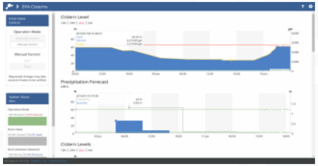
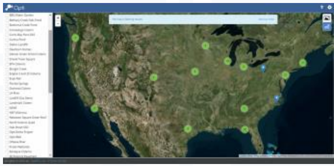
Monitoring and Improving Infrastructure Performance with Adaptive Control

WATER RESILIENT CITIES CONFERENCE

Climate Change, Infrastructure, Economies, and Governance in the Great Lakes Basin
– Cleveland, OH







Marcus Quigley| Chief Executive Officer

Opti

Presentation Overview

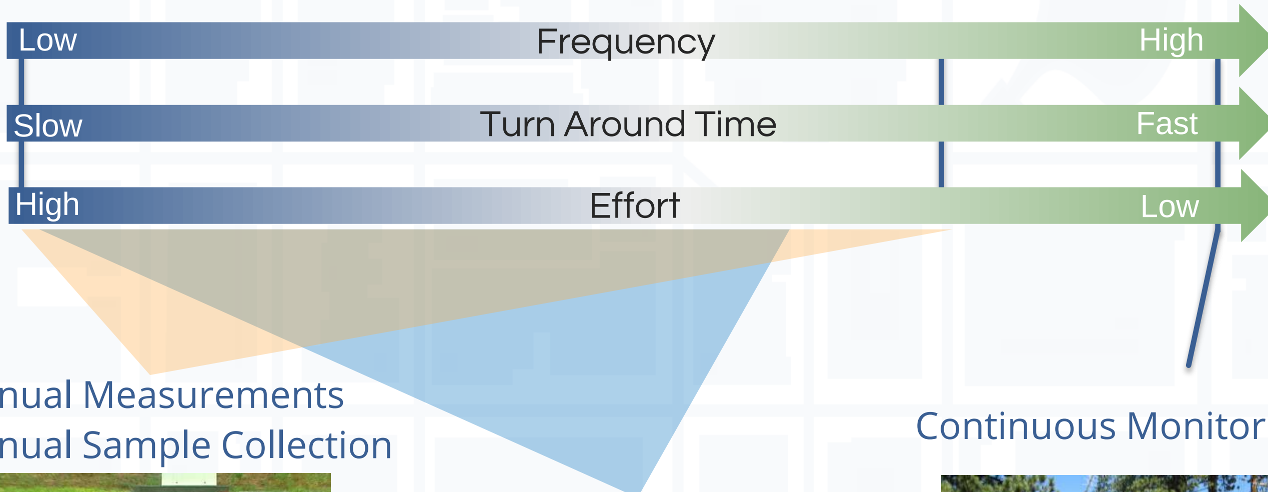
1. Stormwater and Green Infrastructure Monitoring
   - Overview of SW/GI Monitoring
   - Continuous Performance Monitoring
   - Examples and Case Studies

2. Stormwater and Green Infrastructure Control
   - Introduction to Continuous Monitoring and Adaptive Control
   - Case Studies

