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# Reuse of Stormwater in Arid or Humid Climates: It's All the Same, Right?



Brett H Emmons, PE, P.Eng (AB), ENV SP, LEED AP;  
CEO, Emmons and Olivier Resources, Inc. (EOR)



# Emmons & Olivier Resources, Inc.

**EOR** water  
ecology  
community



water | ecology | community

# Overview – Harvest and (Re)Use

## I. Age Old Method Meets Contemporary Issues

- A. Stormwater as a Resource
- B. Not just for Arid Climates

## II. Drivers/Benefits, Examples

- A. Water Conservation
- B. Stormwater Management
- C. Water Quality
- D. Hydrology

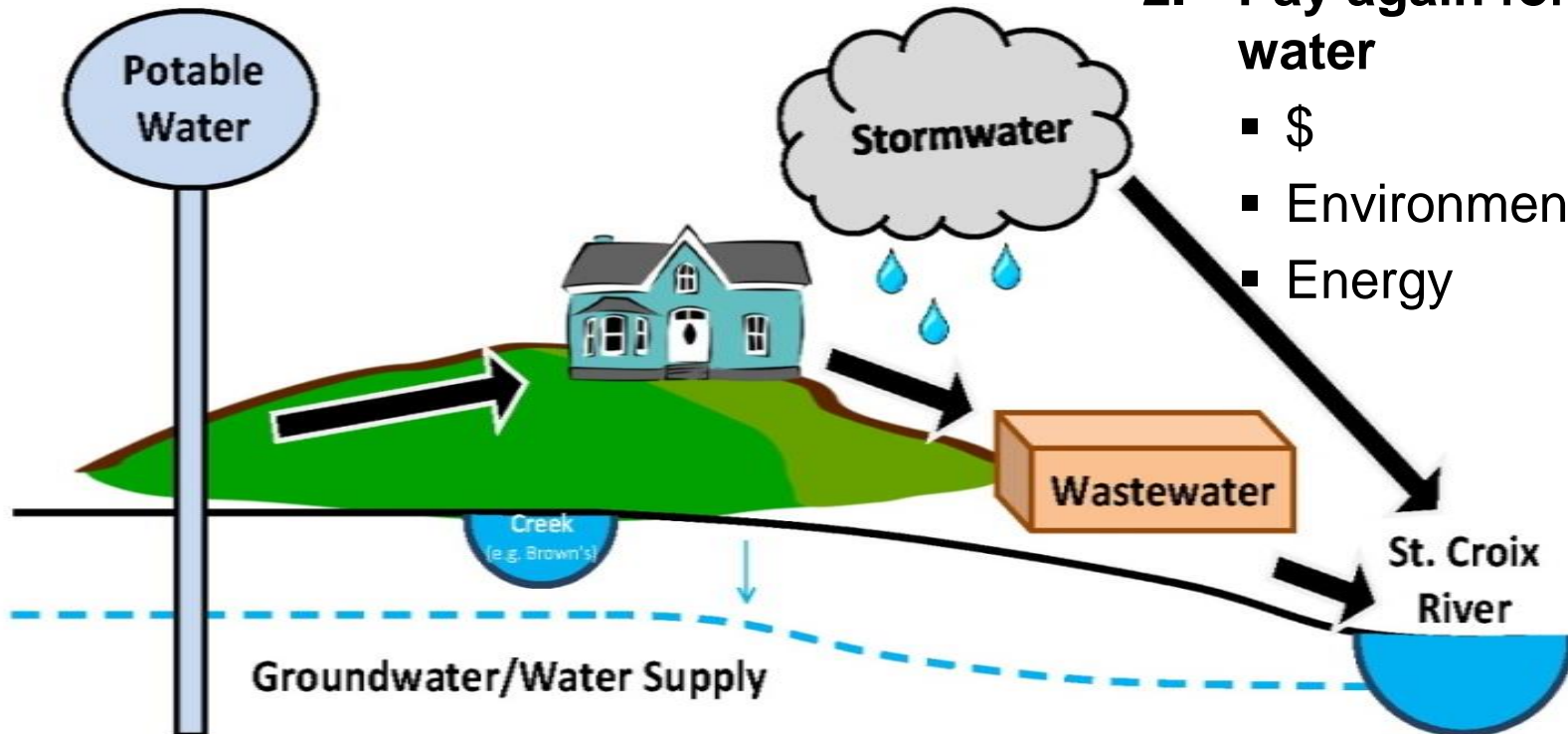
## III. Goals & Potential Pitfalls

## IV. Questions?





# Breaking Linear Thinking

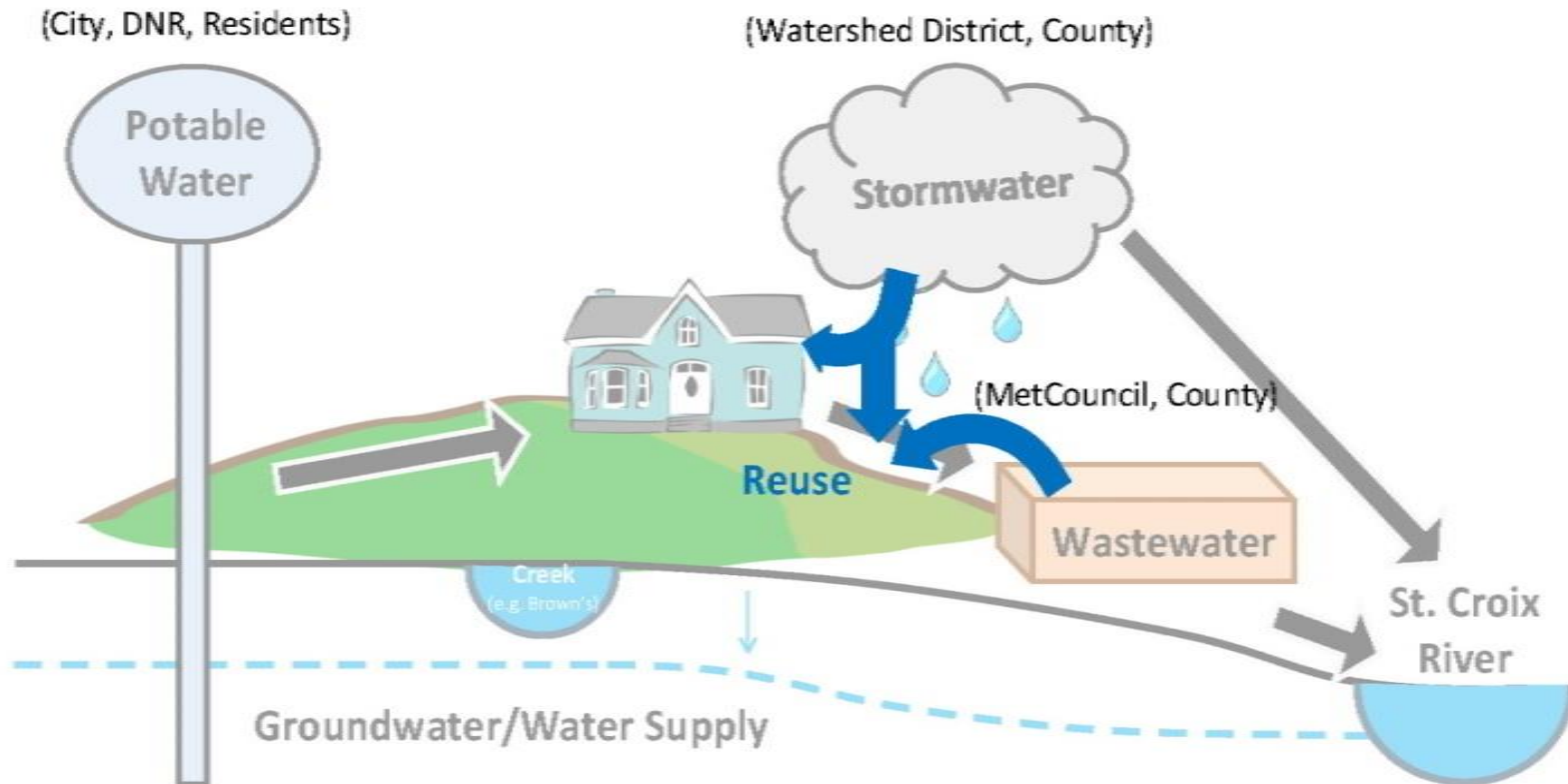


1. Pay to “dispose” of runoff
2. Pay again for potable water
  - \$
  - Environment
  - Energy

Declining GW due to:

- GW Pumping
- Climate Change
- Reduced Recharge

# Breaking Linear Thinking







## Common Practice Globally

### Paradox of Water in the U.S.

- **Paying to “dispose” of runoff**
  - \$ Costs
  - Environmental Costs
- **Paying again for potable water**
  - \$ Costs
  - Environmental
  - Energy / GHG

# Stormwater as a Resource

## WATER & SANITATION

### Large-Scale Rainwater Harvesting Eases Scarcity in Kenya

By Justus Wanzala

Reprint | [f](#) [t](#) [in](#) [v](#) | [Print](#) | [Send by email](#) | [En español](#)



African Water Bank technicians put the final touches on a water storage tank at a homestead in the Duka Moja area of Narok County, Kenya. Credit: Justus Wanzala/IPS

## Rainwater Harvesting

- Simple Technology
- Address water scarcity
- Can be implemented at a variety of scales
- Relatively low cost

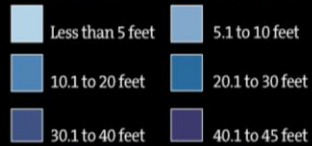




# Re/Use for Stormwater Management has Conservation Benefits

2030 MODEL-PROJECTED  
DRAWDOWN IN THE  
PRAIRIE DU CHIEN-  
JORDAN AQUIFER

## CHANGE IN FUTURE GROUNDWATER DRAWDOWN

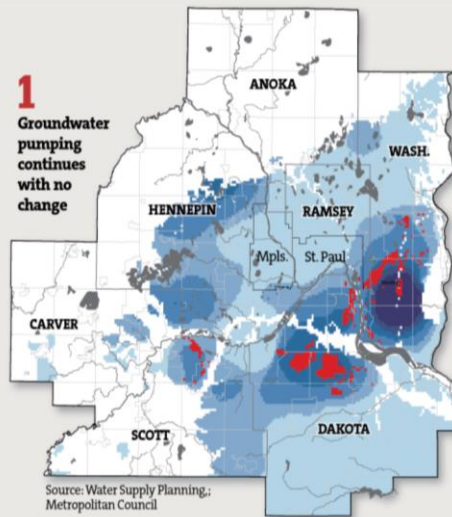


## AREAS MOST AFFECTED

Drawdown exceeds  
50% of available head\*

\*Available head in a well is the height water rises above the physical top of the aquifer; the 50 percent mark is when it becomes the greatest concern.

**Note:** Model 1 results assume long-term average conditions and continued development of traditional water supplies. Models 2 and 3 assume that some communities adopt different water supplies than they currently use.



Source: Minnesota Public Radio News

## Intersection of Stormwater & Water Use

### Volume-Based SW Permitting:

- **Problem Sites**
  - Soils, Bedrock, Contamination, High WT
- **Accounting Method**
  - “How much Volume Control?”

