Cisterns for Stormwater Detention, Rainwater Storage, and Re-Use

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INTRODUCTION
Global Warming and the case for conservation

- Global warming is underway and the effects are being felt locally
- Almost everywhere in the Cascades, snowpack has declined markedly since 1950.
- Nearly every glacier in the Cascades and Olympics has retreated during the past 50-150 years in response to warming.
- For a warming of +4.1°F, which could occur as early as the 2040's (but probably not until later in the century), October through March runoff increases by about 25% and April through September about 25% and decreases by 21%

Lyman Glacier, North Cascades

Tolt Reservoir

Source: Puget Sound Action Team & The Climate Impacts Group, University of Washington

INTRODUCTION
Seattle's conservation achievements

Water consumption reduction program

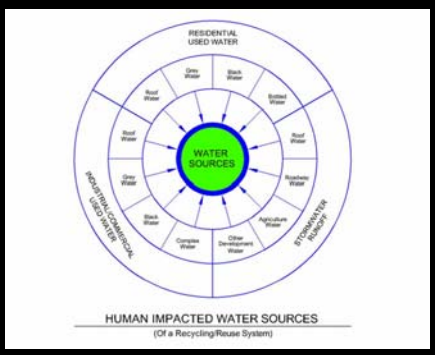
- 130 gallons per day per capita in 1985
- 100 gallons per day per capita in 2000
- Aiming to reduce by 1% annually
- The program includes rates, codes, hardware and behaviour changes
- The program costs: $4.78/gpd of water savings
- Hardware change programs have been found to be cheaper than behaviour change programs

SYSTEMS THINKING

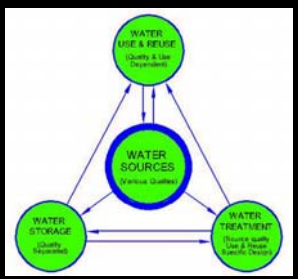
Need to think differently about the problem of water supply…

- Whole System Design
  - "Site & Project" Relationships
- Integrated Design
  - "Design" Relationships
- Sustainable Design
  - Materials & Systems (relationships)

SYSTEMS THINKING
All Water is a Potential Source…



SYSTEMS THINKING
Water Management vs. Water Supply…



SYSTEMS THINKING
Potential Water Sources – Semantics are Important

Water Resources Defined
- Potable Water (Drinking)
- Stormwater (General rainwater run-off from sites)
- "Waste"water (An out-dated term; all types of water are considered resources)
  - Blackwater (Toilet water)
  - Greywater (Sinks, showers, laundry, etc.)
  - Combined Water (Blackwater & greywater)
- Rainwater (Roof run-off)
- Reclaimed Water (Treated "waste"water)

LEED
Water Efficiency

2. Innovative Wastewater Technologies (1)
3. Water Use Reduction (2)

LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

RAINWATER HARVESTING
Introduction

Opportunities
- Rainwater is a clean water source available at the site
- Delivered at no cost
- Initial treatment provided by a very effective large scale distillation process
- Can reduce potable water demand and/or reduce stormwater run-off and address CSO problems
- Global warming is going to decrease water supply (*and as a result increase its cost in the future)*

The hydrologic cycle

RAINWATER HARVESTING
Introduction

Challenges
- Storage costs can challenge the cost-effectiveness of rainwater systems
- Current water prices are relatively low and do not justify much in the way of water conservation
  - *Conservation utility incentives may be available)*
  - *Seattle is better than most jurisdictions with its rate structure*
- The issue of Water Rights is currently unresolved legislatively
- Other regulatory issues can be a challenge for some jurisdictions, particularly with potable usage and with cross-connection

(more on regulatory issues later on in the presentation)

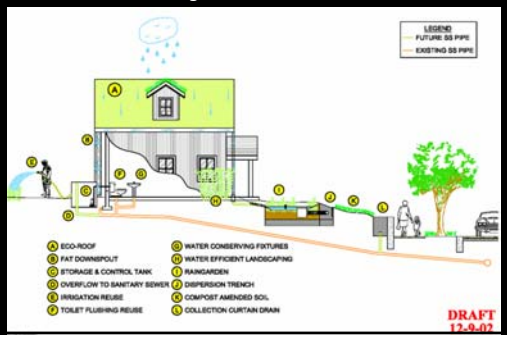
The Cedar River Reservoir

RAINWATER HARVESTING
Introduction

- Rainwater collection should be considered as part of a system, not in isolation, rainwater harvesting is not the whole solution to conservation, other strategies include
  - Conserving fixtures
  - Drought tolerant landscaping
  - Efficient irrigations systems
  - Behaviors
- Be opportunistic, find places to provide storage on projects (parking garages, bridge abutments, under patios, etc.)