3. Questions

Stormwater and Green Infrastructure Monitoring

Traditional & Continuous Monitoring

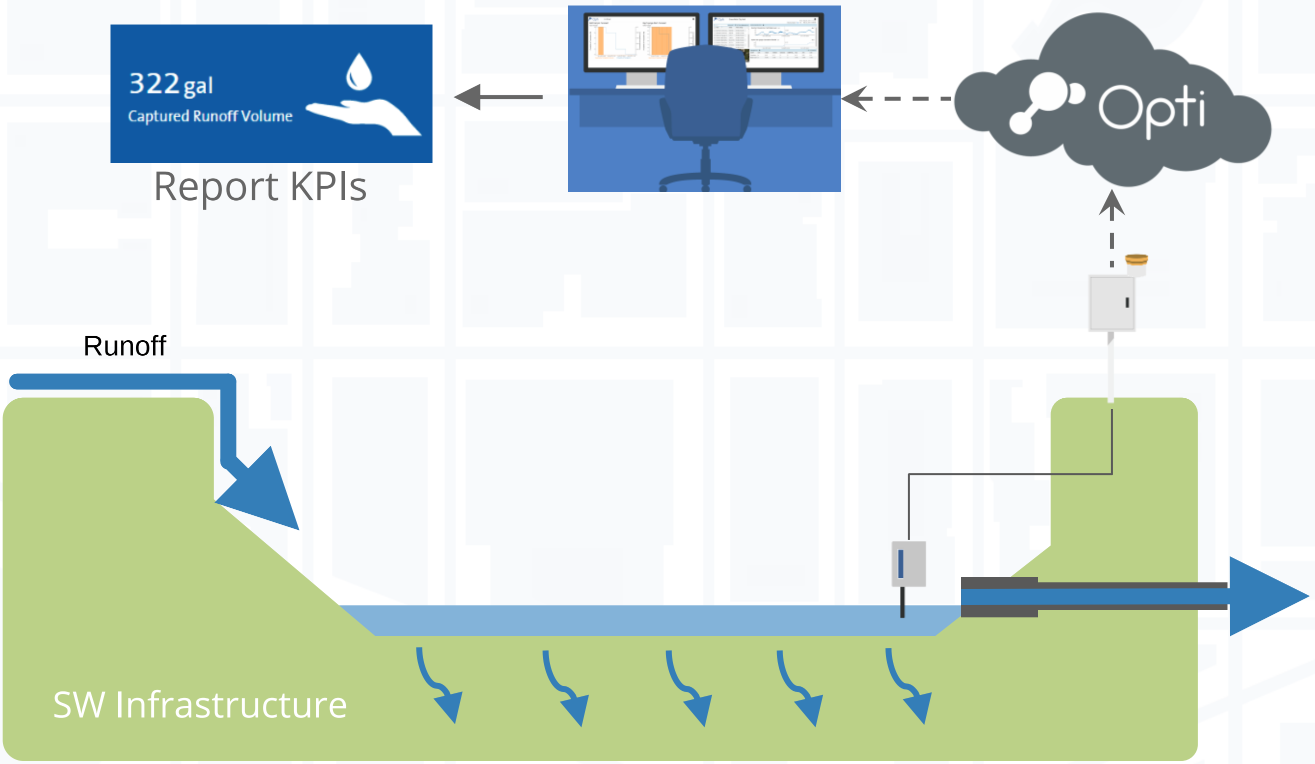


Manual Measurements
Manual Sample Collection

Auto Sampling
On-site Data Logging

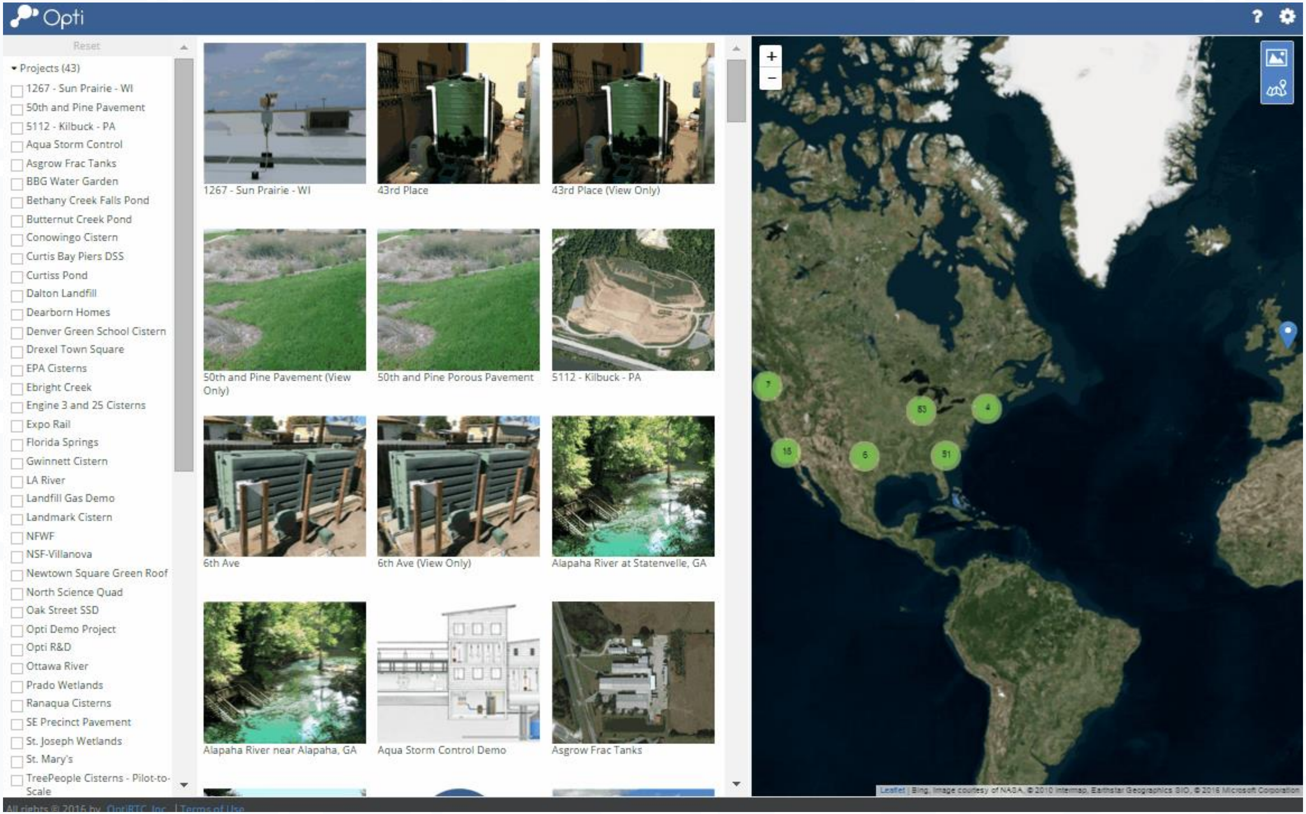
Continuous Monitoring

Continuous Performance Monitoring



Performance Reporting of GI

What does it look like in practice?