### Water Supply Concerns:

- **N. America, Water Supply is Large Issue**
- **MN – GW Decline, e.g., White Bear Lake**
- [https://stormwater.pca.state.mn.us/index.php?title=Stormwater\\_and\\_rainwater\\_harvest\\_and\\_use/reuse](https://stormwater.pca.state.mn.us/index.php?title=Stormwater_and_rainwater_harvest_and_use/reuse)

# Not just for Arid Climates

**Growing Practice in all Climate Regions (including the Midwest)**

**Broad Set of Goals Addressed**

**Re/Use Need Not Be Limited to Rainwater Harvesting**

**Beneficial Use Applications for Many Settings**

	AUST	FLOR	TEX	VIRG	NCAR	WASH
<b>Reuse Program Goals</b>						
Reduce pollution load to surface waters	✓	✓	✓		✓	
Reduce stormwater flows	✓	✓	✓		✓	✓
Reduce potable water demand	✓		✓	✓		
Reduce impacts of urbanization on watershed hydrology			✓			
Reduce stress on water supply infrastructure				✓		
Reduce size of other stormwater BMPs					✓	
<b>Water Sources</b>						
Roofwater – Residential	✓		✓	✓	✓	✓
Roofwater – Nonresidential	✓		✓	✓	✓	✓
Stormwater – Wet Detention Pond	✓	✓	✓			
Stormwater – Urban sewers	✓		✓			
Stormwater – Waterways	✓		✓			
Stormwater – Wetlands	✓		✓			
Sewage	✓					
Greywater	✓					
<b>Reuse Applications</b>						
Irrigation – Playing fields, golf courses, public parks and gardens, residential, commercial	✓	✓	✓	✓	✓	✓
Irrigation – Agricultural	✓	✓	✓			
Residential – Toilet flushing, vehicle washing	✓	✓	✓	✓		✓
Residential – Washing machine use	✓			✓		✓
Residential – Dual reticulation	✓					
Municipal – Fire-fighting or fire-suppression	✓	✓	✓	✓		
Municipal – Water features and ponds	✓	✓	✓	✓		
Municipal – Street cleaning	✓		✓	✓		
Industrial – Cooling tower make-up	✓	✓	✓	✓		
Industrial – Miscellaneous	✓		✓	✓		
Industrial – Dust control	✓		✓			
Industrial – Feed lot cleaning		✓				
Hydrological – Downstream flow augmentation		✓	✓			
Hydrological – Aquifer storage and recovery	✓		✓			



# San Francisco Public Utilities Commission (SFPUC)



## **BLUEPRINT** for Onsite Water Systems

**A Step-by-Step Guide for Developing a Local Program to Manage Onsite Water Systems**

An aerial night photograph of the San Francisco skyline, showing numerous illuminated skyscrapers. In the foreground, a green rooftop garden with trees and walkways is superimposed over the cityscape. The Golden Gate Bridge is visible in the background, illuminated with lights.

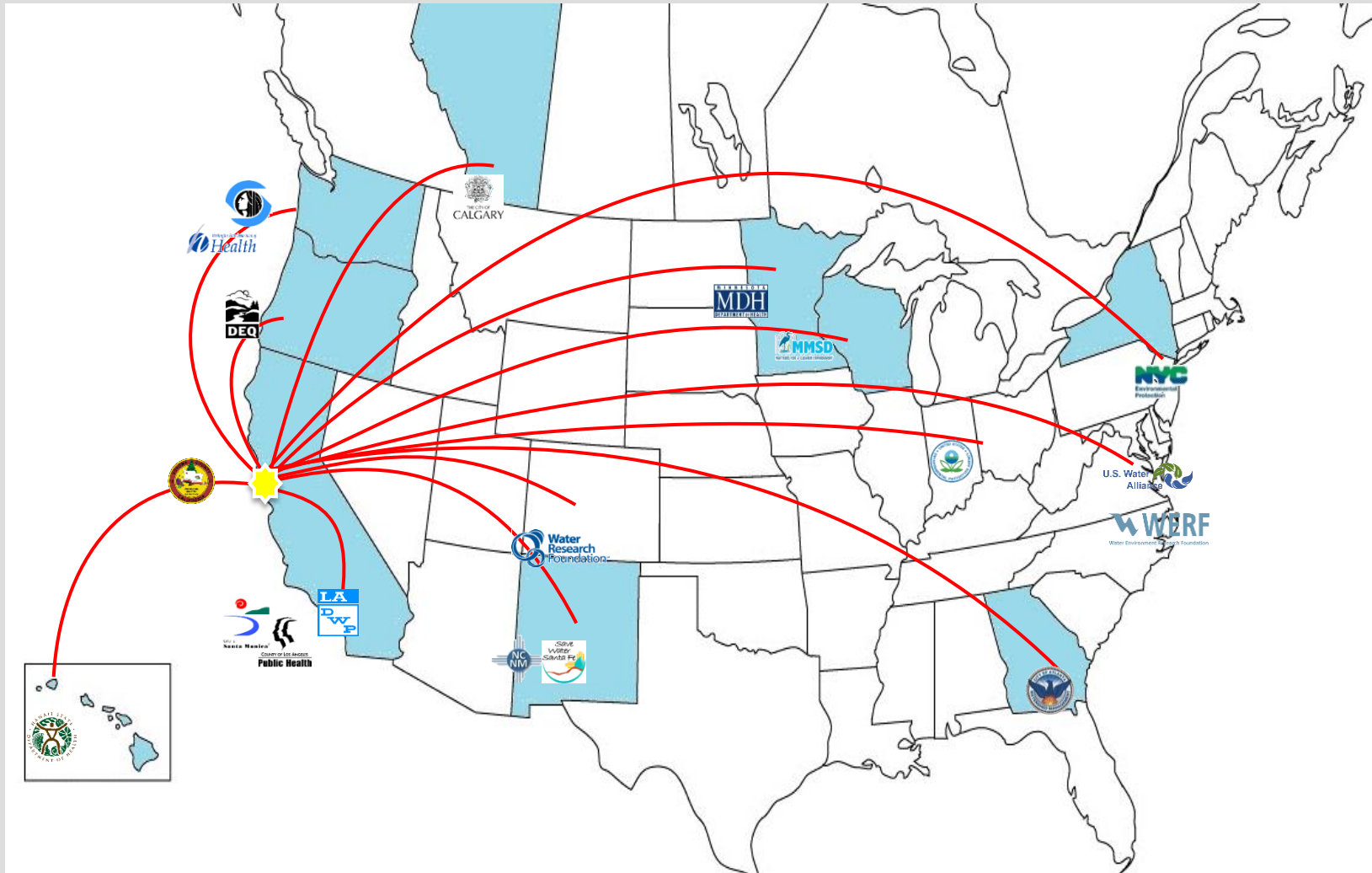
**Re-think Building Design &  
Re-imagine How Water is Used**

# On-site Water Systems Worldwide – It's Happening Now!



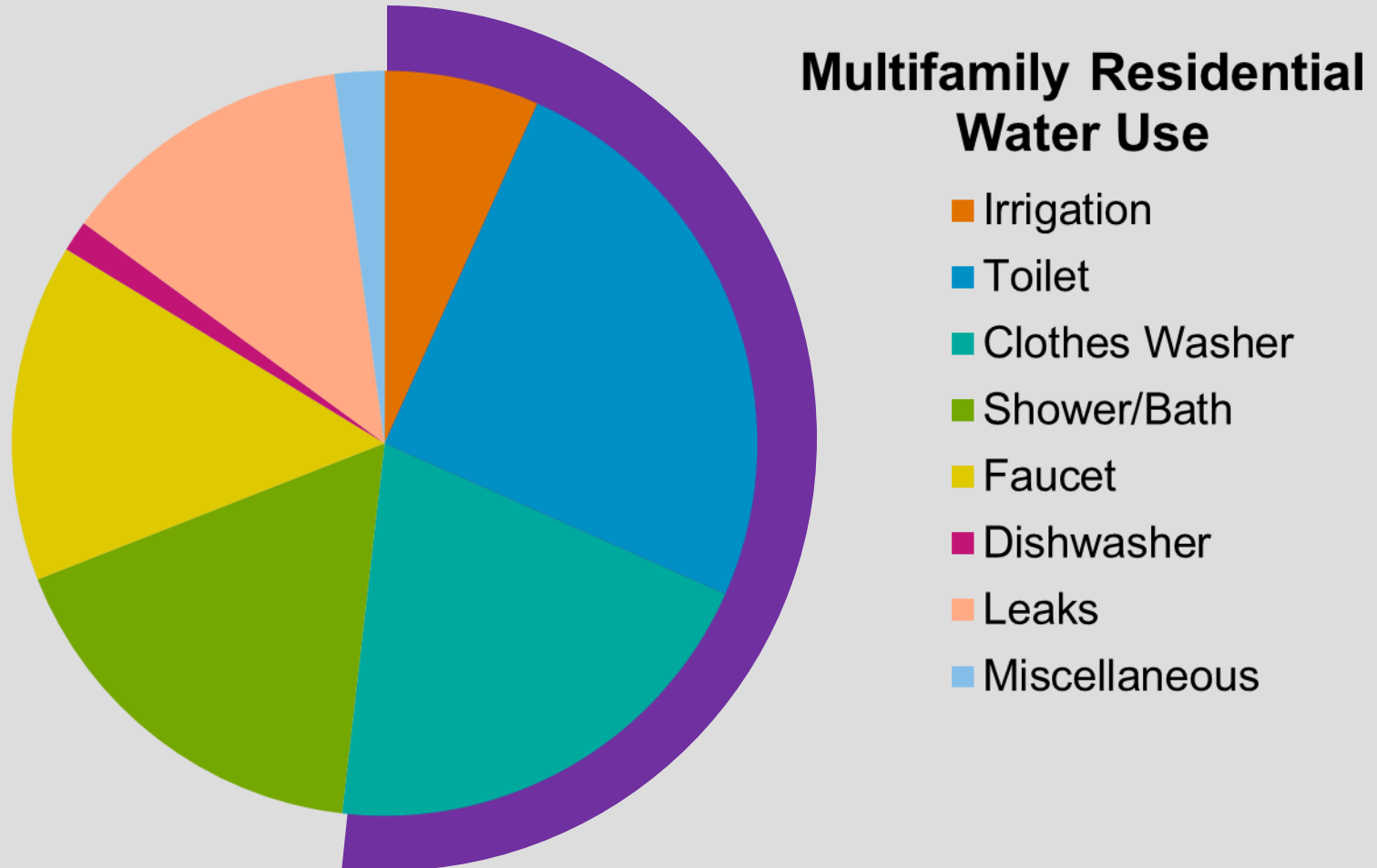


# Collaborating with Others



# Re/Use for Conservation

**Up to 50% of Demands are Non-potable in Multifamily Residential Buildings**



Source: adapted from Alliance for Water Efficiency

Source: SFPUC



**Up to 95% of Demands are Non-potable in Commercial Buildings**



## Office Water Use

- Sanitary
- Cooling Tower Make-up
- Irrigation
- Single-Pass Cooling
- Kitchen
- Miscellaneous

