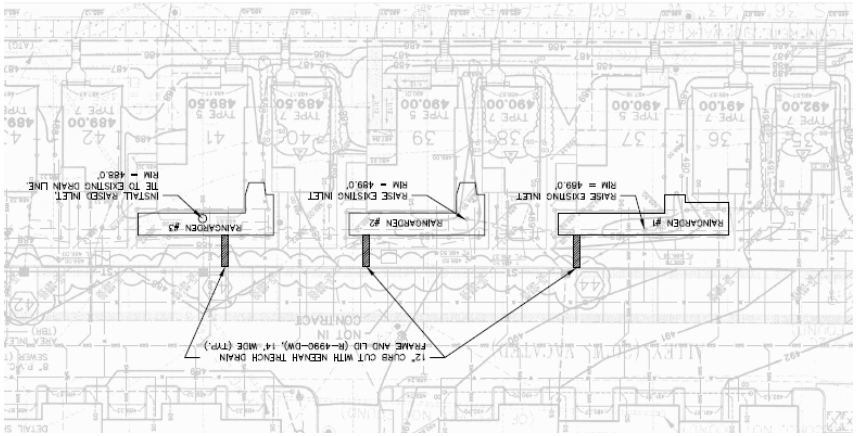
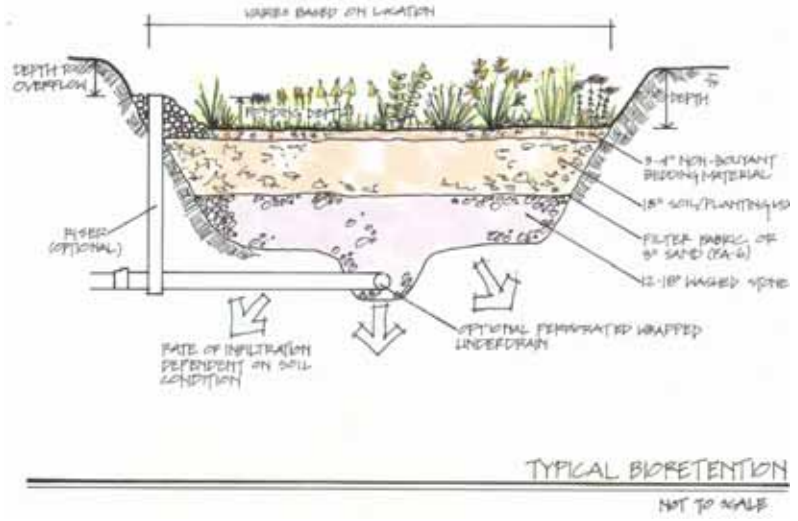
Community Rain Gardens





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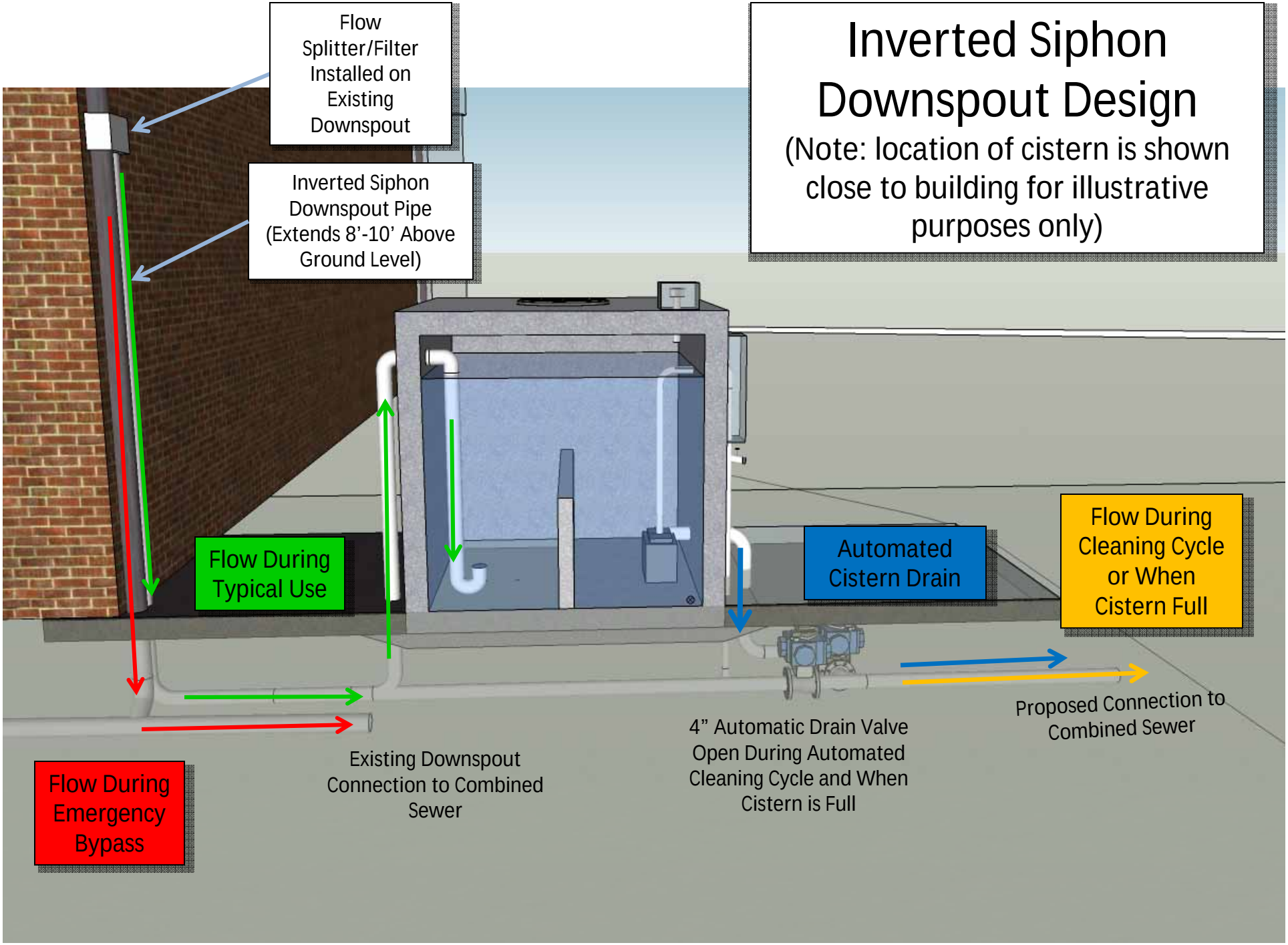
District of Columbia Rainwater Harvesting Project

Engine House #25 – Washington, DC

Engine House #3 – Washington, DC

Inverted Siphon Downspout Design

(Note: location of cistern is shown close to building for illustrative purposes only)