Milwaukee, WI
Greenfield City Hall – 7:20 am Today

Greenfield City Hall

12:00 18:00 20 Apr 06:00 12:00 18:00 21 Apr 06:00

Connectivity
(48hr)

Gateway 1
99.8% Online | 0.2% Offline

Gateway 2
99.9% Online | 0.1% Offline

Control Panel Door
(48hr)

66.6% Closed | 33.4% Open

Greenfield City Hall Camera

Latest Image | 12hr | 24hr

04/21/2016 07:15

KPI

99.2 %
Percent of time successfully controlled by Opti

System Control
6" Butterfly Valve

Operation Mode

Automatic Control
Manual Control

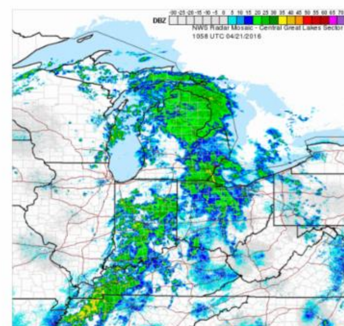
Drain Valve

Open
Close

Requested changes may take several minutes to be verified.

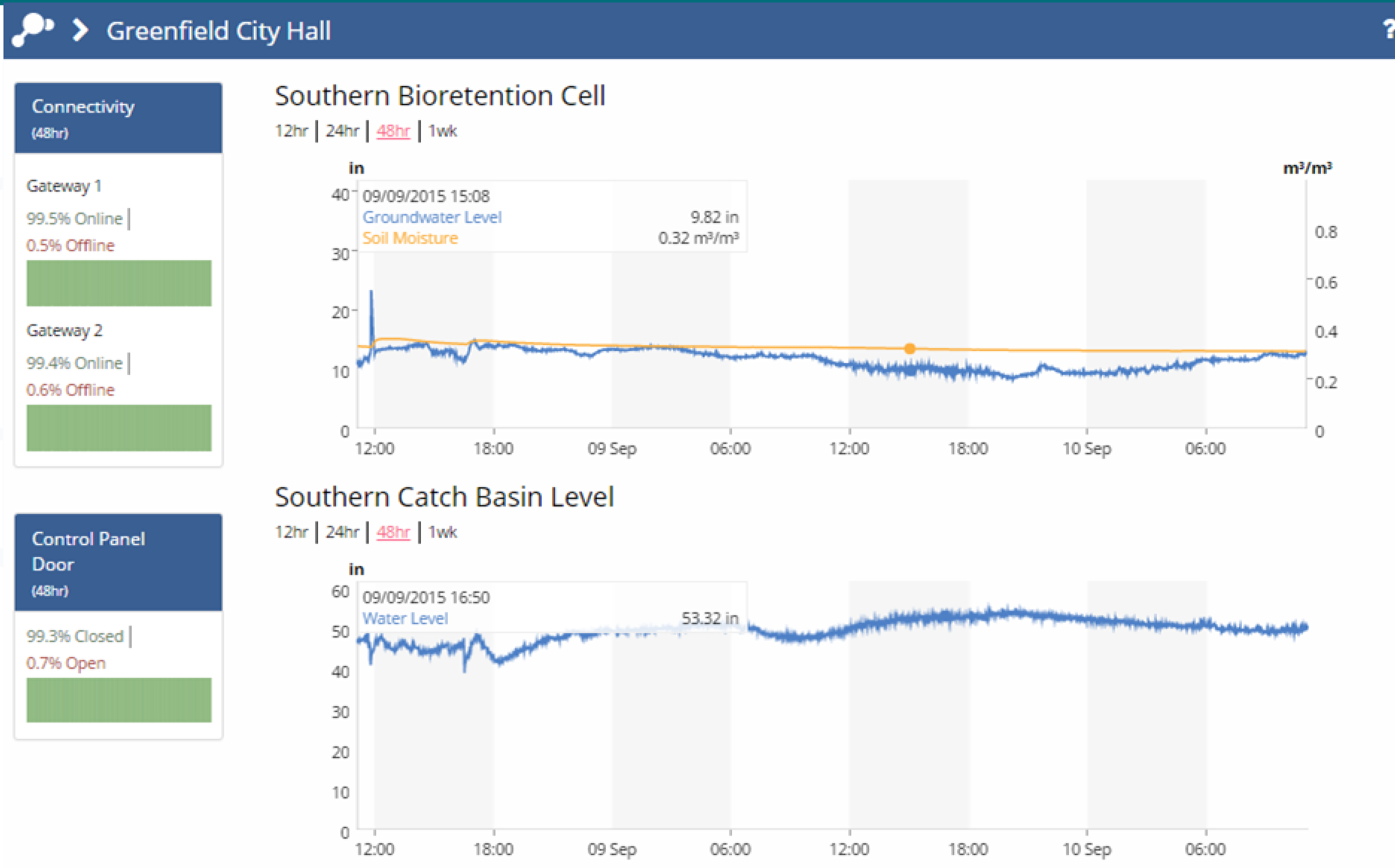
Great Lakes Radar
(NOAA)