# City Ordinance Codifies Program & Streamlines Process

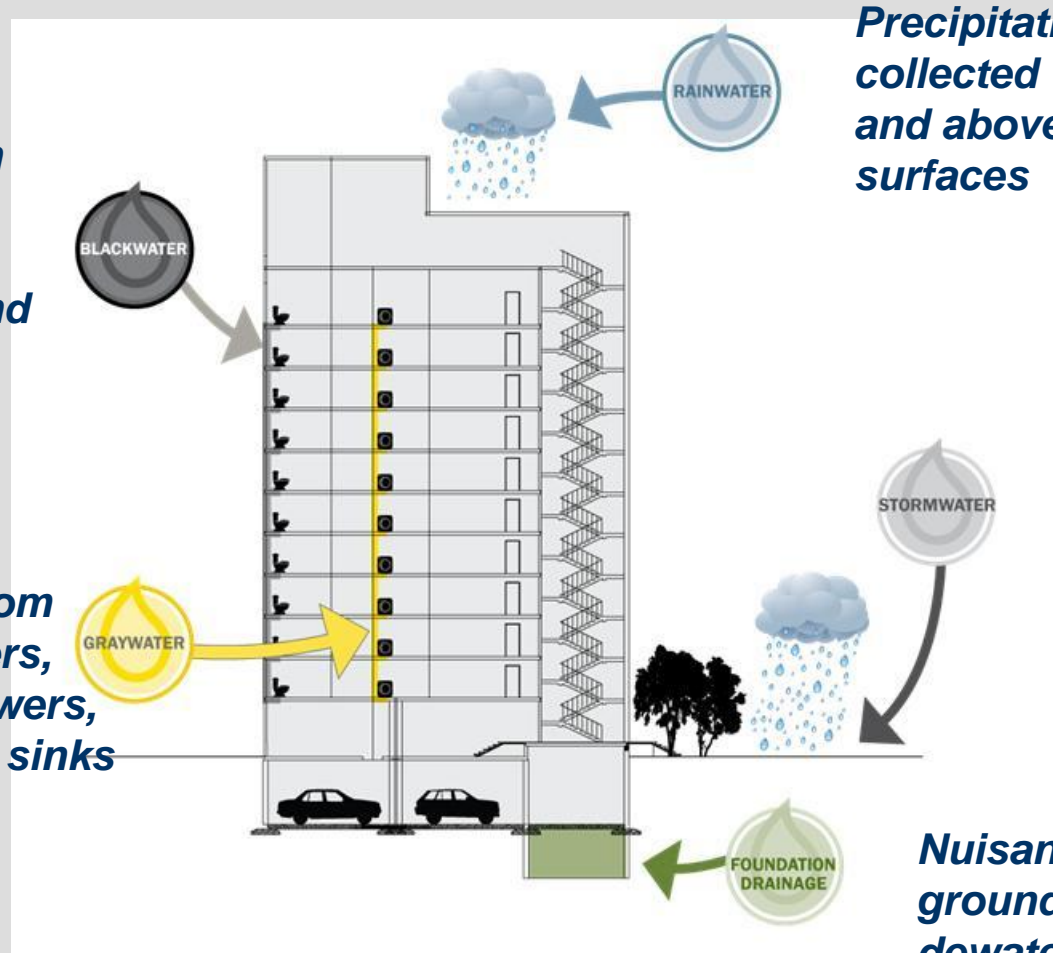
SFPUC	SFDPH	SFDBI	SFDPW
Program Administration	Public Health	Construction	Right of Way and Mapping
<p>Review onsite non-potable water supplies &amp; demands</p> <p>Administer citywide project tracking &amp; annual potable offset achieved</p> <p>Provide technical support &amp; outreach to developers</p> <p>Provide financial incentives to developers</p>	<p><b>Issue water quality &amp; monitoring requirements</b></p> <p><b>Review and approve non-potable engineering report</b></p> <p><b>Issue permit to operate onsite systems</b></p> <p><b>Review water quality reporting</b></p>	<p>Conduct Plumbing Plan check and issue Plumbing Permit</p> <p>Inspect and approve system installations</p>	<p>Issue Encroachment Permits as needed for infrastructure in the Right-of-Way (if needed)</p> <p>Includes condition on a subdivision map or a parcel map requiring compliance with the Non-potable Ordinance prior to approval and issuance of said map (if applicable)</p>



# Types of Alternate Water Sources for Non-potable Applications

*Wastewater from toilets, dishwashers, kitchen sinks, and utility sinks*

*Wastewater from clothes washers, bathtubs, showers, and bathroom sinks*



*Precipitation collected from roofs and above-grade surfaces*

*Precipitation collected at or below grade*

*Nuisance groundwater from dewatering operations*

# On-site Non-potable Water Use at Innovative SFPUC Headquarters

## Rainwater Harvesting System

**25,000 gallon cistern**

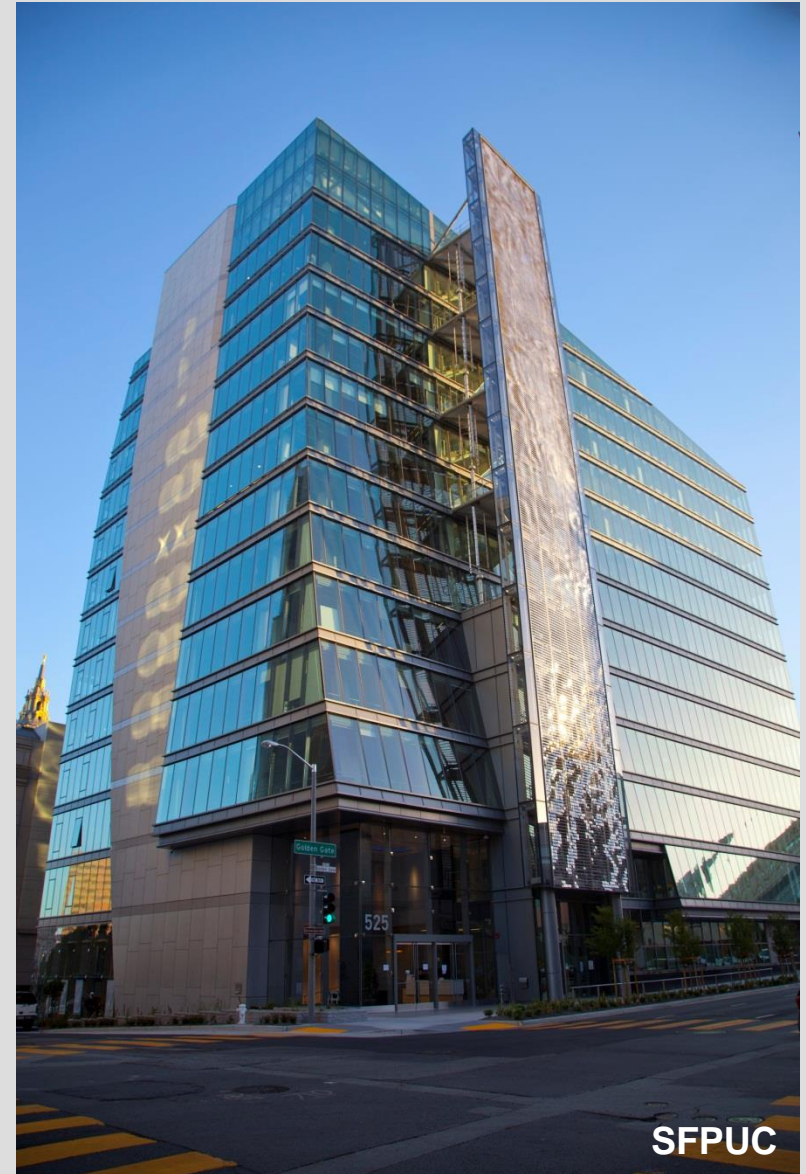
**Reuse for irrigation**

## Wetland Treatment System

**Collects and treats  
building's wastewater**

**Reuse for toilet flushing**

**5,000 gpd capacity**





# Runoff Treatment - A Paradigm Hierarchy Shift



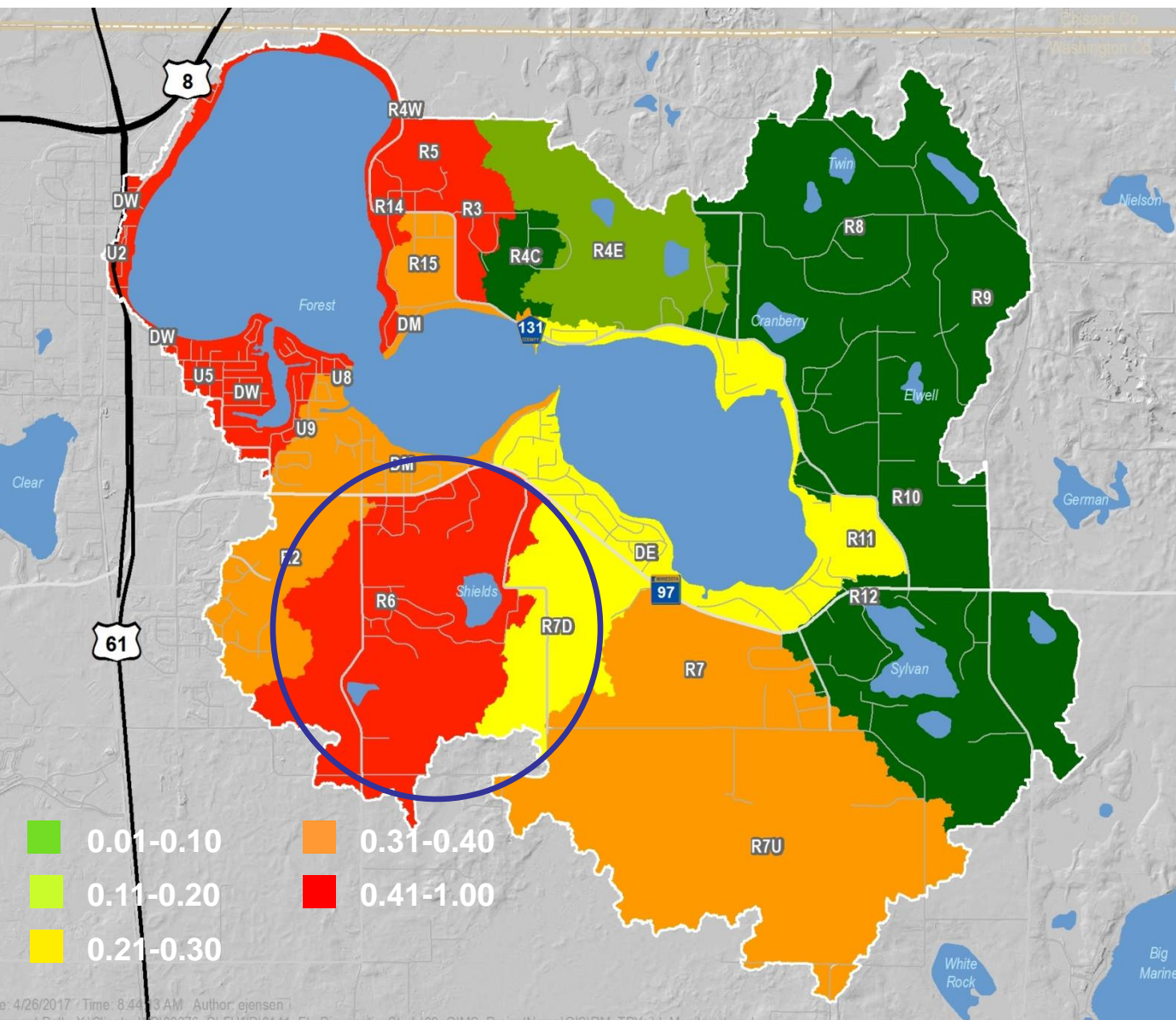
Source: City of Santa Monica, CA - Office of Sustainability and the Environment