DDOE
DISTRICT DEPARTMENT OF THE ENVIRONMENT

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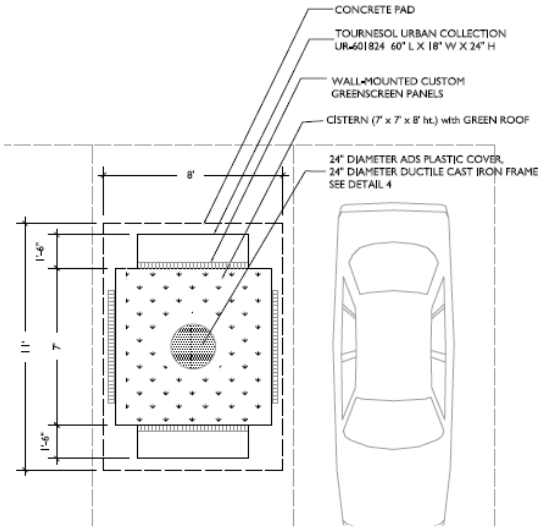
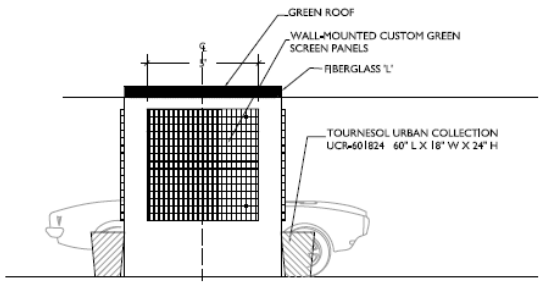
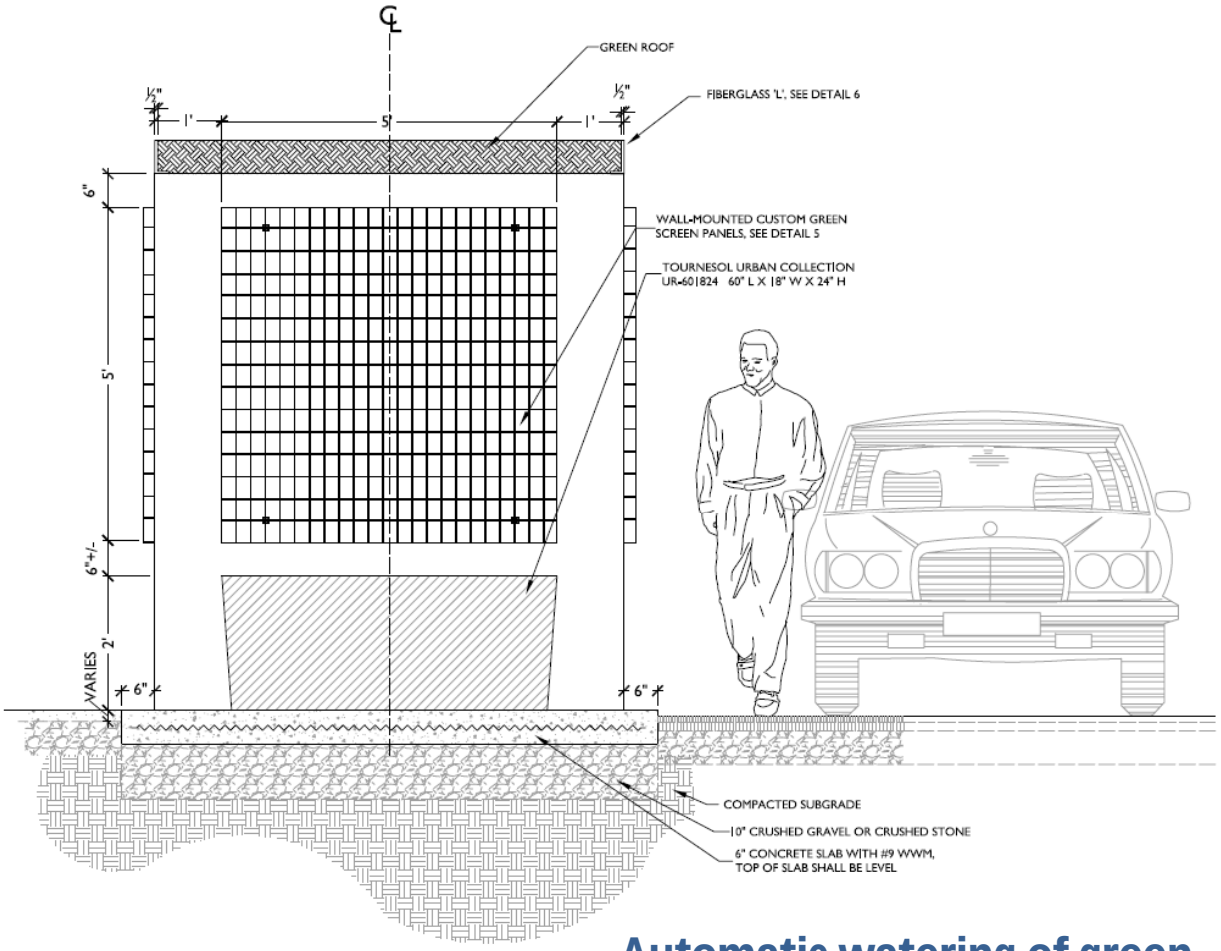
Green Harvesting Cube



1 LAYOUT PLAN
scale: 1/4" = 1'-0"



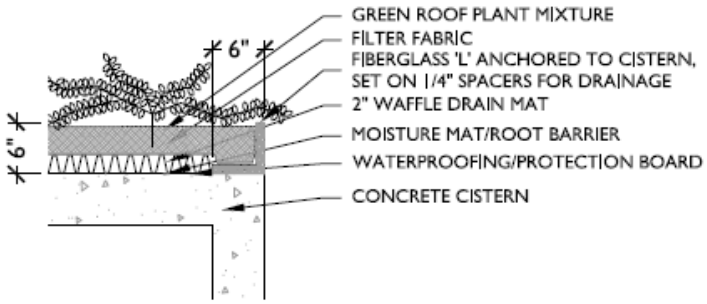
2 SIDE ELEVATION
scale: 1/4" = 1'-0"



3 FRONT SECTION-ELEVATION
scale: 3/4" = 1'-0"

Automatic watering of green harvesting cube.

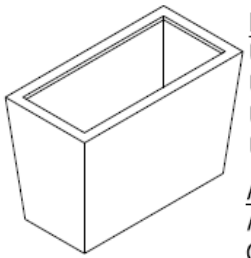
Green Roof & Planter Boxes



SECTION

8 GREEN ROOF ASSEMBLY

scale: 3/4" = 1'-0"



RECTANGULAR

UR OR UCR-241818 24" L X 18" W X 24" H
UR OR UCR-361818 36" L X 18" W X 24" H
UR OR UCR-481818 48" L X 18" W X 24" H
UR OR UCR-601818 60" L X 18" W X 24" H

AVAILABLE MATERIALS (ALL PRODUCTS):

AVAILABLE IN FIBERGLASS (UR-XXXX) OR
GLASS FIBER REINFORCED CONCRETE (UCR-XXXX)