Latest Image | 12hr | 24hr

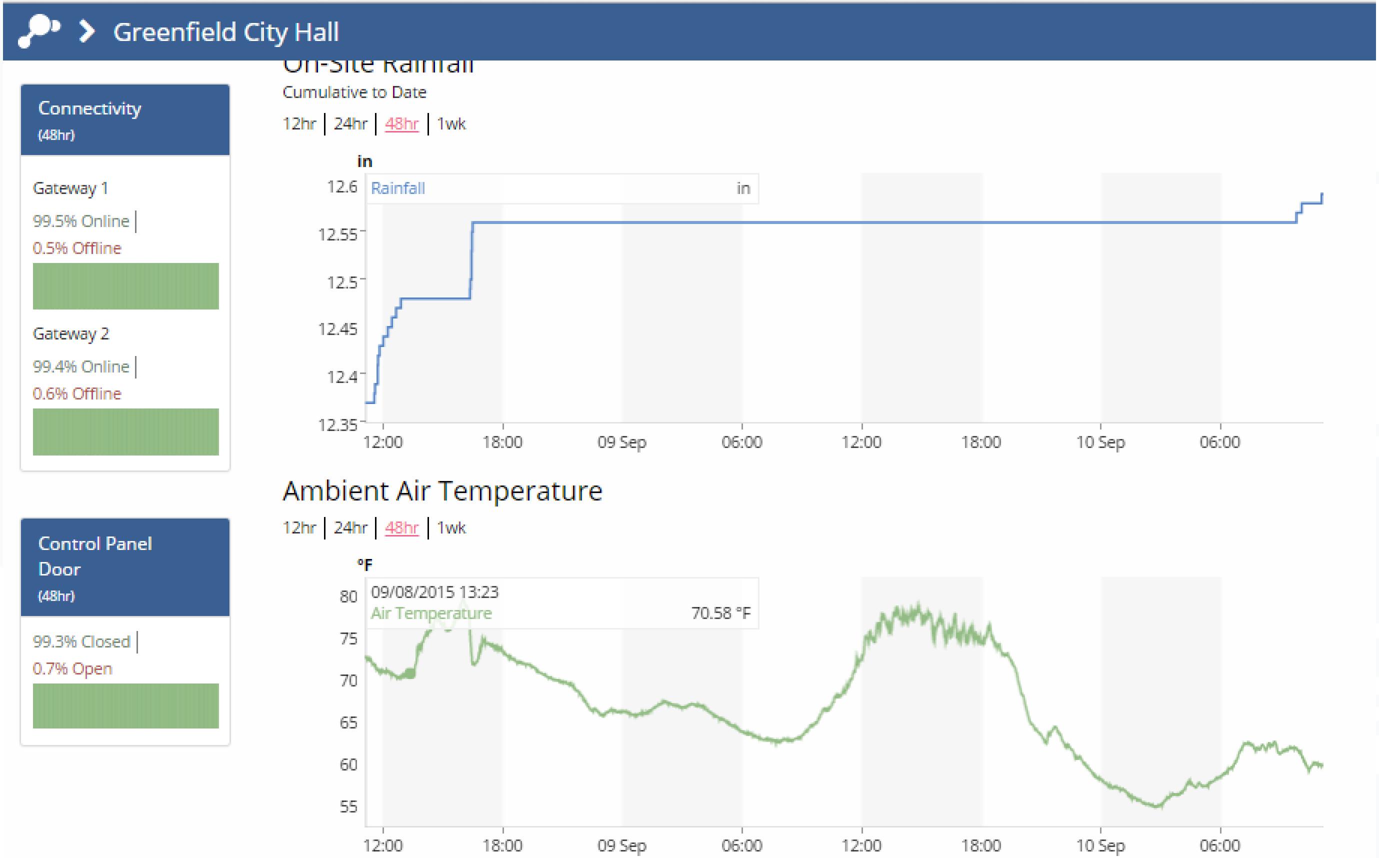


04/21/2016 07:25

Dashboard Detail
Continuous Performance Monitoring



Dashboard Detail
Continuous Performance Monitoring