Underground parking garage

RAINWATER HARVESTING
As part of overall Low-Impact Development (LID) and water conservation design



WATER EFFICIENCY
Water Conserving Fixtures

Drought Tolerant Landscaping

Washing Machines

Waterless Urinals

Composting Toilets

Drip Irrigation

Low Flow Shower and sink Fixtures

Dual Flush Toilets

RAINWATER HARVESTING
Introduction

- Not a new idea, been done for centuries…

Cistern under the Ancient Egyptian City of Alexandria

Cisterns were commonplace on farmhouses in the US through the 1950's

RAINWATER HARVESTING
Introduction

- In many areas rainwater harvesting is commonplace
- Many jurisdictions support or require Rainwater Harvesting
  - States of Texas, California, Hawaii allow rainwater catchment
  - City of Portland, Oregon allows rainwater catchment
  - San Juan County, Washington permits rainwater catchment systems for new construction
  - Jefferson County, Washington allows rainwater catchment if salt water intrusion is present
  - Bermuda and US Virgin Islands require the use of cisterns in all new construction
  - In rural Australia rainwater catchment is very common

A cistern in Australia

A cistern in the Virgin Islands

RAINWATER HARVESTING
Introduction

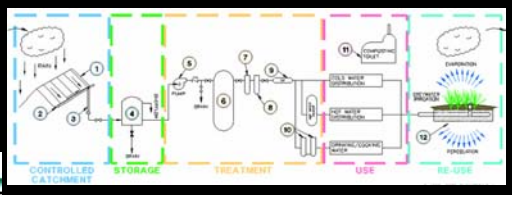
- In this brief talk we are covering two topics with competing needs…
  - Rainwater Re-use cisterns for water conservation *(tries to make tank full)*
  - Stormwater detention cisterns for flow-control during storms *(tries to make tank empty)*
- Hybrid systems are possible, but they require seasonal changes in operation in this climate *(The City of Seattle has allowed the use of detention for rainwater storage in some cases…)*

RAINWATER HARVESTING
Major System Types

- Irrigation
- Toilet Flushing
- Potable
- Industrial
- Stormwater / CSO Control
- Hybrids of the above
- Each has pros and cons and the cost effectiveness of each type depends on site specific conditions and project goals

RAINWATER HARVESTING
Major System Components

- Catchment
- Pre-Treatment
- Storage
- Treatment
- Distribution/Use
- Back-up / Cross Connection
- Re-Use
- O&M and Education



RAINWATER HARVESTING
Component Design: Catchment Area

- Controlled catchment area
  - Roofs only for potable water systems (no augmenting with surface water)
  - Roofing materials, flashing, adhesives very important for potable systems
  - Ideally standing seam metal roofs
  - Source control on particulates
  - Irrigation and toilet flush systems could include some surface water or non standard roof water but aesthetic issues can arise (i.e. Seattle city hall)
- Course Pre-Treatment
  - ¼" leaf screens
  - 1/16" bug screens, self-cleaning


Standing seam metal roof


Self cleaning course pre-treatment screen

RAINWATER HARVESTING
Component Design: Storage

- Cistern Storage Tank Types
  - Underground Concrete (CIP, or Pre-Cast)
  - Underground Fiberglass
  - Partial Bury Plastic
  - Above Ground Plastic
  - Above Ground other (recycled stainless steel, etc.)
  - A portion of a below grade structure / basement
- Structural Considerations (geotechnical, seismic, etc.)

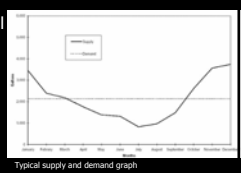
RAINWATER HARVESTING
Component Design: Catchment and Storage

Many types of tanks are available

$0.50/gal - $4-6/gal.

RAINWATER HARVESTING
System Design: Sizing for Potable Use

- Supply
  - Catchment Area
  - Historic monthly rainfall data
  - Select design water year total rainfall as drier than 90% of all years on record
  - Apply this total rainfall to the average monthly rainfall distribution
- Demand
  - Estimate potable uses based on typical per capita daily uses values plus engineering judgment
- Size Storage and Conveyance
  - Mass balance on total storage volume
  - Pumping capacity for peak demand
  - Safety factor (say 90 days min.)