AVAILABLE IN A RANGE OF METAL INFUSED FINISHES:
BRONZE, ALUMINIUM, AGED COPPER, IRON

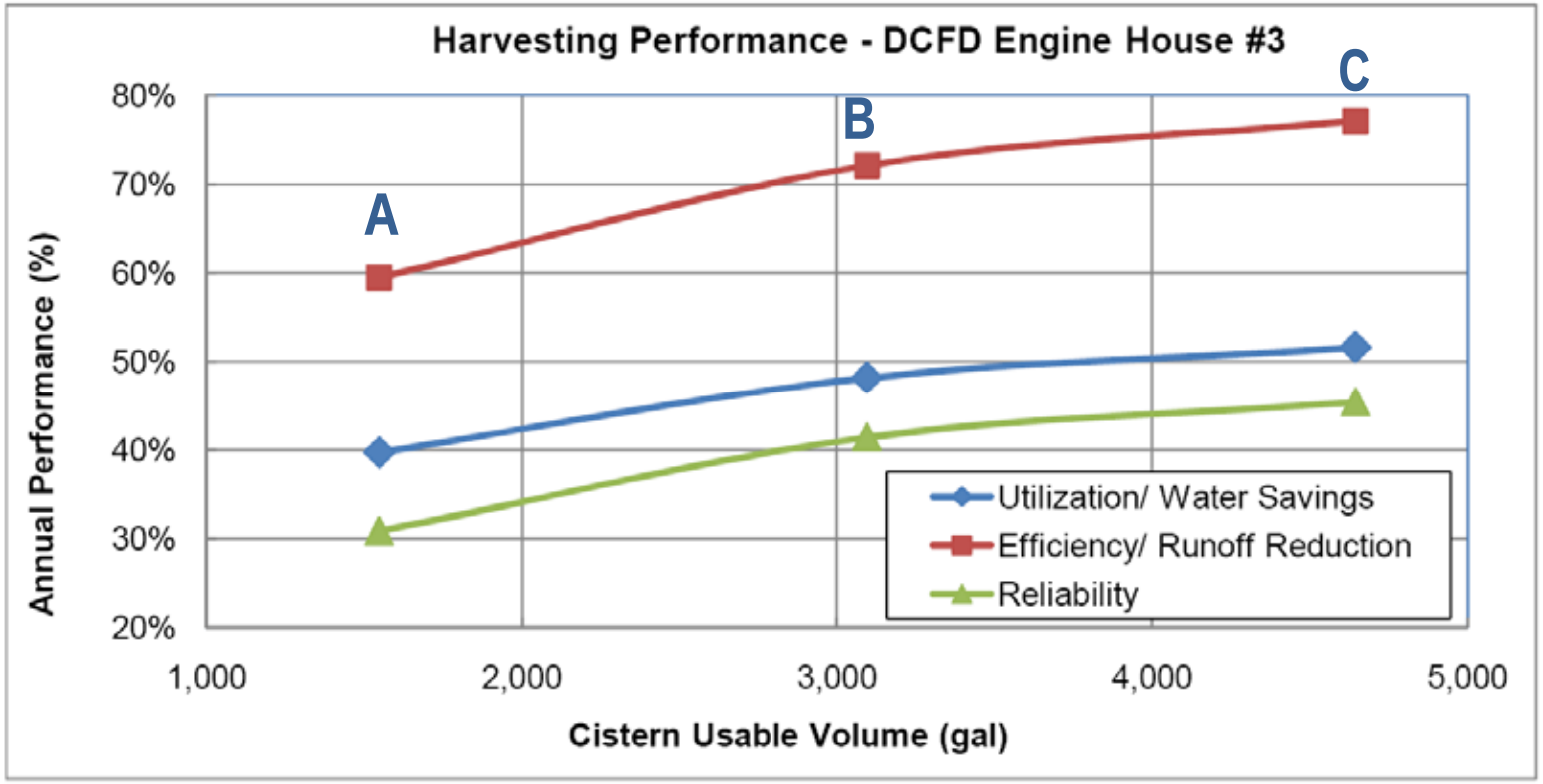
9 TOURNESOL PLANTERS

scale: N.T.S

Water Budget Analysis

Harvesting Performance Summary
DDOE Green Tanks
Engine House #3
6/9/10

Harvesting Scenario	Demand (gal/day)	Cistern Volume (gal)	Roof Collection Area (sf)	Rainfall Depth Captured (in)	Average Annual Performance				
					Water Savings		Runoff Reduction		Hourly Reliability (%)
					Utilization (%)	Volume (gal)	Efficiency (%)	Volume (gal)	
A	400	1,548	3,530	0.74	40%	63,824	59%	63,669	31%
B	400	3,097	3,530	1.48	48%	77,446	72%	77,136	41%
C	400	4,645	3,530	2.22	52%	82,983	77%	82,519	45%



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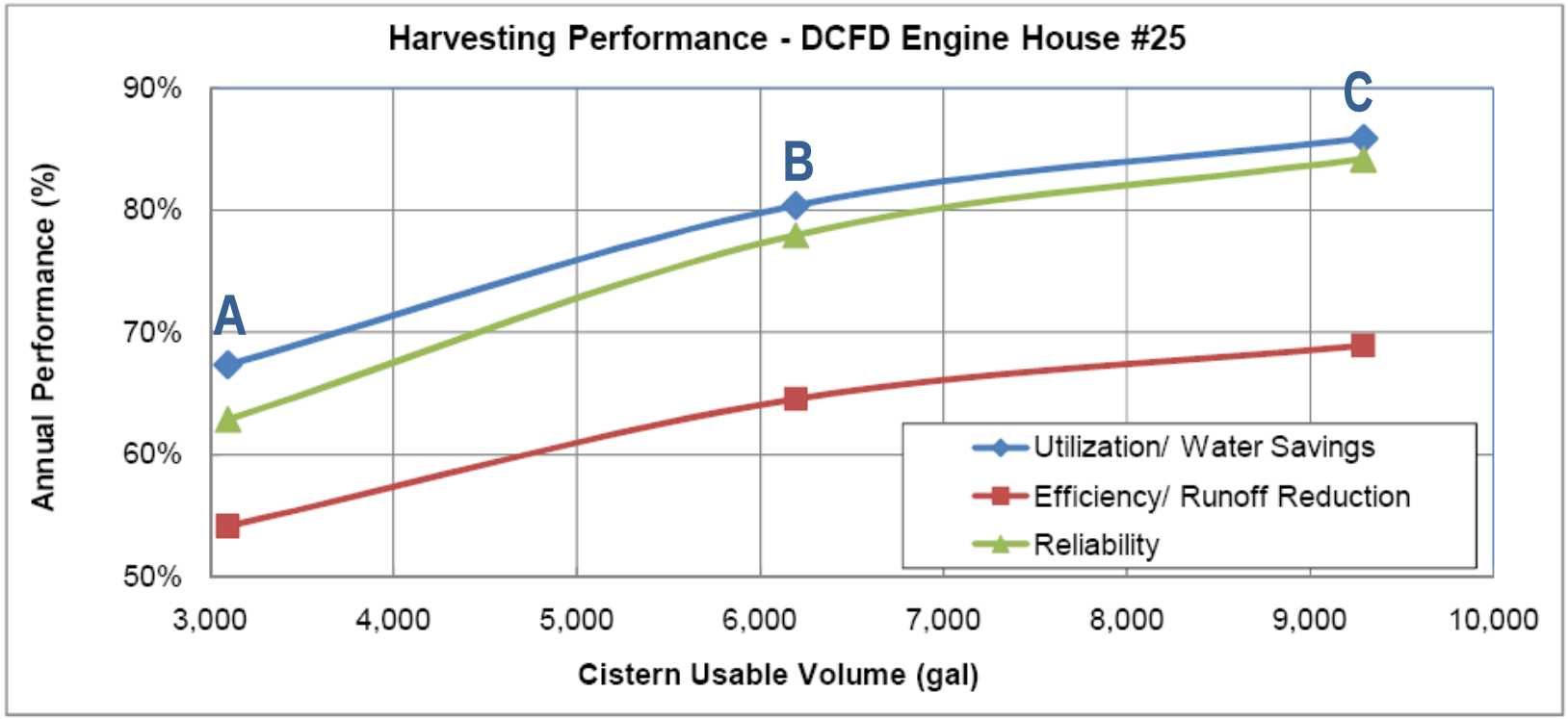
Water Budget Analysis

Harvesting Performance Summary
DDOE Green Tanks
Engine House #25
6/9/10

Harvesting Scenario	Demand (gal/day)	Cistern Volume (gal)	Roof Collection Area (sf)	Pavement Collection Area (sf)	Rainfall Depth Captured (in)	Average Annual Performance				
						Water Savings		Runoff Reduction		Hourly Reliability (%)
						Utilization (%)	Volume (gal)	Efficiency (%)	Volume (gal)	
A	400	3,097	5,559	2,200	0.68	67%	108,272	54%	107,962	63%
B	400	6,193	5,559	2,200	1.37	80%	129,201	65%	128,779	78%
C	400	9,290	5,559	2,200	2.05	86%	137,997	69%	137,518	84%