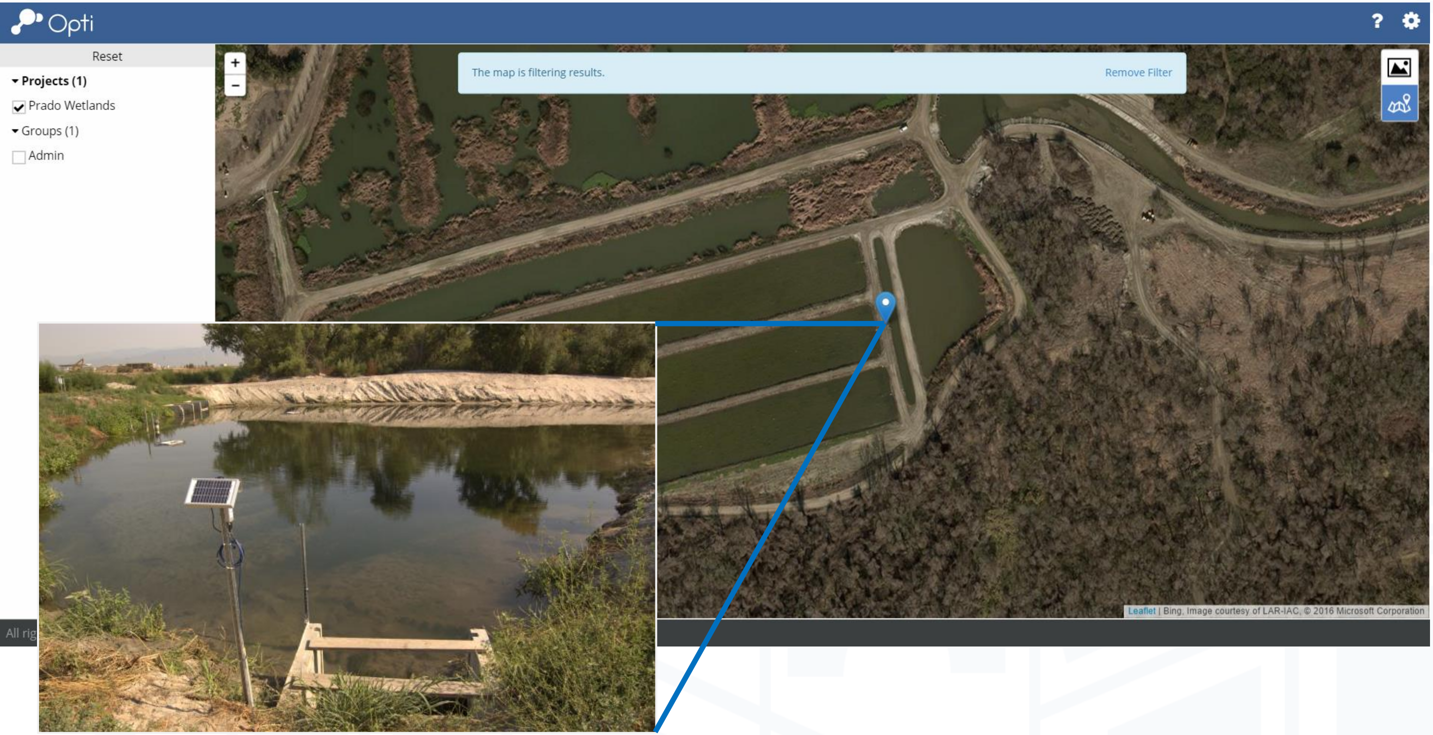


Orange County

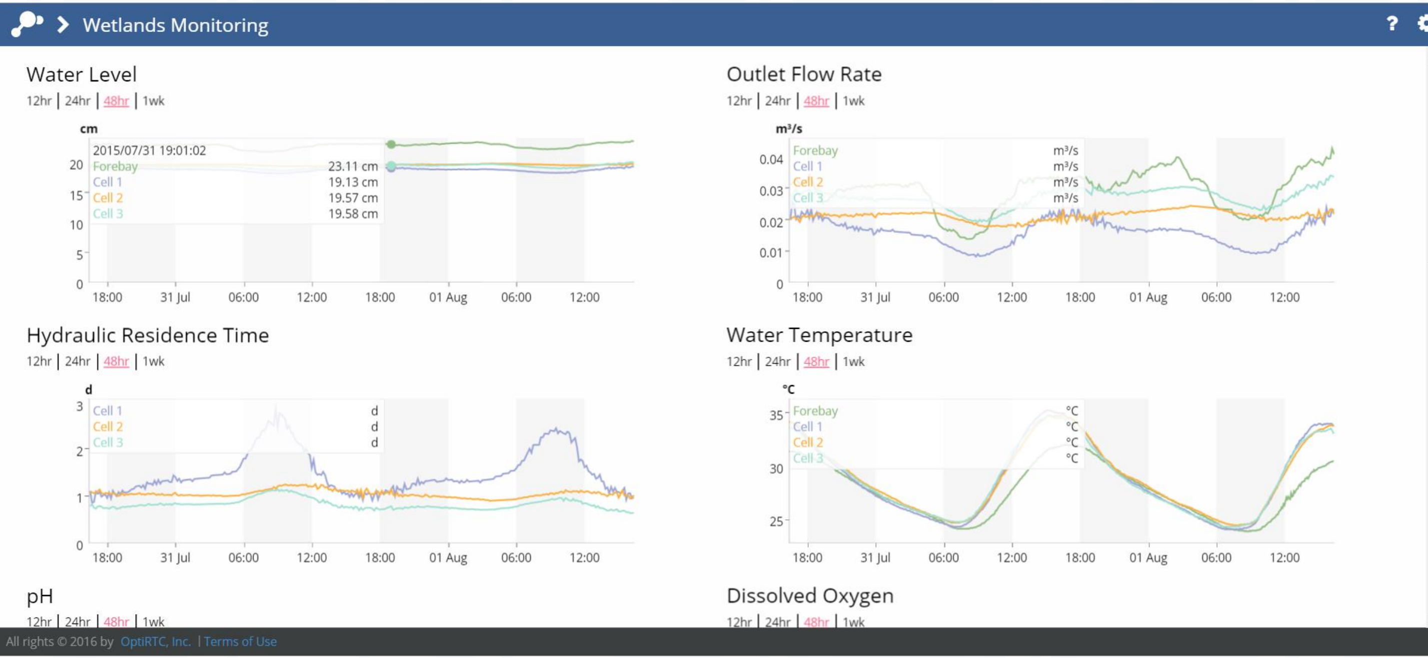
Prado Wetlands

Orange County Water District
SINCE 1933

ReNUWIt
Re-Inventing the Nation's Urban Water Infrastructure