# Reuse Examples

- 
- A photograph of a golf course landscape. In the foreground, there is a green lawn. In the middle ground, a sand trap is visible on the left, and a pond with reeds is on the right. A line of tall evergreen trees runs across the background. A small building is partially visible behind the trees on the right. The sky is clear and blue.
1. Rural/Agr./Golf Course – Shields Lake
  2. Residential (Suburban) – Argenta Hills, IGH
  3. Residential (Ultra Urban) – Rose, Mpls
  4. School/Residential – Waconia Athletic Fields
  5. Office (Ultra Urban) – Capital Region WD



# Shields Lake Reuse Project 2016 TP Yields (lb/ac-yr)



**West (761 ac)**

**450 lb**

**Middle (1,841 ac)**

**958 lb**

**East (5,948 ac)**

**1,258 lb**

**Priority Subsheds**

**% of Total Load:**

JD6 = 30%

**Shields = 28%**

Direct = 16%

Hayward Ave = 9%

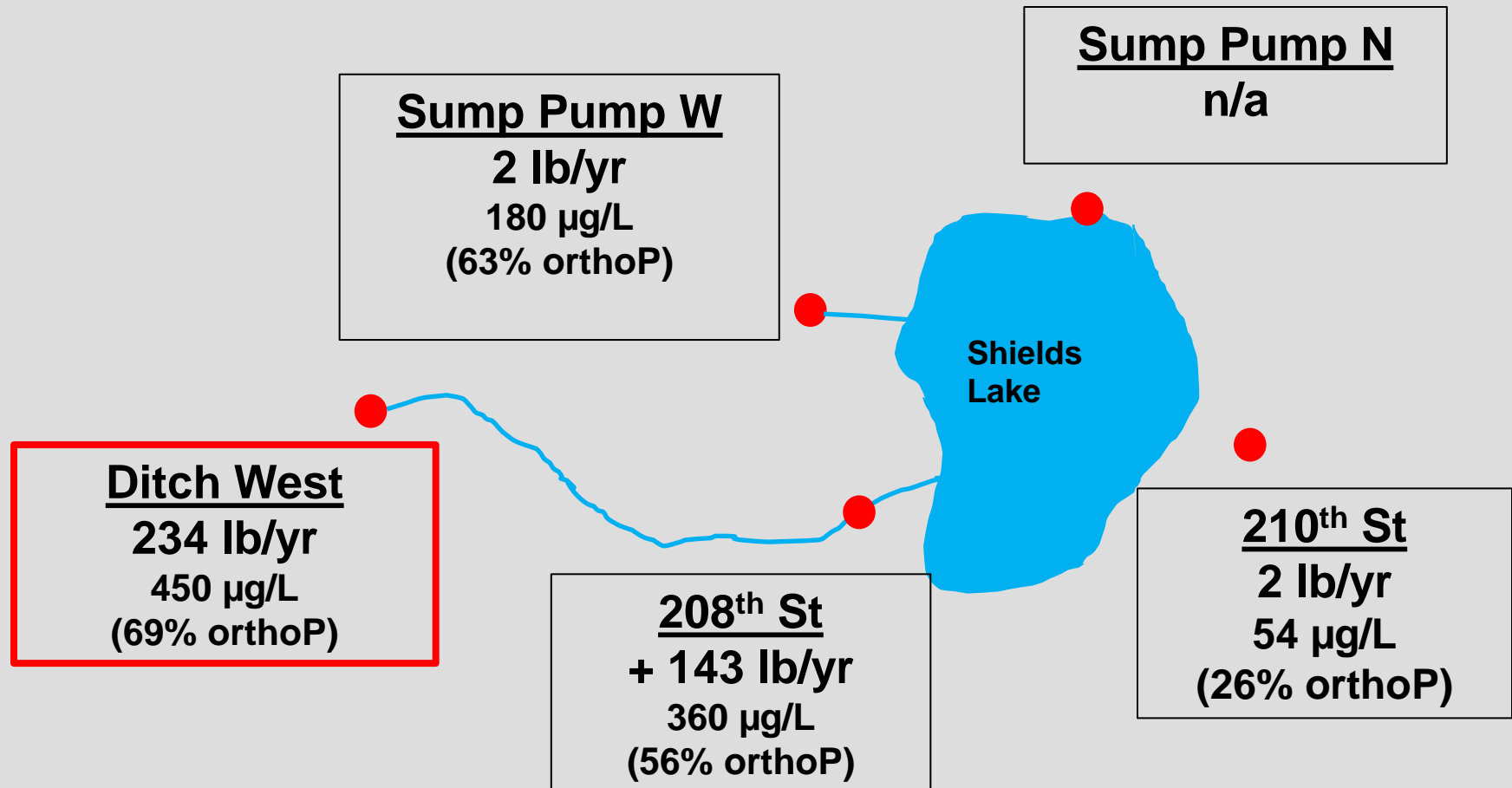
Castlewood E = 5%



# Shields Lake Diagnostic Monitoring

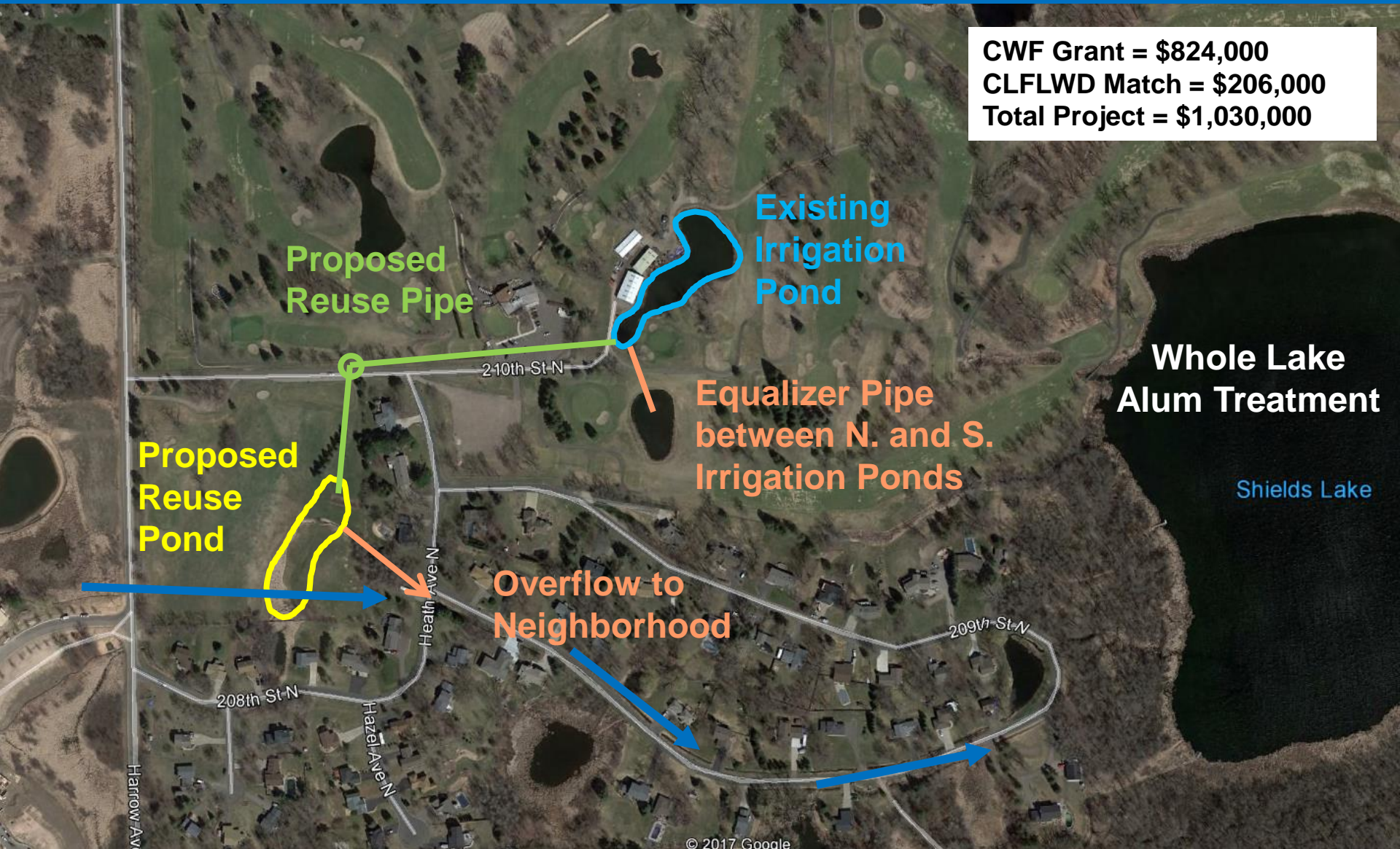
June 4, 2015 - June 6, 2016

Captured runoff from 89% of total watershed area



# Shields Lake Stormwater Reuse System & Alum Treatment Project

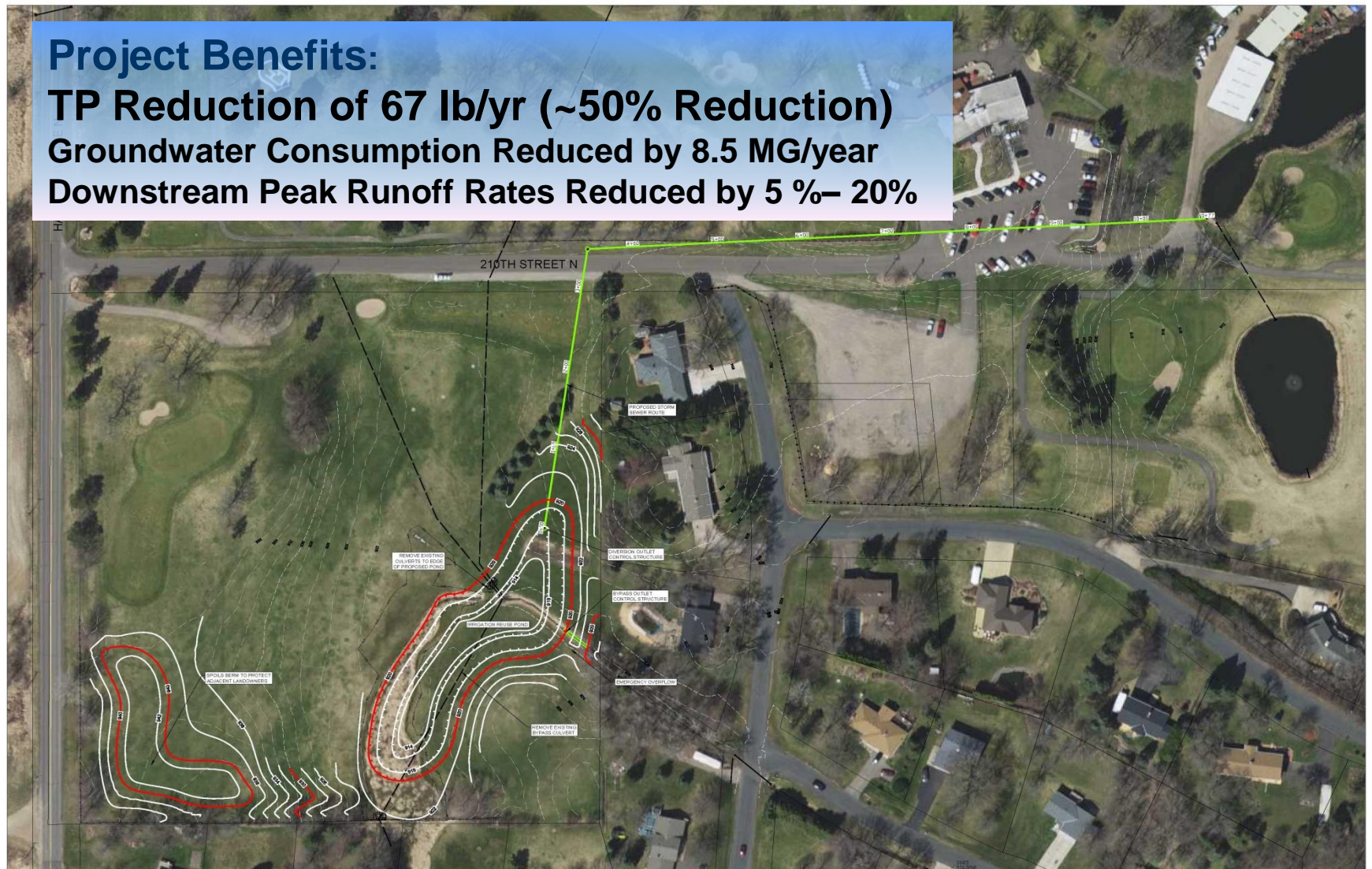
CWF Grant = \$824,000  
CLFLWD Match = \$206,000  