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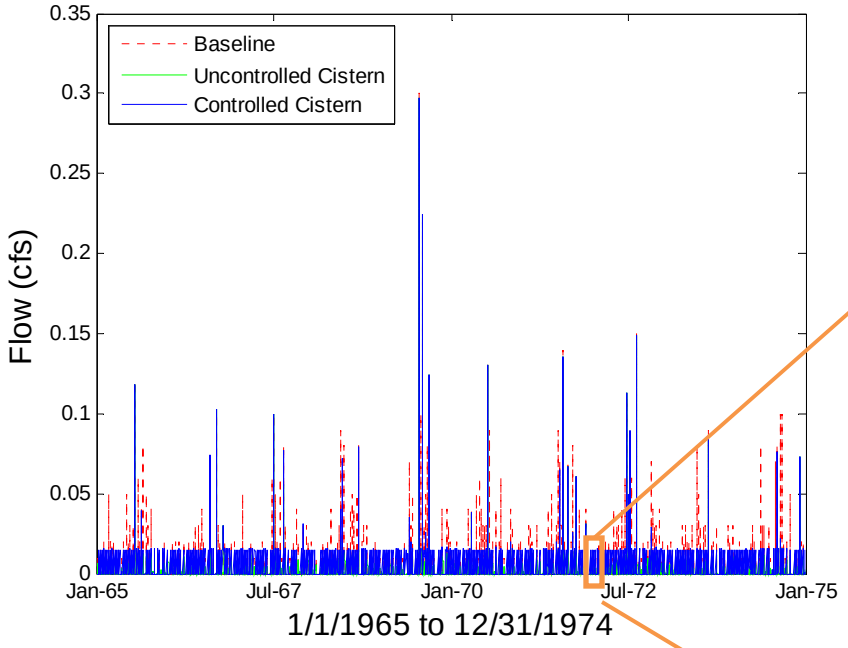
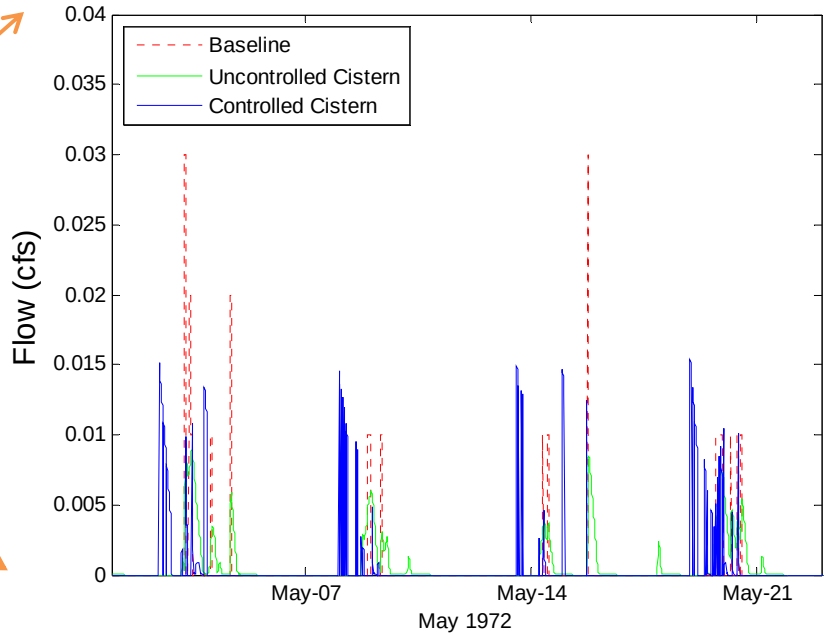
Stormwater Modeling

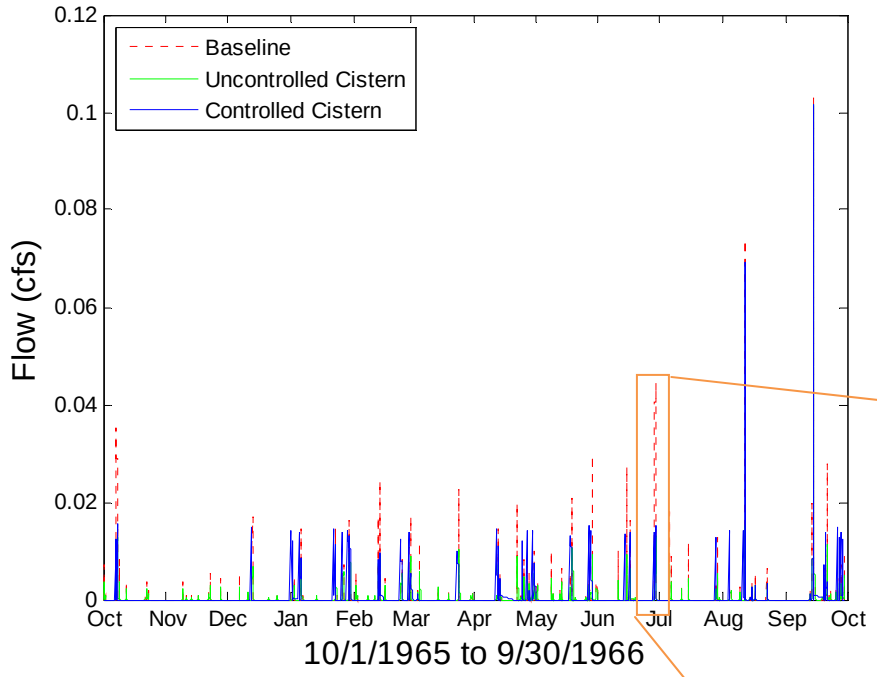
- Continuous simulation - USEPA SWMM 5
- Hourly rainfall data (DCA)
- 3900 sf of roof area
- Drain a 2500 gallon, 6-ft deep tank when full in 12 hours (orifice)
- Both an uncontrolled cistern and a forecast controlled cistern were modeled
- Selected model years: 01/1/1965 - 12/31/1974
- No non-potable demand evaluated