Prado Wetlands

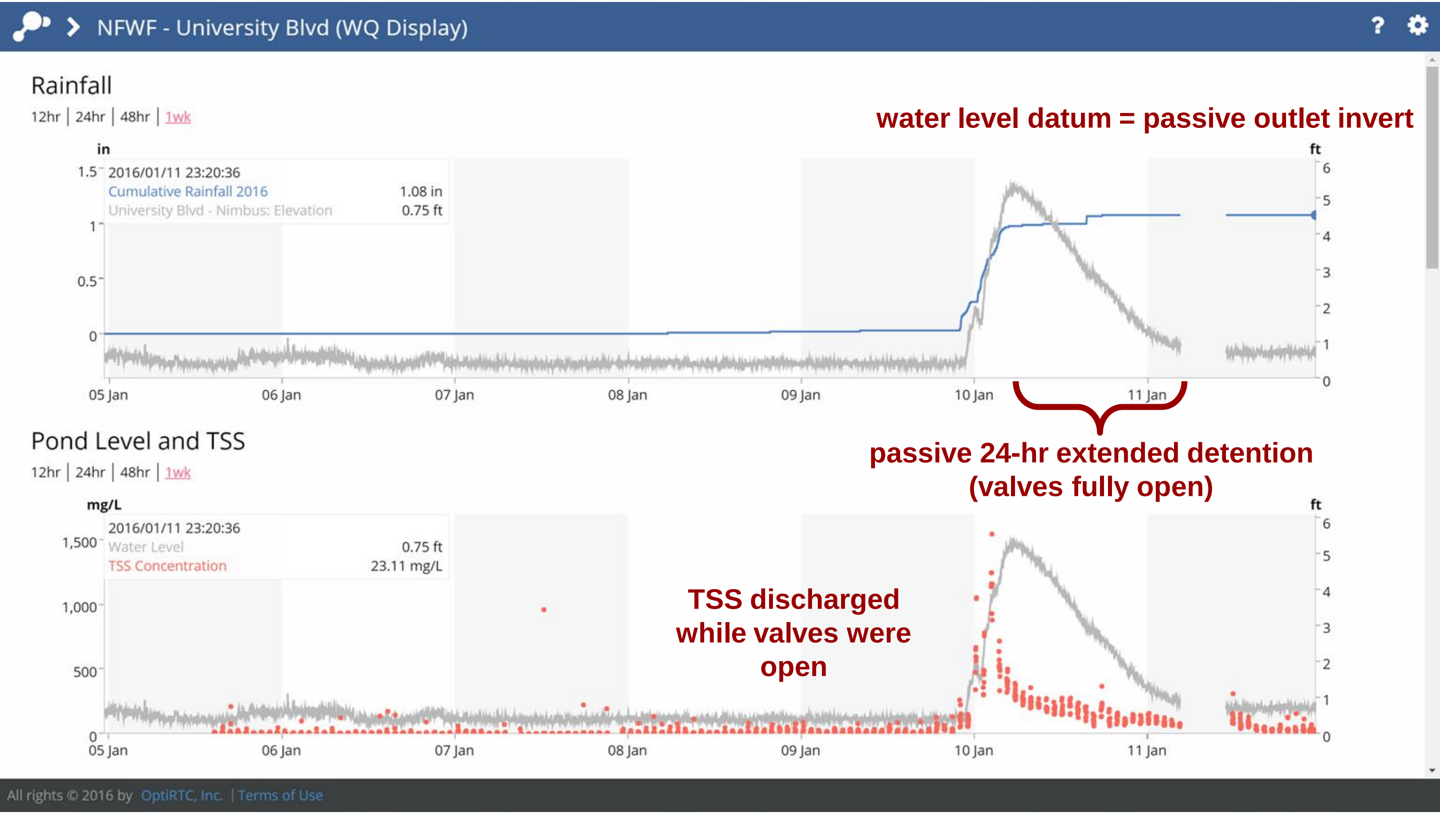


University Blvd Ponds - Silver Spring, MD

5:08 pm April 20, 2016

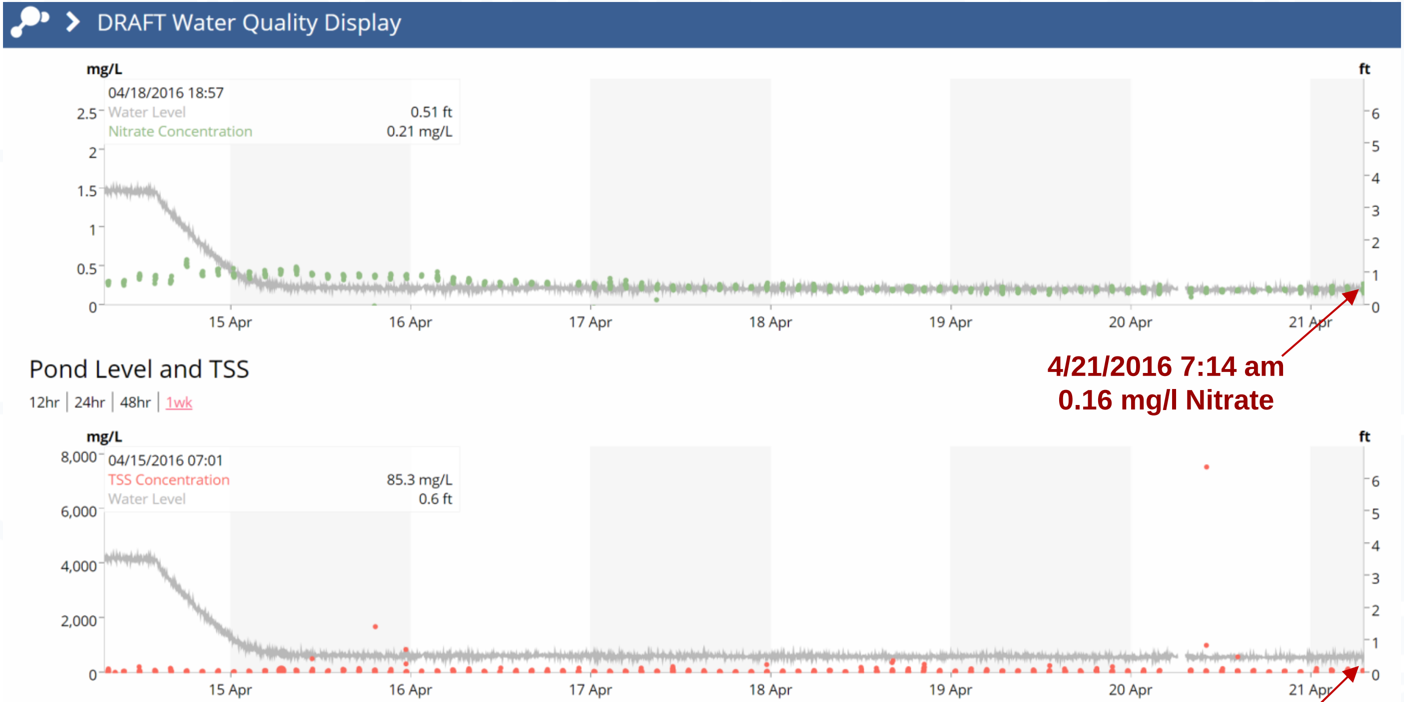
Control Panel

Real Time Water Quality Data (baseline)



Real Time Water Quality Data (baseline)

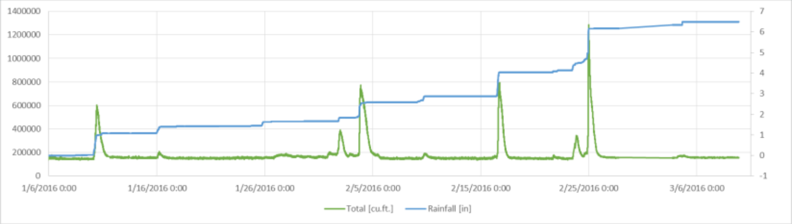
What was University Pond Doing While You Were Eating Breakfast?