Total Project = \$1,030,000



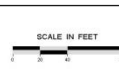


**EO** water  
ecology  
community

**TP Reduction of 67 lb/yr (~50% Reduction)**  
**Groundwater Consumption Reduced by 8.5 MG/year**  
**Downstream Peak Runoff Rates Reduced by 5 %– 20%**



6			
5			
4			
3			
2			
1			
NO	DATE	BY	REVISION



SUBMISSION DATE: 02-26-2018	
DESIGN BY SLP	DRAWN BY KDC
EOR PROJECT NO. 00376-0157	

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**Emmons & Olivier  
Resources, Inc.**  
651 Hale Avenue North  
Oakdale, MN 55128  
Tele: 651.770.8448  
[www.eorinc.com](http://www.eorinc.com)

**CLFLWD**  
44 LAKE STREET SOUTH, SUITE A  
FOREST LAKE, MN 55025

SHIELDS LAKE REUSE	
FOREST HILLS GOLF COURSE	
FOREST LAKE, MN	
STATE PROJECT NO.	CITY PROJECT NO.

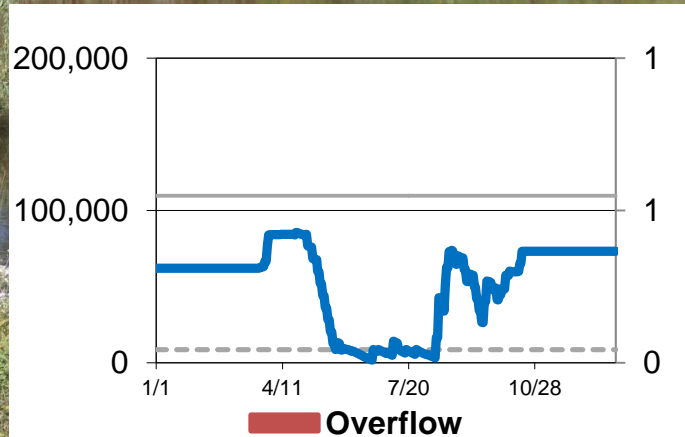
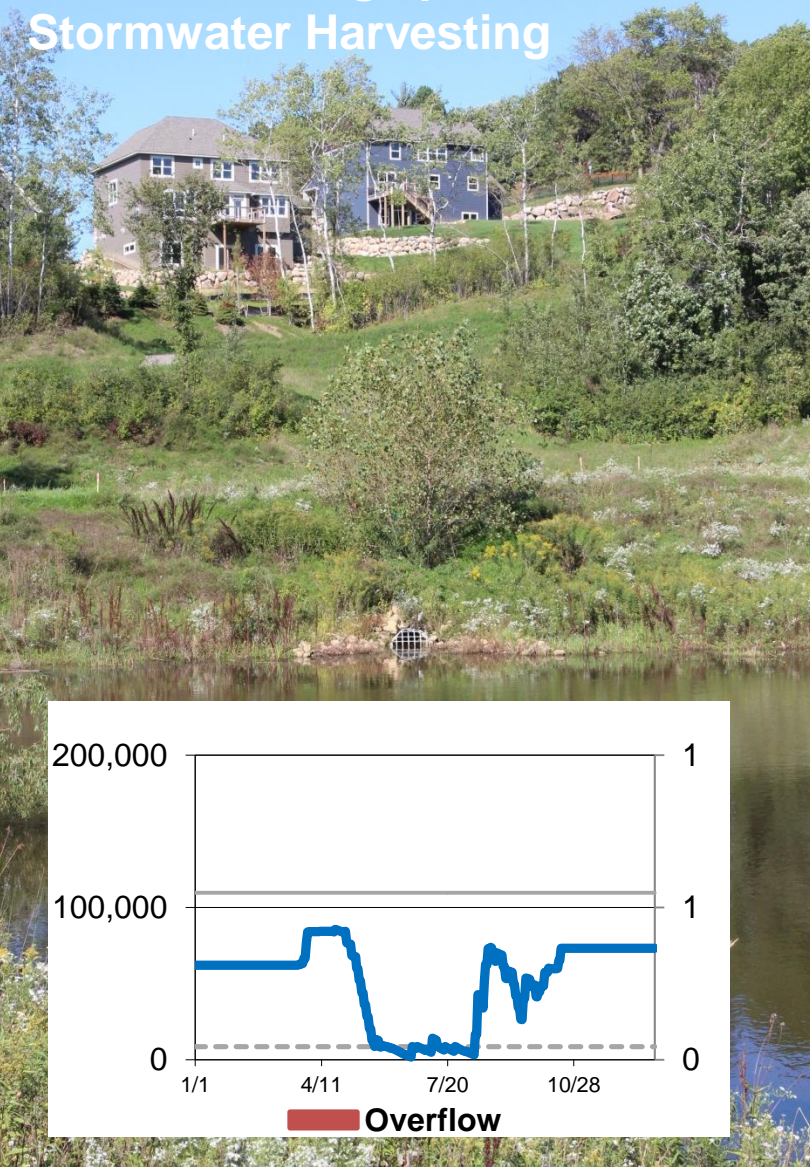
## SITE PLAN

SHEET 01 OF 01 SHEETS



# Argenta Hills Development

Natural drainage patterns,  
Stormwater Harvesting



Cul-de-sac filtration gardens



Open/green space planning





## Argenta Hills Development





# The Rose - Urban Redevelopment

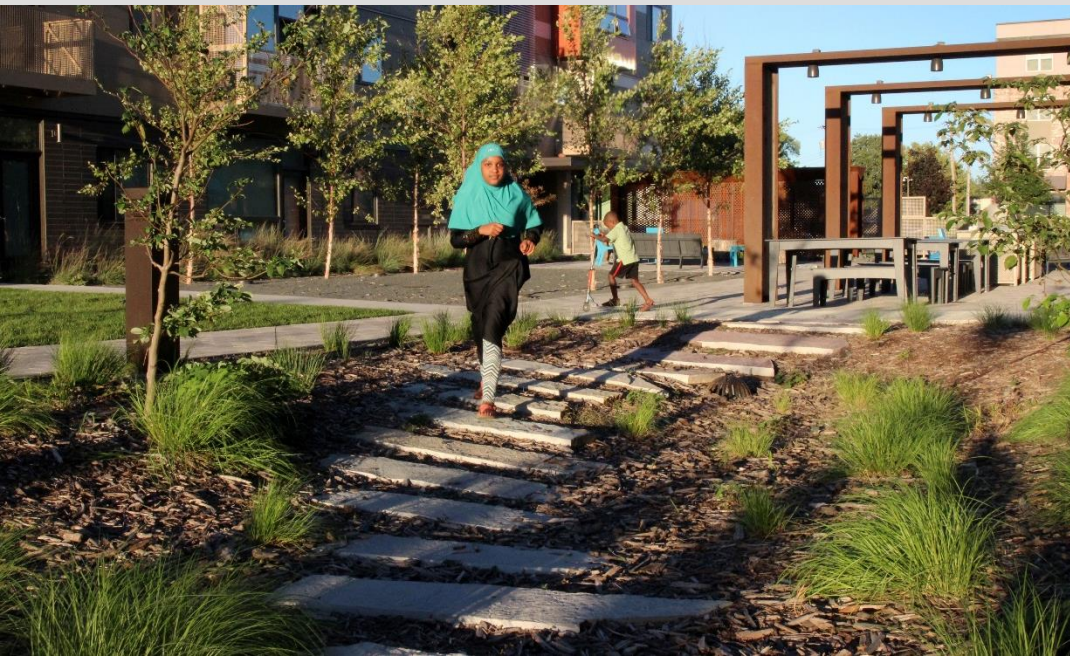
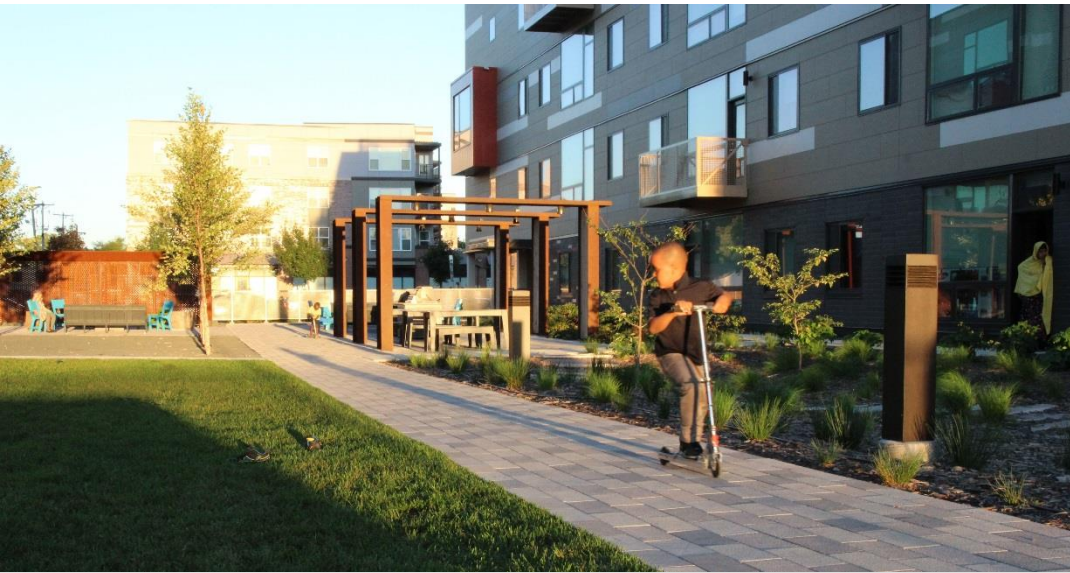
## Livable Communities / Quality of Life