Stormwater Model Results

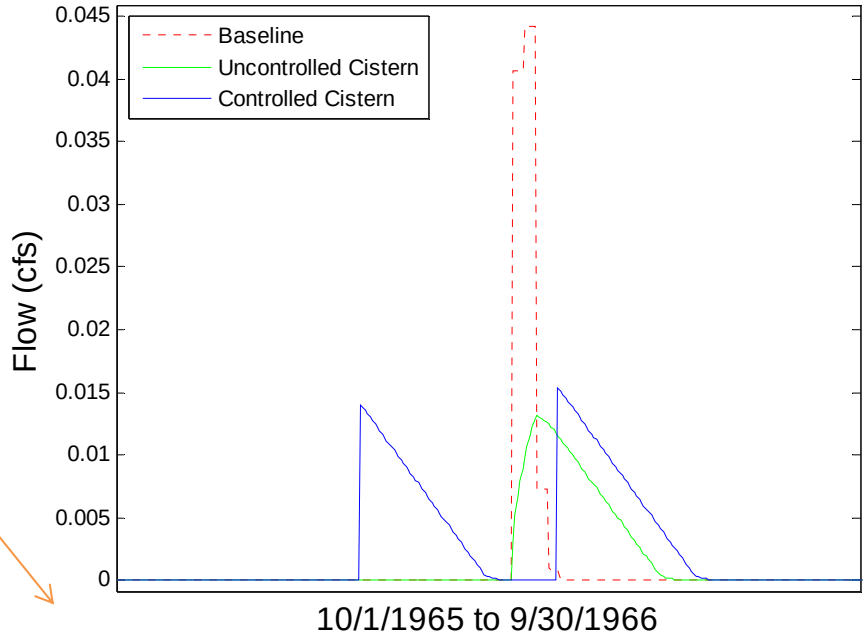




Flow Comparison

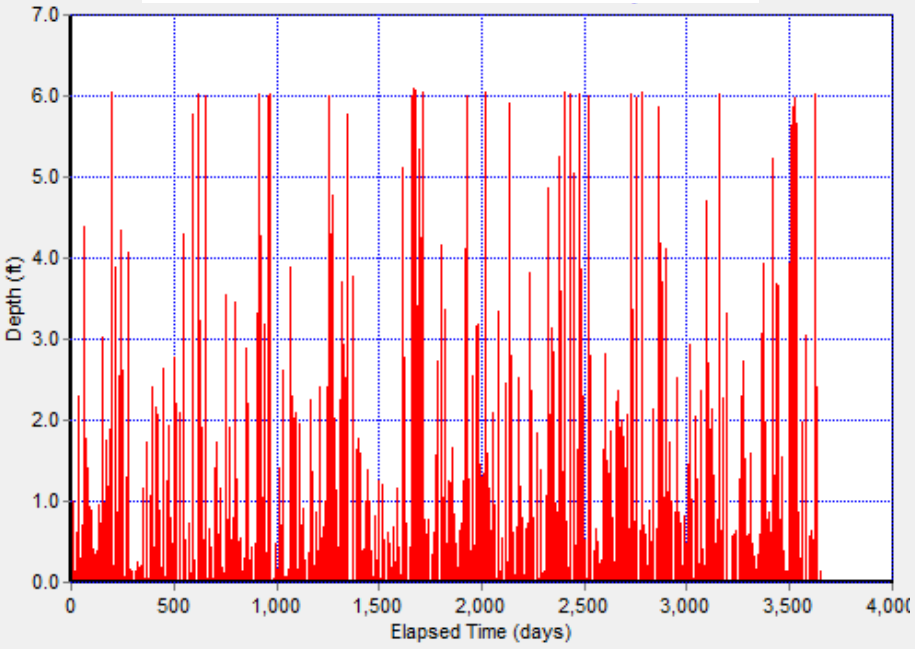


Baseline: Runoff without detention storage
Uncontrolled Cistern: Runoff with passive orifice
Controlled Cistern: Runoff with active orifice