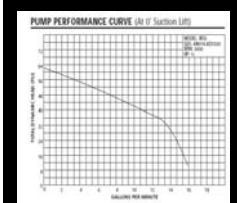

Typical supply and demand graph

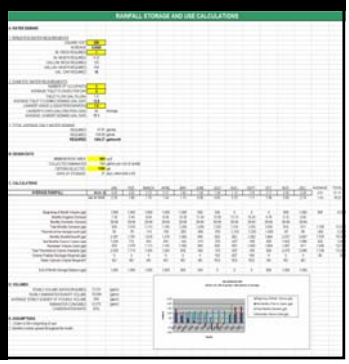
RAINWATER HARVESTING
System Design: Sizing for Irrigation and Toilet Flushing

- Supply
  - Determine the conservation goal of the client (i.e. how much water do you want to save)
  - Look at catchment area and historic rainfall just like the potable system but probably base the supply on the average rainfall
- Demand
  - Determine irrigation needs of the vegetation to be irrigated (0.25" – 1" per week?)
  - Factor in the efficiency of the irrigation method (i.e. drip irrigation vs. soaker hose vs. sprinklers)
  - Estimate WC demand (use conserving fixture)
- Size Storage and Conveyance
  - Mass balance on total storage volume
  - Pumping capacity
  - Typically limited by volume available or budget


Drip Irrigation

RAINWATER HARVESTING
System Design: Typical mass balance sizing spreadsheet and typical pump curve





RAINWATER HARVESTING
Component Design: Pumping and Conveyance


Shallow Well Jet Pump


Pressure Tanks


Combination pressure tank and pump systems


Variable Speed Pumps


Commercial pumping system

RAINWATER HARVESTING
System Design: Treatment

- Potable Systems
  - Meet drinking water standards and regulations
  - 20 micron
  - 5 micron
  - Disinfection (typically UV)
  - Point of use filter for taste and odor issues (if present) or if source control is an issue (i.e. retrofit on a house with an asphalt comp. roof
- Irrigation Systems
  - Sediment filter to protect equipment
- Toilet Flush Systems
  - Sediment filter to protect equipment
  - Ozone for aesthetic considerations (i.e. color) may be needed

RAINWATER HARVESTING
Component Design: Treatment


Sand Filters


Cartridge Filters


Cartridge Filters


Point of Use Sink Filters


Point of Use Shower Filter


UV Disinfection Unit

RAINWATER HARVESTING
System Design: Cross-Connection / back-flow

- Necessary when a potable system is connected to the system for back-up (i.e. city water)
- Prevents back-siphonage of the rainwater into the potable system
- Code requirement
- Often the primary concern for regulators
- RP devices and other backflow preventors require a special permit and annual inspection and testing


An air gap between rainwater cistern and potable back-up

RAINWATER HARVESTING
Component Design: Cross-Connection / back-flow


6" Air gap (at King Street Center)


Double check valve backflow assembly


Reduced pressure principle backflow assembly

RAINWATER HARVESTING
Component Design: Overflow and Release

- Per local stormwater management code
- Re-Use (conservation) system design assumes tank is full and therefore storm is un-detained
- Therefore another retention/detention Best Management Practice (BMP) may be required (same as what would be required of a downspout)
- Prefer Low-Impact Development (LID) BMP's
- Stormwater cisterns are the BMP….

LOW-IMPACT DEVELOPMENT
Bioretention / Raingardens

Cistern overflow could be led to a raingarden…




RAINWATER HARVESTING
Local Rainwater Projects

- Some local Public Buildings with Toilet Flush and Irrigation Systems
  - King Street Center (re-use for toilet flushing)
  - Seattle Central Library (re-use for irrigation)
  - Seattle City Hall (retrofit for irrigation and fountain) (under construction)
  - Cascade Eco-Renovation at the Cascade Neighborhood Center and P-Patch (re-use for toilet flushing and irrigation) (*in design)*
  - Carkeek Park Environmental Education Center
  - Portland State University dorm (toilet flushing)
  - Others…

RAINWATER HARVESTING
Example Projects - Industrial Re-Use at

Two local composting facilities:

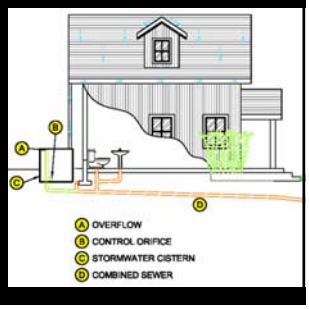
- Skagit Soils (3,000,000 gal. of storage)
  - Eliminated contaminated run-off
  - Eliminated the need for a costly water line extension
- NAS Whidbey Composting Facility (10,000 gallons of storage)
  - Re-used captured roof water in a recycled tank to balance moisture content in in-vessel compost units


Windrow Compost facility


NAS Whidbey Island In-Vessel Compost facility

RAINWATER HARVESTING
System Design: Stormwater

- Typically sized for a particular design event, say the 2-year storm
- Seasonal operational changes may be needed
- The design of these small volumes (300-3,000 gallon) can be very sensitive to orifice size
- Design depends location in the basin (i.e. do not detain in the lower reaches)
- Peak shaving is the design goal
- Initial calculations appear to indicate that the benefit is there and worth investigating further



RAINWATER HARVESTING
As possible CSO mitigation strategy

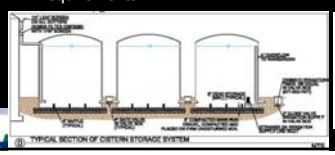
- Large centralized CSO tanks are expensive (~$5-8/gallon)
- Small decentralized CSO tanks are less expensive ($0.30 - $1/gallon)
- Small decentralized allow seasonal re-use for irrigation or other uses
- Maintenance and control issues need to be handled in design and operation procedures

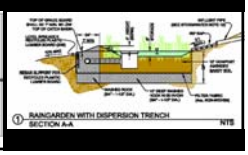
RAINWATER HARVESTING
Residential Hybrid Example Project

Bainbridge Island, WA,

Rainwater as source of irrigation water for small market garden

- 1,100 sf roof
- 18,000 gal. storage
- 5,000 sf market garden irrigation
- Raingarden Bioretention Area for overflow, meets COBI stormwater requirements





RAINWATER HARVESTING
Commercial Hybrid Example Project

Bayview Corner Public Restroom Building – Rainwater Collection for toilet flushing

- Serves a Farmers Market and Plant Nursery
- Combines other strategies to be essentially "off the water grid"

RAINWATER HARVESTING
Residential Potable Water Example Project

Swinomish Indian Reservation, Skagit County, WA, built 1999

- Rainwater as sole source of potable water
- 1,600 sf metal roof, 5,600 gal. Storage, 2 people, 20/5 micron cartridge filtration, 1/0.5 micron carbon at taps, UV disinfection
- Composting toilets & small greywater re-use system

RAINWATER HARVESTING
Residential Potable Water Example Project




RAINWATER HARVESTING
Residential Non-Potable Water Example Project

Private Residence, Seattle, WA, built 2003

- Rainwater for non-potable uses (toilet flushing and irrigation)
- Cistern tank is the patio
- City water back-up
- Many green building strategies
- Simple 20 micron filtration
- http://www.sensiblehouse.org/prc_rainwater.htm

RAINWATER HARVESTING
Residential Non-Potable Water Example Project

The cistern is the patio…

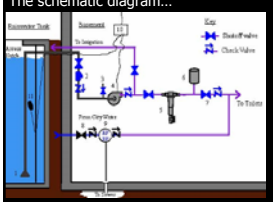



Inside the cistern:


In-line downspout screens…

RAINWATER HARVESTING
Residential Non-Potable Water Example Project

The schematic diagram…



In the basement…

ADDITIONAL INFORMATION
ARCSA

American Rainwater Catchment Systems Association (ARCSA)

www.arcsa-usa.org

RAINWATER HARVESTING
Community Scale Non-Potable Water Example Project

Nine Homes, Lummi Island, WA, built 2004/2005

- Saltwater intrusion issues on islands
- Rainwater for non-potable uses (toilet flushing, clothes washing, and irrigation)
- Cisterns are recycled food oil tanks
- Small community water system back-up
- Conservation was a requirement of the platting due to capacity of typical exempt well
- Simple 20 micron filtration
- http://www.lummiislandclt.org/projects/

RAINWATER HARVESTING
Community Scale Non-Potable Water Example Project

ADDITIONAL INFORMATION
Suppliers

- Cisterns
  - Norwesco: http://www.norwesco.com/
  - Premier Plastics: http://www.premierplastics.com/
  - Metal tanks: http://www.watertanks.com/
  - Septic tanks: available widely
- Pumps, filters, backflow preventors
  - Any plumbing supply house that deals with well systems

THANK YOU…

Questions ?

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