Rendering by MSR Design



# The Rose- Urban Redevelopment



## Urban Greyfield Redevelopment to Multi-Family, Mixed-Income, Sustainable Community Housing

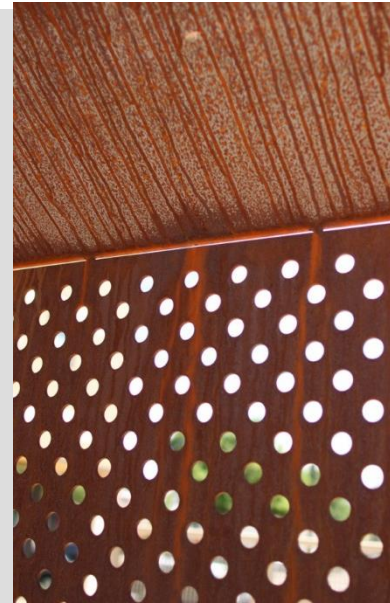




# The Rose- Urban Redevelopment



Community garden with  
stormwater reuse system for irrigation



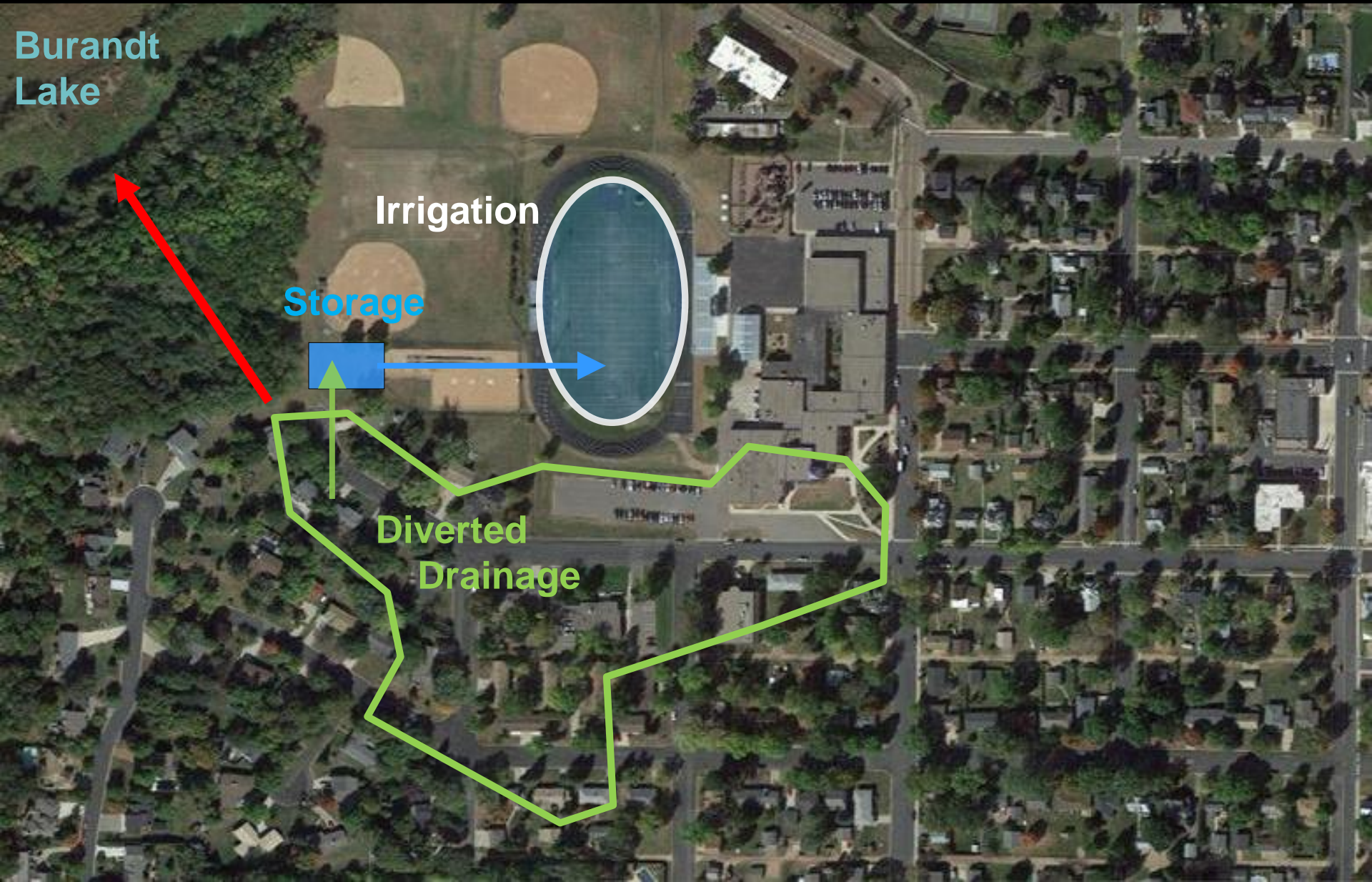
Interpretive Water-Wall



Native landscaping with  
stormwater storage



# Reuse Helps a School: Bayview School, Waconia, MN (win-win-win)





# Reuse Helps a School: Bayview School, Waconia, MN:





# Office Redevelopment – CRWD Offices

## Work Space and Teaching Lab



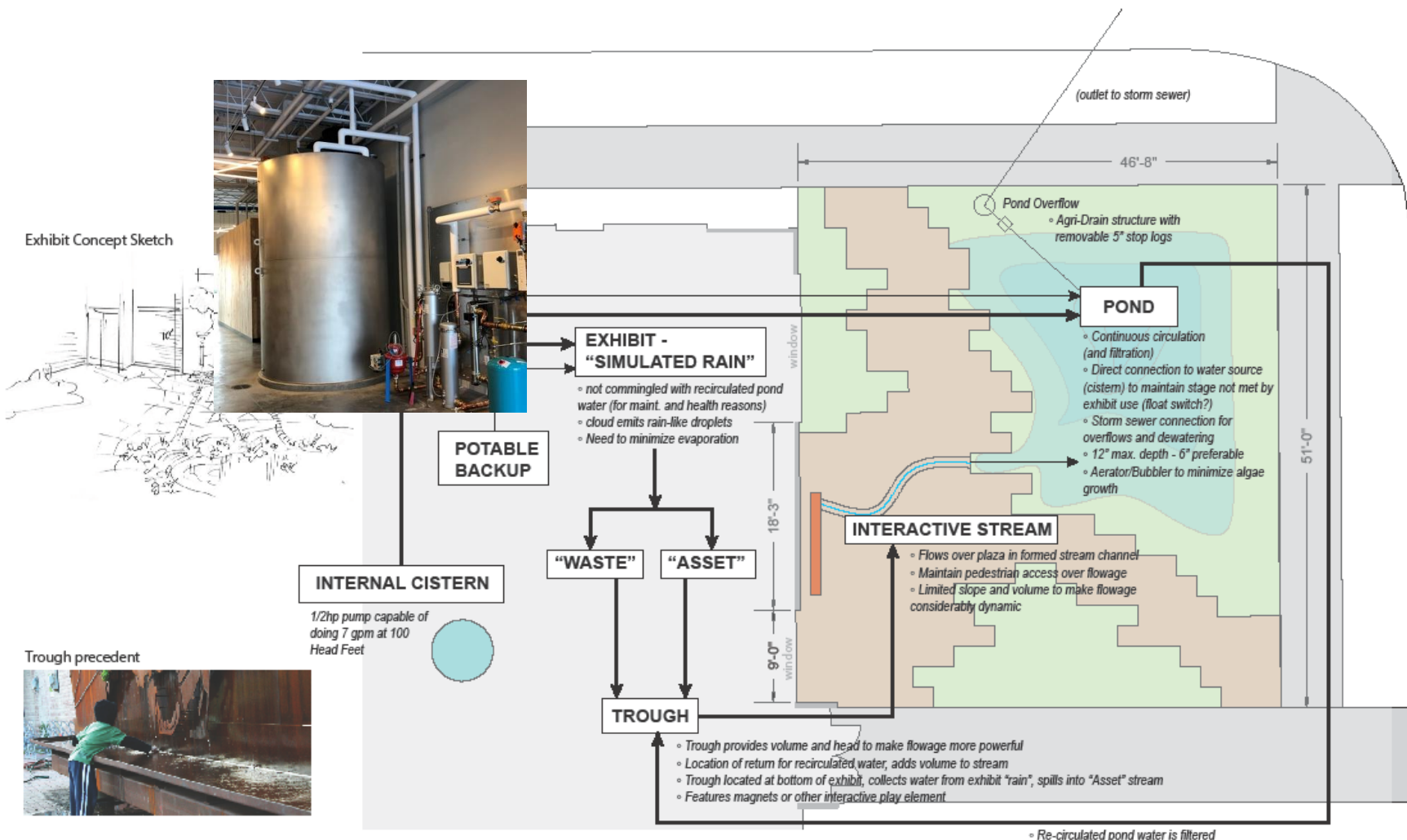


## Example 2: CRWD Office



**Urban Greyfield Redevelopment  
to Sustainable Office  
Reuse – Indoor and Outdoor**

# Example 2: CRWD Office



## POCKET PARK - STORMWATER ROUTING DIAGRAM













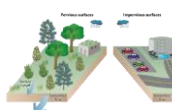

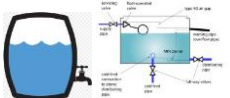













6/25/2018



## Reuse Models (Reviewed in MN Stormwater Manual)








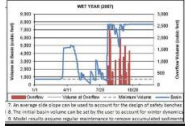
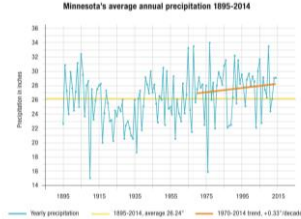
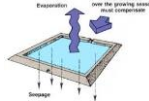





1. Virginia Department of Conservation and Recreation (VDCR)
2. North Carolina State University (NCSU)
3. Texas Water Development Board (TWDB)/ American Rainwater Catchment Systems Association (ARCSA)
4. San Francisco Public Utilities Commission (SFPUC)
5. MN Mississippi Watershed Management Organization (MWMO) / Minnehaha Creek Watershed District (MCWD)
6. MN Metropolitan (Met) Council
7. Minnesota Pollution Control Agency (MPCA) / Ramsey-Washington Metro Watershed District (RWMWD)