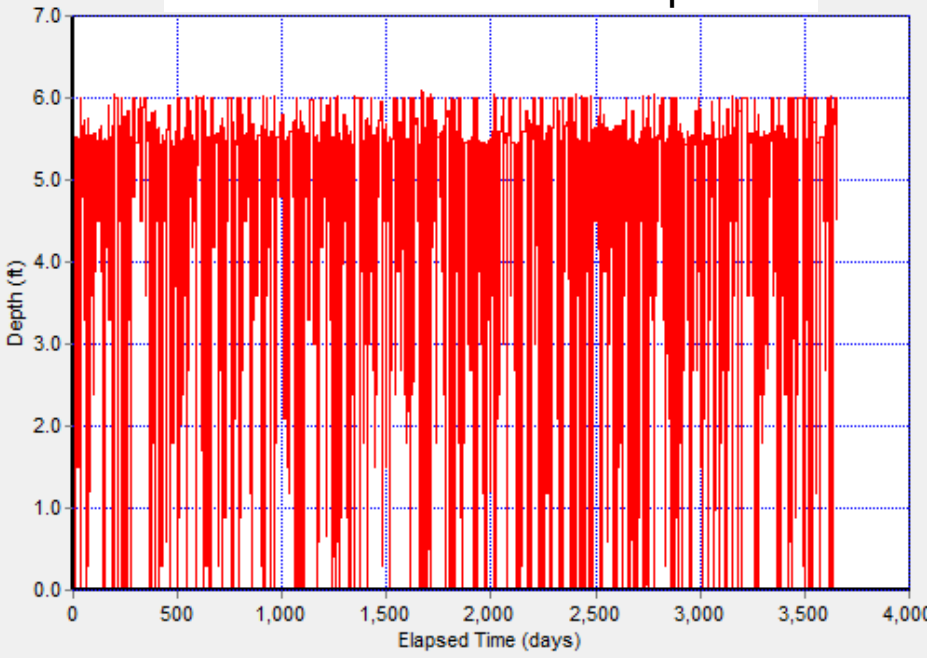


Cistern Depths

Uncontrolled Cistern Depth

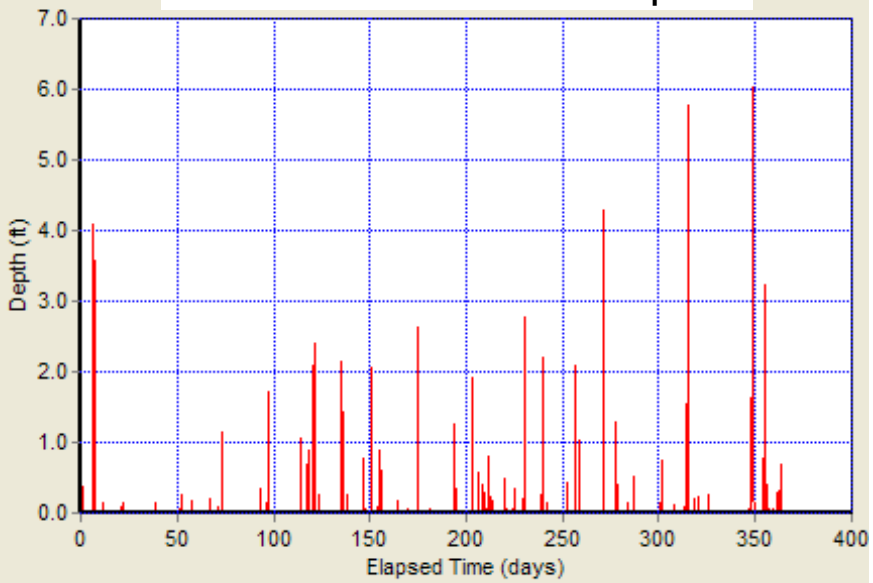


Controlled Cistern Depth

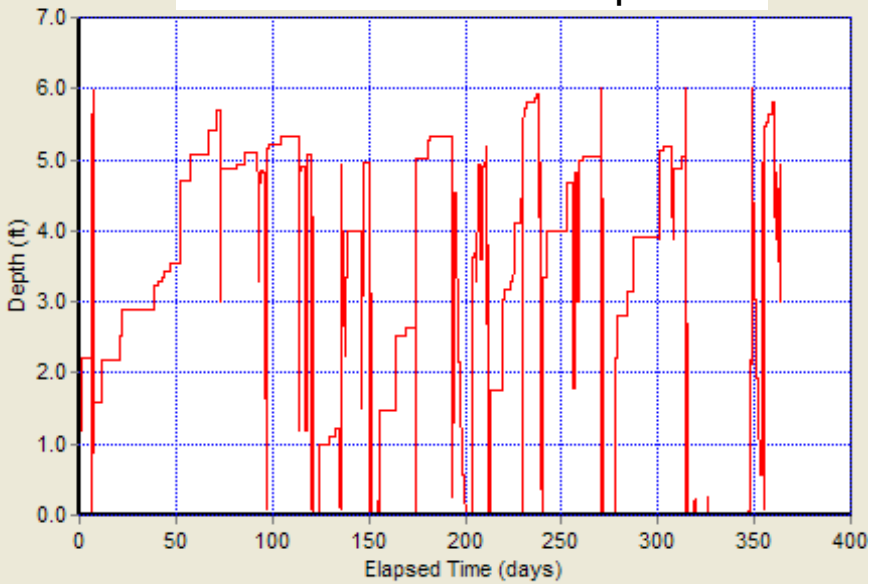


Tank Storage Volumes

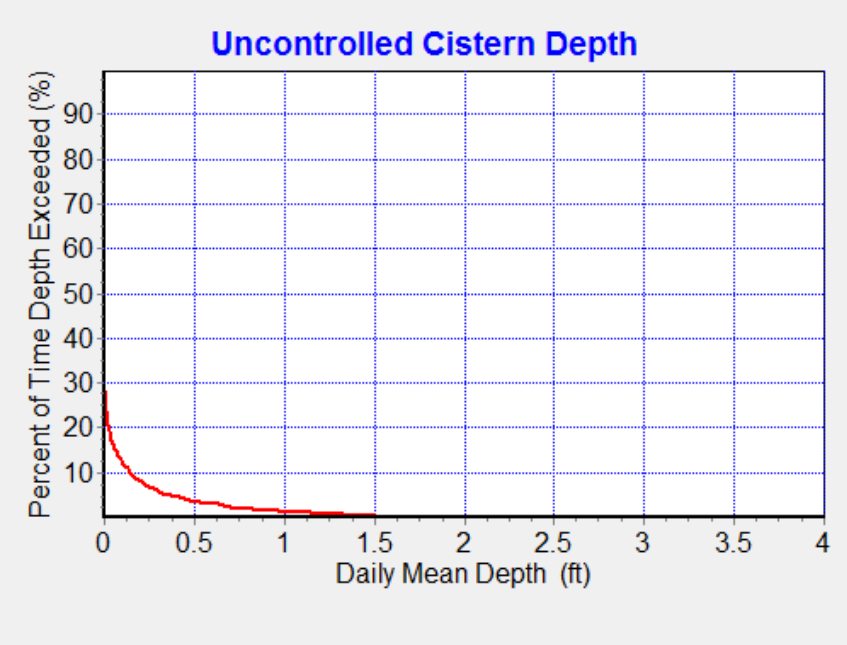
Uncontrolled Cistern Depth



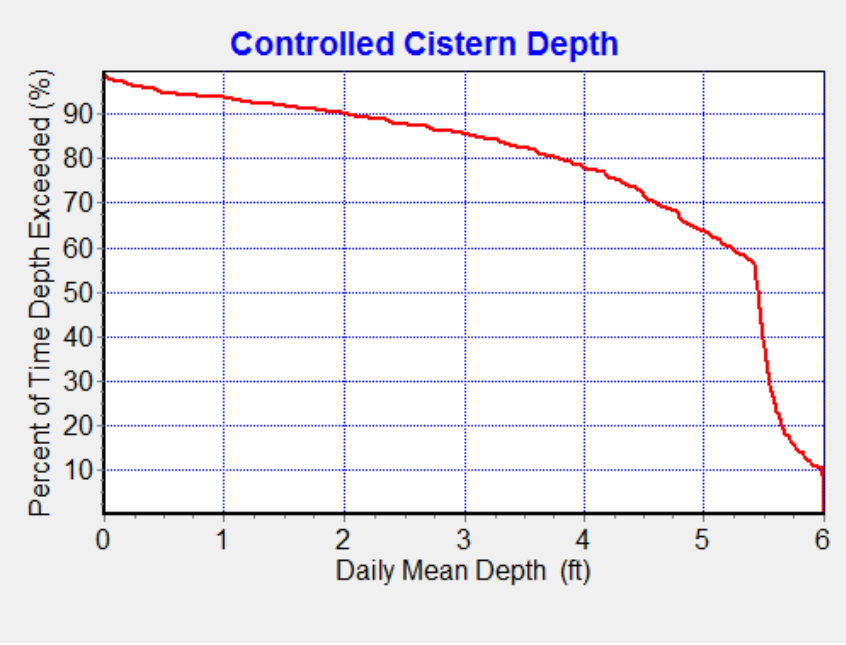
Controlled Cistern Depth



Tank Storage Volumes



Mean Daily Water Depth = 0.064 feet



Mean Daily Water Depth = 4.7 feet

Wet-Weather Runoff Volumes

- Summation of runoff volume during times when baseline flow is greater than zero
- Baseline runoff volume:
  - 12,680 cf/yr
- Uncontrolled wet-weather runoff volume:
  - 11,326 cf/yr (11% reduction)
- Controlled wet-weather runoff volume:
  - 3,899 cf/yr (69% reduction)

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Where are we headed?

- Conducting WERF Funded Nationwide Research During 2011
- RTC Modeled Hydrograph Matching
- Actuated Blue Roofs, Green Roofs, Bioretention (WERF Project)
- Retrofits for Constructed Wetlands
- Retrofit Flood Control Facilities
- Embedded Modeling (SWMM)
- Active Hydromodification Control
- Etc…

Contact Information

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Geosyntec consultants

engineers | scientists | innovators

Performance Monitoring

Parameter	Monitoring Equipment
Flow Rate to Drains (all 4 roof sections)	Bubbler Level Sensors
Volume (Weight) of Water in Trays	Weather Resistant Scales with Data Loggers
Evaporation Rate	Weather Resistant Scale with Data Logger
Precipitation/Weather Conditions	Full Weather Station
Conditions/Performance of System	Video Camera Time-Lapse Camera

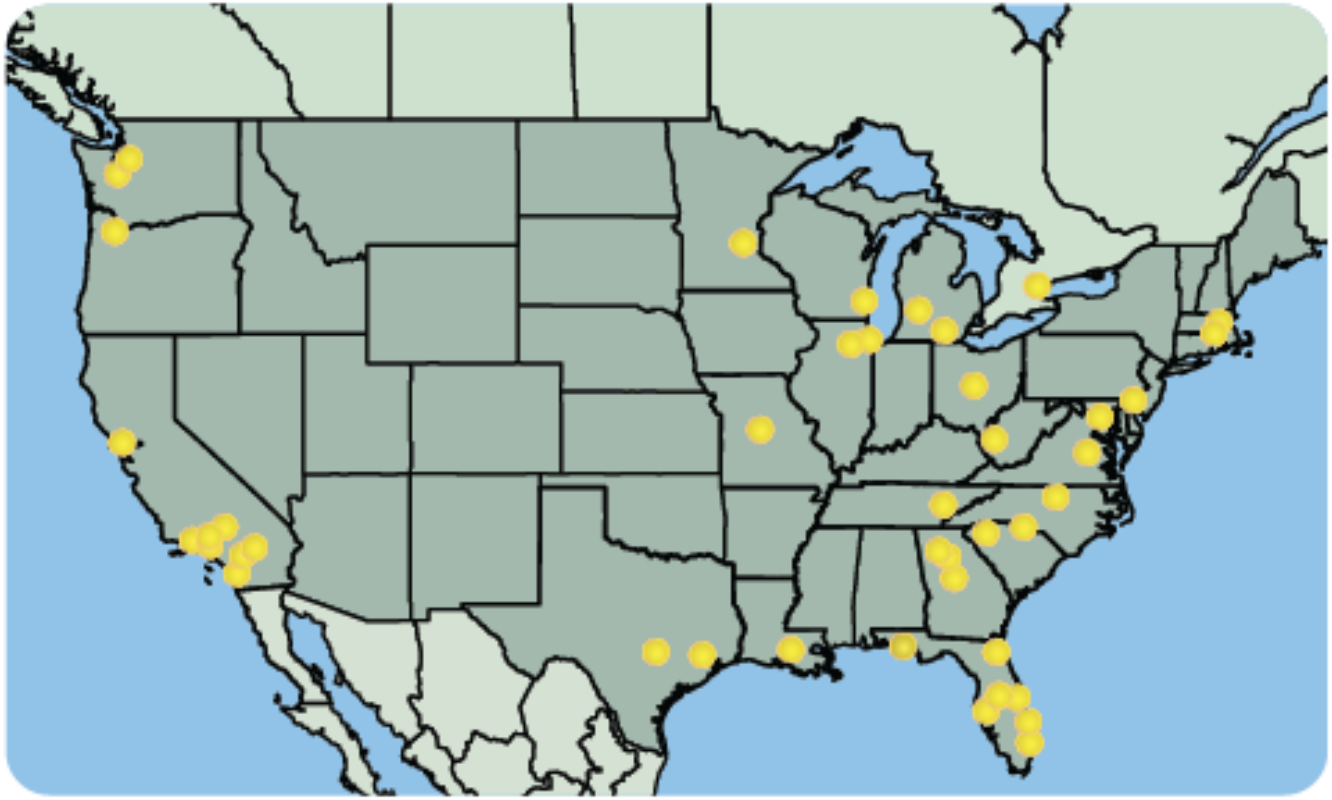
Active Controls

- Actuated Valves to Open/Close Roof Drains or Adjust Size of Openings Based On:
  - Precipitation Forecasts
  - CSO Status
  - Depth of Ponding on Roof Surface
  - Structural Loading Roof System
- Real-Time Control Logic
  - Geosyntec OptiRTC/OptiStorm System

Opportunities for implementation

- As site control
  - Market: Site managers, new construction
    - » Meet permitting requirements
    - » Low-cost alternative for runoff reduction
      - Stand-alone or reduce cost of other systems in combination
- As a CSO control
  - De-centralized control – potential for significant impact on CSO volumes when applied at large scales?
- Extremely Low Cost Pilot Projects (<$15,000)
  - Purchase, Install, and Monitor

Geosyntec Locations – North America

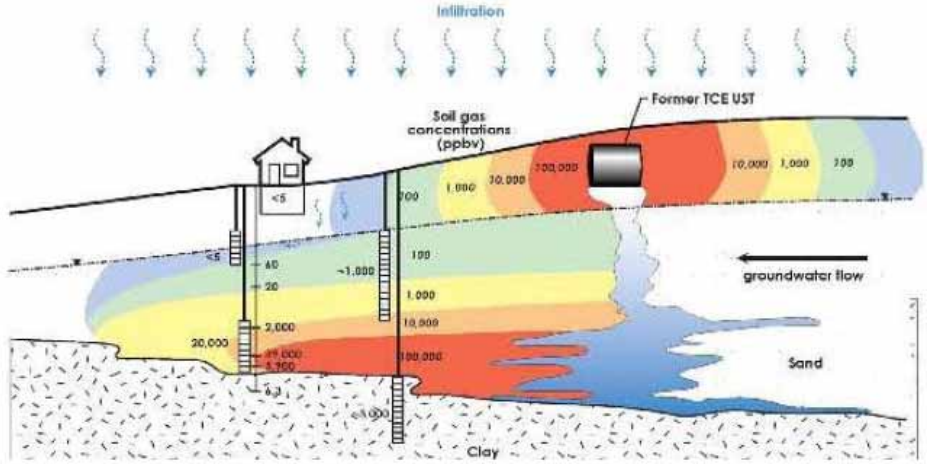


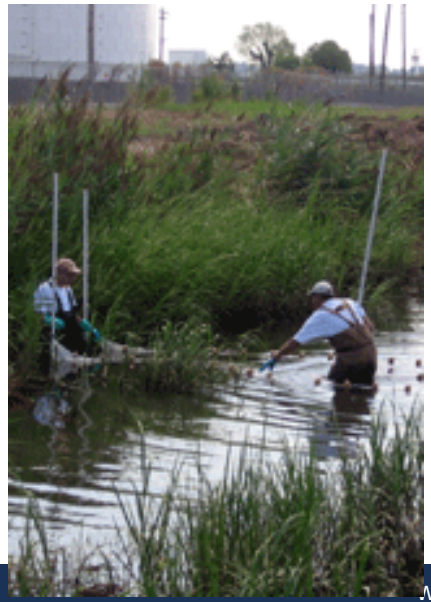
Geosyntec consultants

Geosyntec Locations – Great Lake

Geosyntec Consultants' Services

- Environmental Studies & Cleanup
  - Site Investigation
  - Brownfield Redevelopment Planning and Design
  - Groundwater Assessment and Remediation
  - Soil Assessment and Remediation
  - Specialized In Situ Treatment
  - Risk Assessment and Applied Toxicology





Geosyntec Consultants' Services

- Infrastructure Engineering and Design
  - Geotechnical Infrastructure/Foundation Engineering

Geosyntec Consultants' Services

- Water and Natural Resources
  - Stormwater Management
  - Watershed Management
  - BMP Evaluation and Design
  - Water and Natural Resources Conservation and Restoration
  - Surface Water/Groundwater Supply Studies and Development
  - Erosion and Sediment Control
- Environmental Management

Local Regulatory Drivers:

- NEED MSD Regulations Here
  - 1.1 inch retention

Source: MSD

Other Regulatory Drivers:

- Encourage and Promote Programs that:
  - Minimize negative stormwater impacts
  - Protect and conserve land and water resources
  - Prevent pollution
  - Minimize stormwater flows into the combined sewer system by minimizing impervious surfaces, promoting infiltration or discharging to local waters
  - Preserve the natural characteristics of stream corridors
  - Preserve the natural hydrologic and hydraulic functions of watercourses
  - Manage stormwater on-site

Source: City of Chicago Stormwater Management Ordinance Manual, 2010

Draft MWRD Permitting

DRAFT WMO Standards
Volume Control

- Capture and retain 1-inch of stormwater runoff from new impervious areas for all development over 1 acre
- Redevelopment Sites, capture and retain 1-inch of stormwater runoff from new impervious areas for redevelopment sites over 1 acre OR achieve 20% reduction in impervious surface from existing conditions
- If capture or reduction not feasible, then variance may be granted (Fee-in-lieu)

Creating Sustainable Communities

- Meets or exceeds regulatory requirements
- Provides positive health benefits
- Improved quality of life
- Economic benefits
- Positive example to community