**EOR** water  
ecology  
community

Category	Subcategory	VDCR Cistern Design Spreadsheet	NCSU Rainwater Harvester	TWDB Rainwater Calculator	SFPUC Rainwater Harvesting Calculator	MWMO Stormwater Reuse Calculator	Met Council Water Balance Tool	MPCA MIDS Calculator
Required Inputs	Precipitation		 Hourly  RATES			Wet Average Dry Years		
	Evapo- transpiration	N/A						
	Runoff Generation							
		N/A	NITROGEN	N/A	N/A	TP	N/A	TP, TSS
	Storage							
		 Types of PLANTS	 Types of PLANTS	 Climate Factors				
	Use: Irrigation	 Area		 Rate	 Start/End Irrigation Season			
Use: Non- irrigation		 USER DEFINED	USER DEFINED		USER DEFINED	N/A	N/A	



# Know Your Context & Pick the Tool

	VDCR Cistern Design Spreadsheet	NCSU Rainwater Harvester	TWDB Rainwater Calculator	SFPUC Rainwater Harvesting Calculator	MWMO Stormwater Reuse Calculator	Met Council Water Balance Tool	MPCA MIDS Calculator
Generated Outputs	Annual Average		Monthly Average		Annual Average Daily Average	Annual Average	
							
							
Advantages							
		DD/MM/YY to DD/MM/YY					
Limitations		Black Box	Monthly Time Step		Representative Precipitation Years		Designed Primarily for Other BMPs
	Based on Climate and Precipitation Data From:						
							

# Source and Use Considerations

Beneficial Uses		Harvested Water	
		Rainwater (Rooftops)	Stormwater
Outdoor	Sanitary sewer flushing	○	●
	Irrigation – low exposure risk	(●)	●(●)
	Irrigation – high exposure risk	●(●)	●●(●)
	Vehicle/building washing	●(●)	●(●)
	Fire fighting	(●)	●(●)
	Water features (uncontrolled access)	●●	●●
	Street cleaning/ dust control	●(●)	●(●)
Indoor	Fire suppression	●●	●●
	Cooling	●(●)	●(●●)
	Process /Boiler Water	●(●)	●(●●)
	Flushing	●(●)	●●(●)
	Washing	●●	●●(●)
	Drinking water	●●●●	●●●●

## Required Water Quality at Point of Use

● = 1 Limited human exposure

●● = 2

●●● = 3

●●●● = 4 Drinking water standards



## Effort Required to Treat Source

○ = no treatment needed

● = minimal (pretreatment)

●● = medium (pretreatment + disinfection)

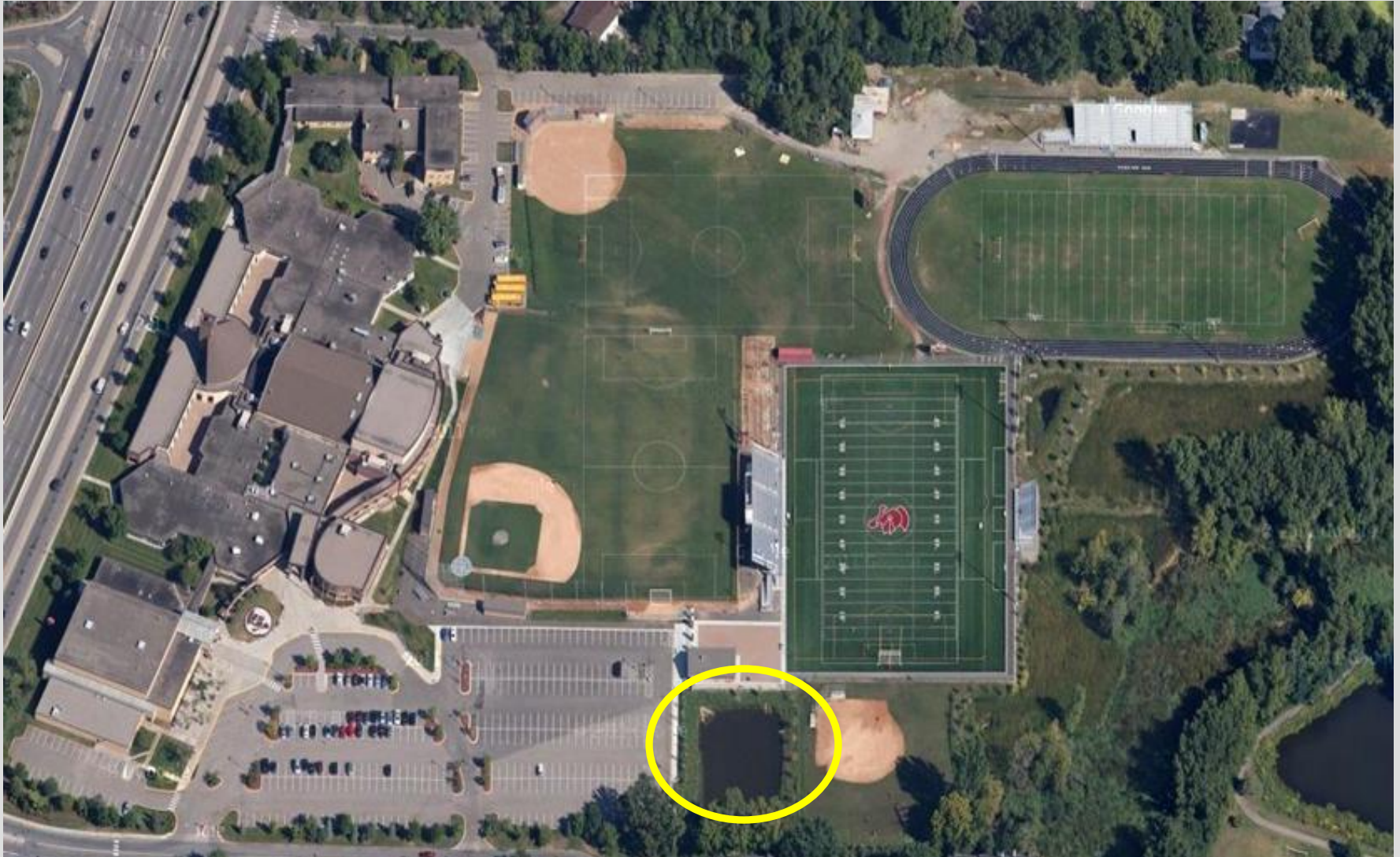
●●● = high (pretreatment + treatment + disinfection)