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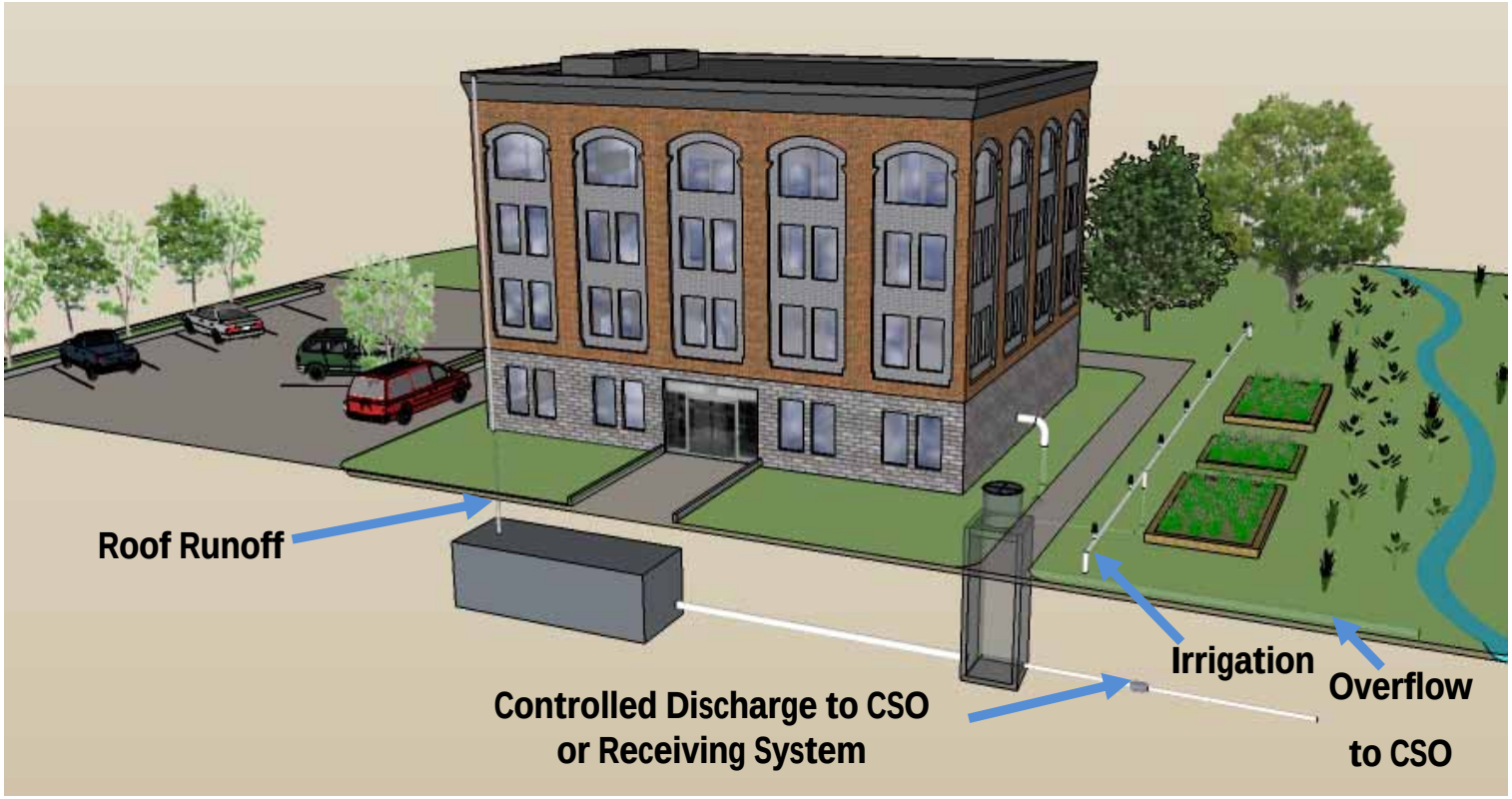
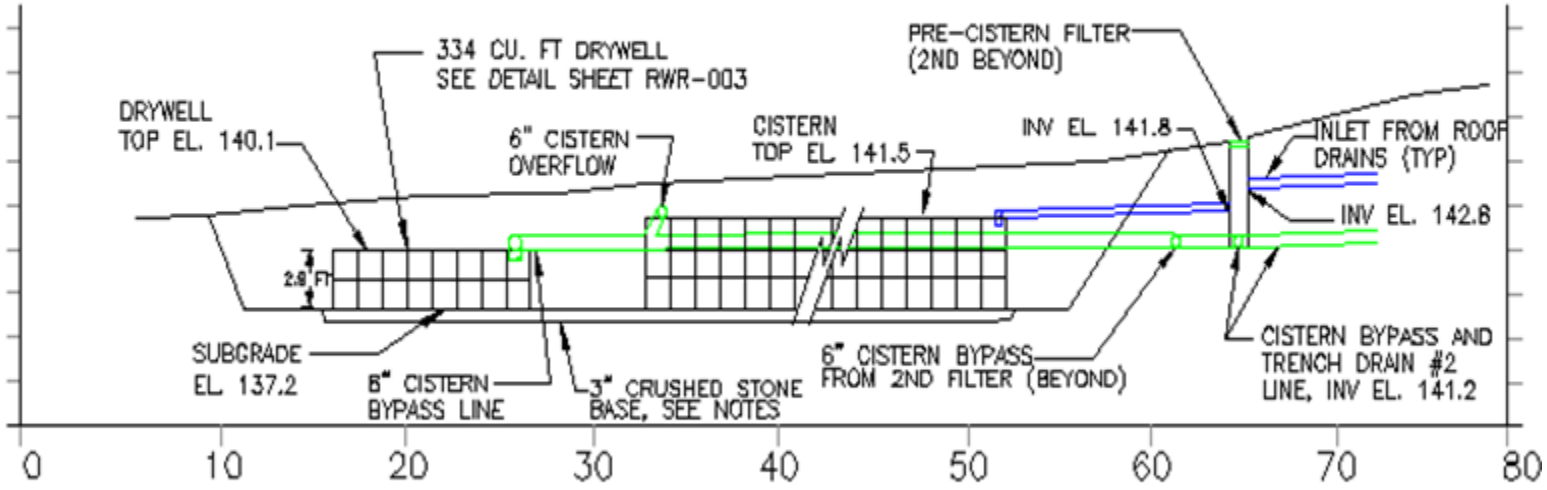
Advanced Harvesting System



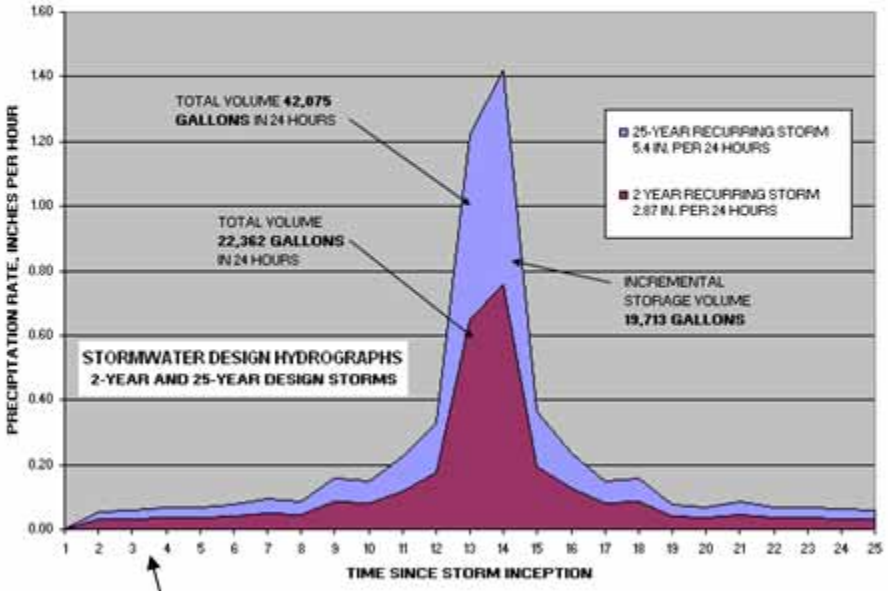
Rainwater Harvesting - Traditional

Harvesting Storage Inserted into Drainage Profile

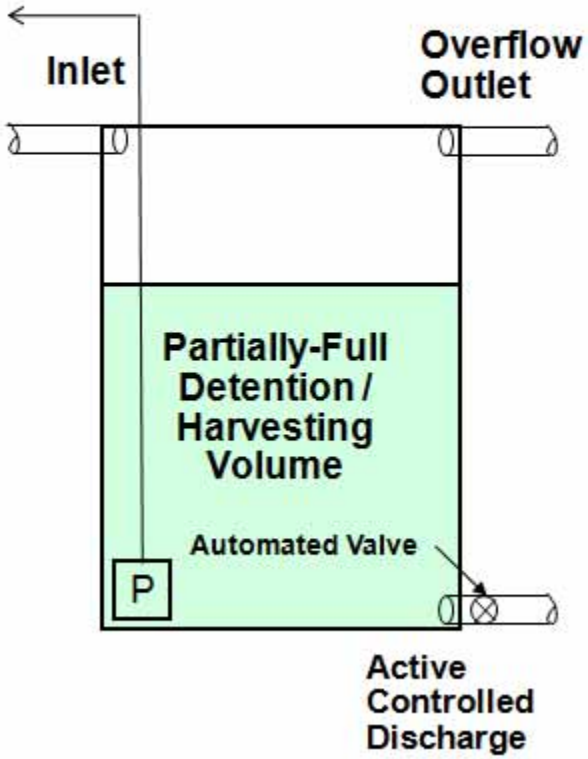


Rainwater Harvesting – Integrated / Active

Integrating Detention Volume with Harvesting Volume – Cont.



Controls-Based Discharge Trigger Point



Rainwater Harvesting – Summary

- **Two modes of integrating harvesting in stormwater management:**
  - Mid-height passive controlled discharge
  - Active Controlled discharge
- **Provides water for beneficial use at small or no incremental cost**
- **Advances in controllers offer wide range of creative opportunities**
- **Limitations on applicability**
  - Not fully beneficial for seasonal applications
  - Prioritize surface water runoff
  - Back-up power for non-passive controls
  - High-intensity storms
  - Variable regulatory acceptance