●●●● = drinking water standards



# The Reuse Calculator

## Benilde-St. Margaret Example:





# The Reuse Calculator

## Benilde-St. Margaret Example:

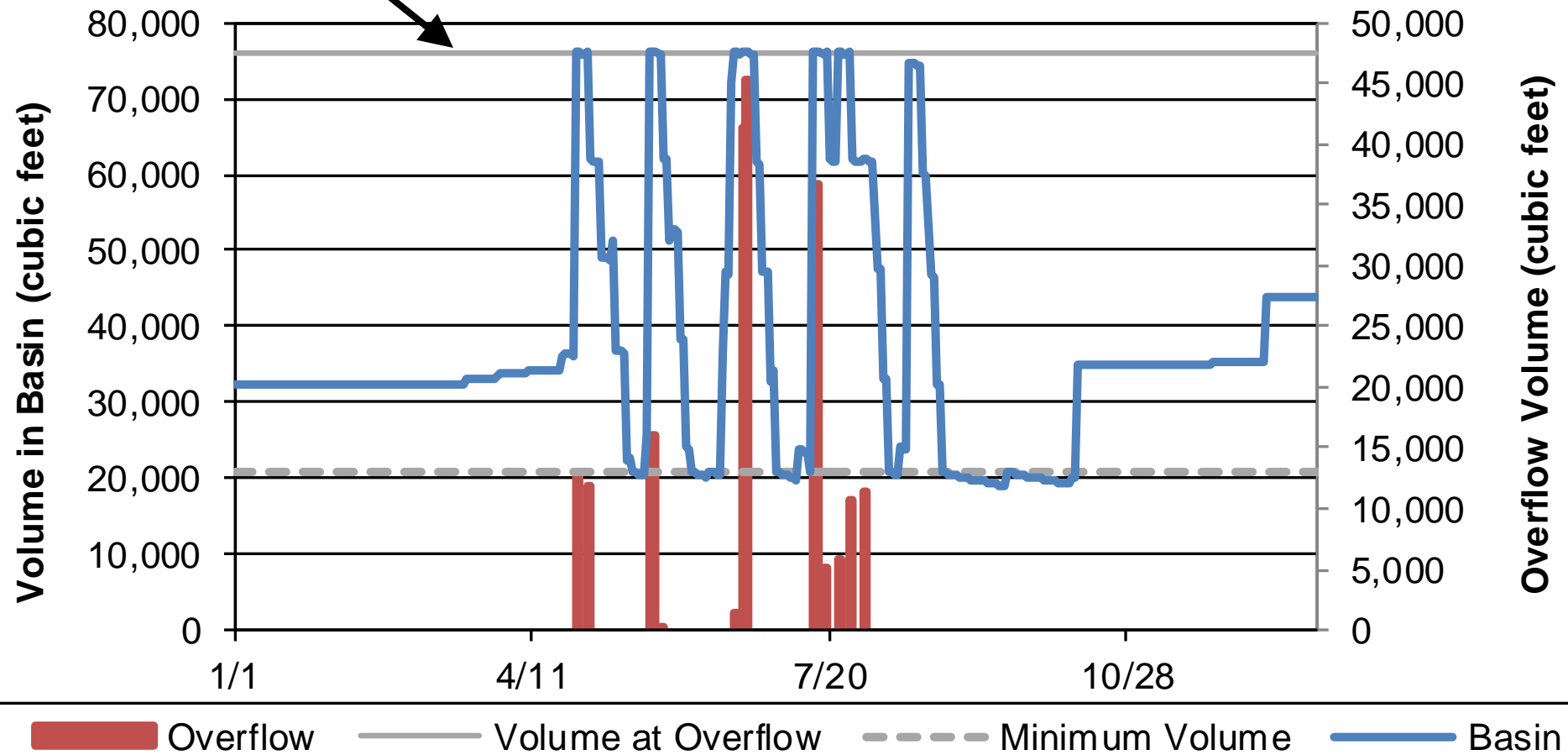




## Benilde-St. Margaret Example:

**Overflow**

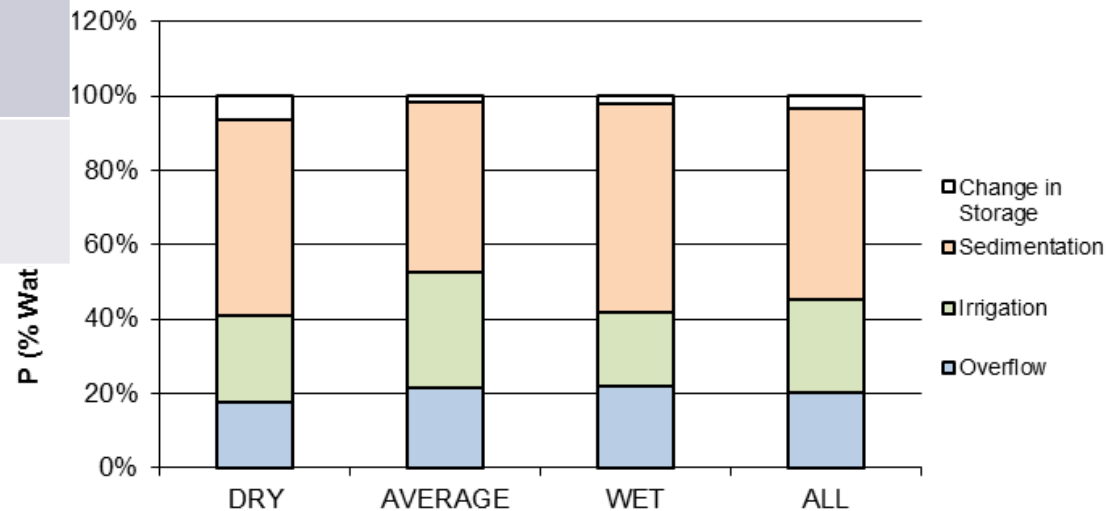
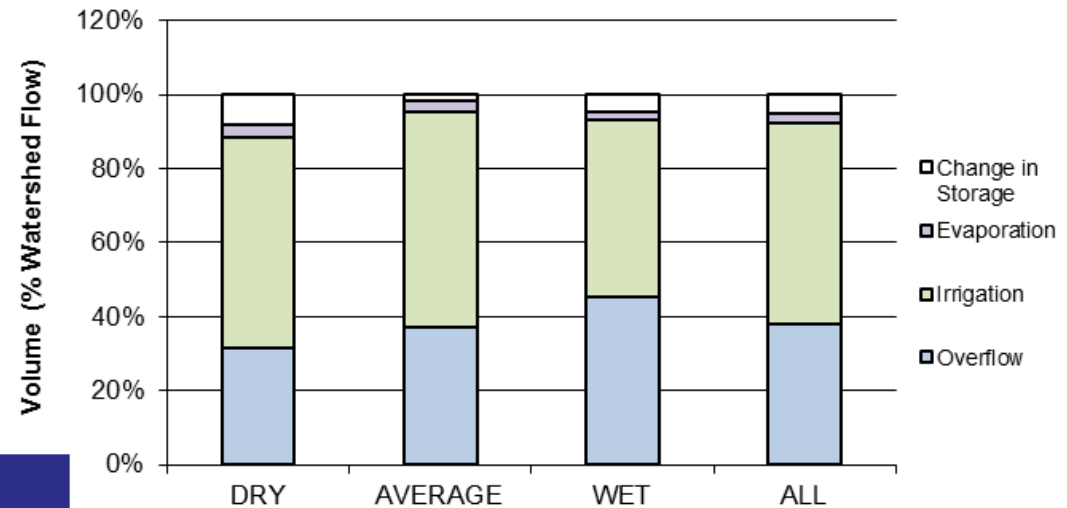
**AVERAGE YEAR (2011)**



# The Reuse Calculator: Benilde-St. Margaret Example

**Area = 31 Ac.  
Impervious = 38%**

**Treatment Reductions:**

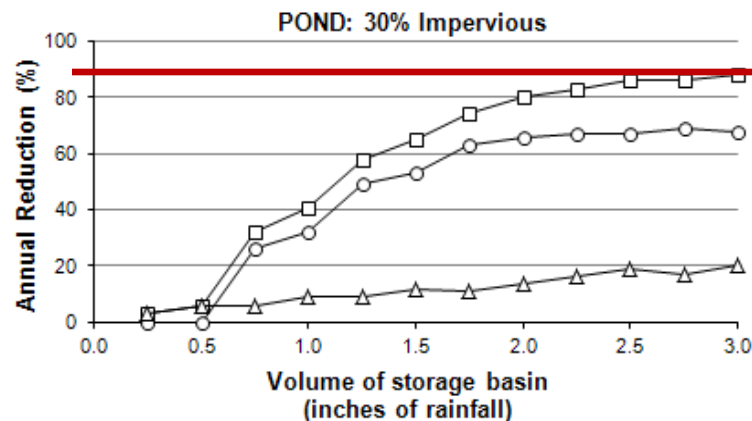
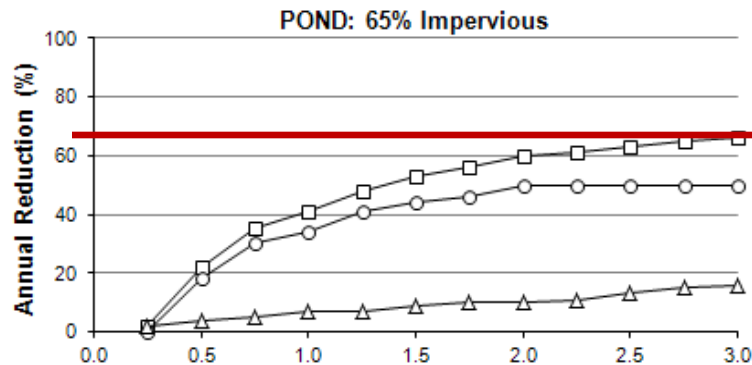
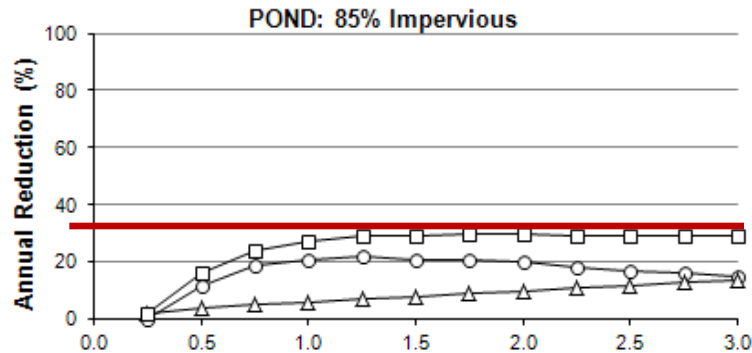


	Phosphorus	Volume
Conventional	50 %	3 %
Reuse	80 %	62 %



# Conclusions

—○— Volume - Irrigation —△— Volume - Evaporation —□— Volume - Total



**Need to optimize storage (\$)  
with stormwater reduction (%)**

**Available green space as  
limitation in ultra-urban  
settings (off-site, parks)**

**Size (& \$) of storage basin is  
only limitation with open  
space**

**Retrofit existing  
ponds/reservoirs?**

- **Reduce Strain on Supply**
  - **Alternative Water Supply**
- **Shift Irrigation away from Potable (e.g., Golf Courses)**
- **Sustainability Goals**
  - **Energy Conservation / GHG Reductions**
- **Distributed System (less Centralized) – Resiliency**
- **Reduce Stormwater Impacts! – Overcome:**
  - **New LID/GI Tool**
  - **Clayey Soils, Contamination, High Water Table, Shallow Bedrock**
  - **Highly Urban Areas – Building setbacks**
  - **...Regional Approaches!**

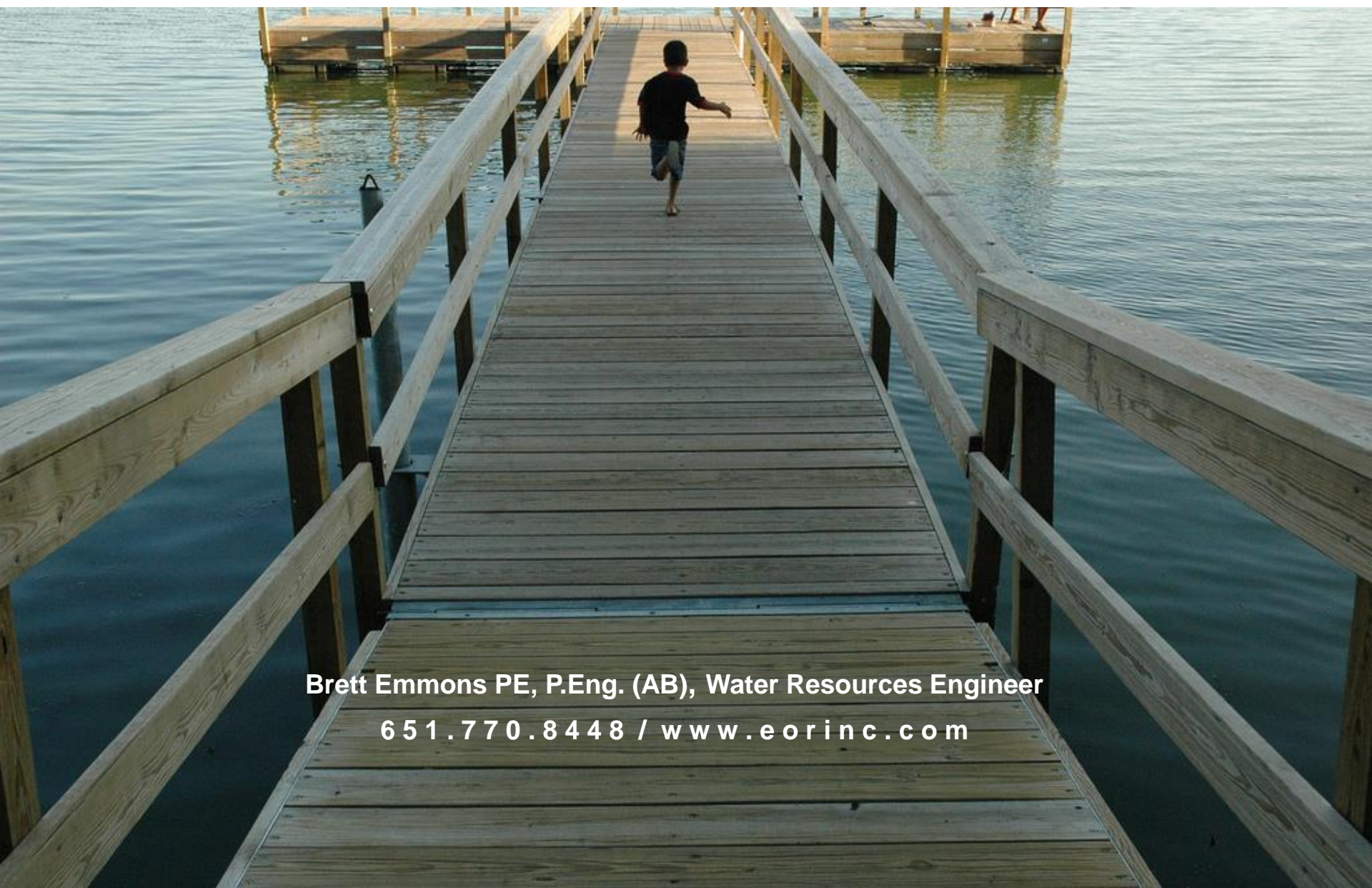


# Understand Your Goals

- 
- **Municipal Water System Design - Driven by Peak Demand (peak demand + fireflow)**
  - **Peak Demand can be x 2-4 Avg. Use in Summer (Irrigation)**
  - **--> Major Savings on Water Supply Infrastructure (water towers, pipe sizing) by Addressing Irrigation**



# Thank you



**Brett Emmons PE, P.Eng. (AB), Water Resources Engineer**

**651.770.8448 / [www.eorinc.com](http://www.eorinc.com)**



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