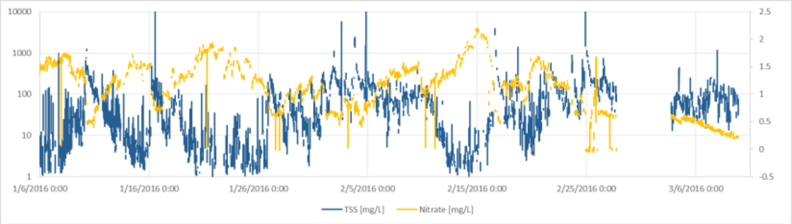
4/21/2016 7:14 am
0.16 mg/l Nitrate

4/21/2016 7:14 am
59.95 mg/l TSS

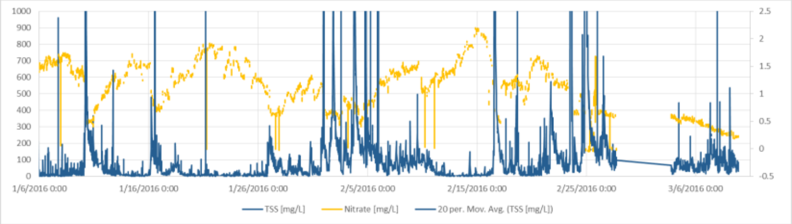
University Pond – Montgomery County Q1 – 2016



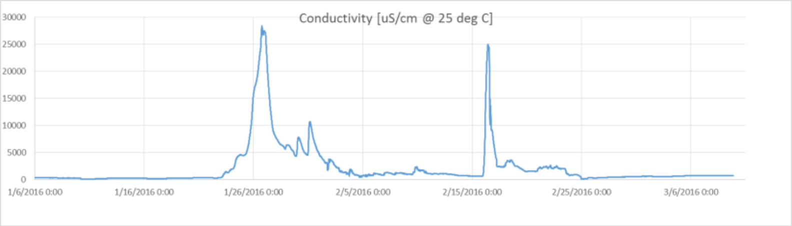
Rainfall and Storage



TSS and Nitrate (log scale)



TSS and Nitrate (linear scale)

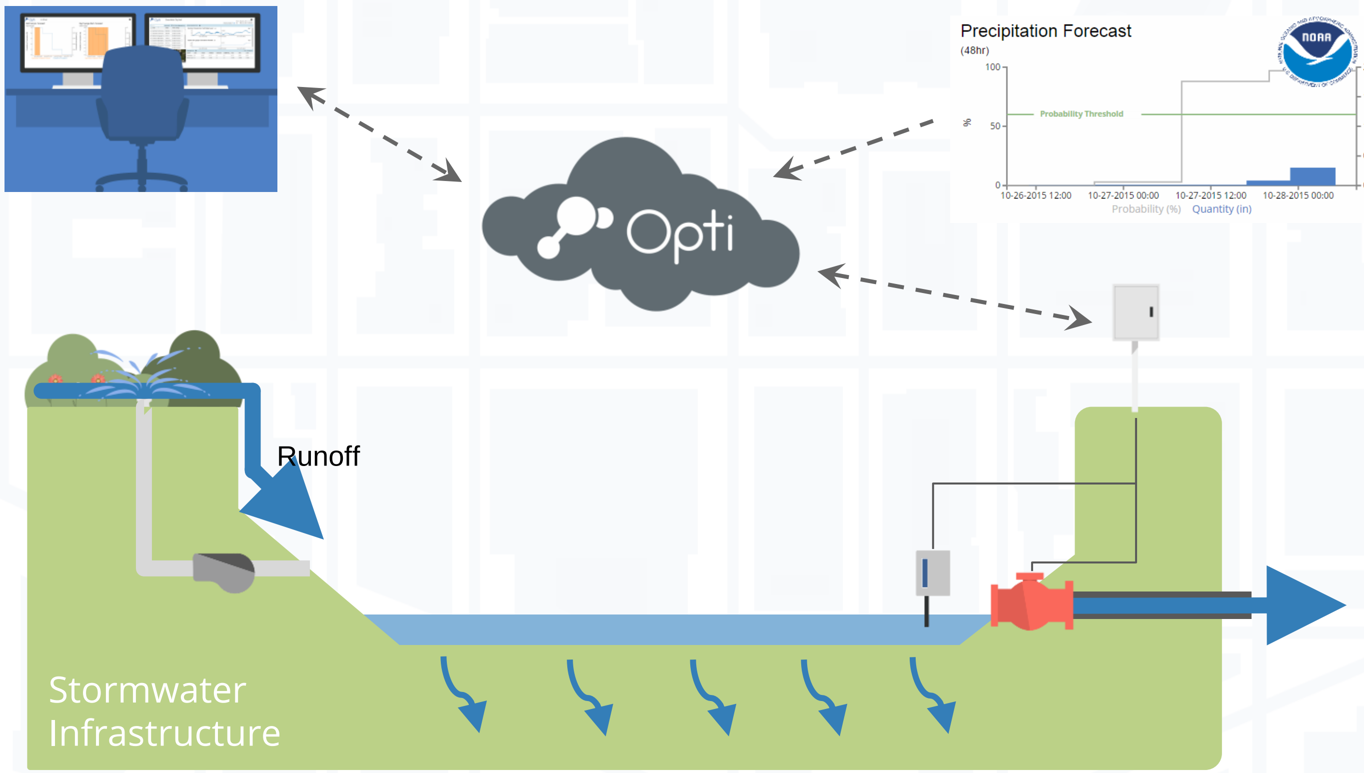


Conductivity

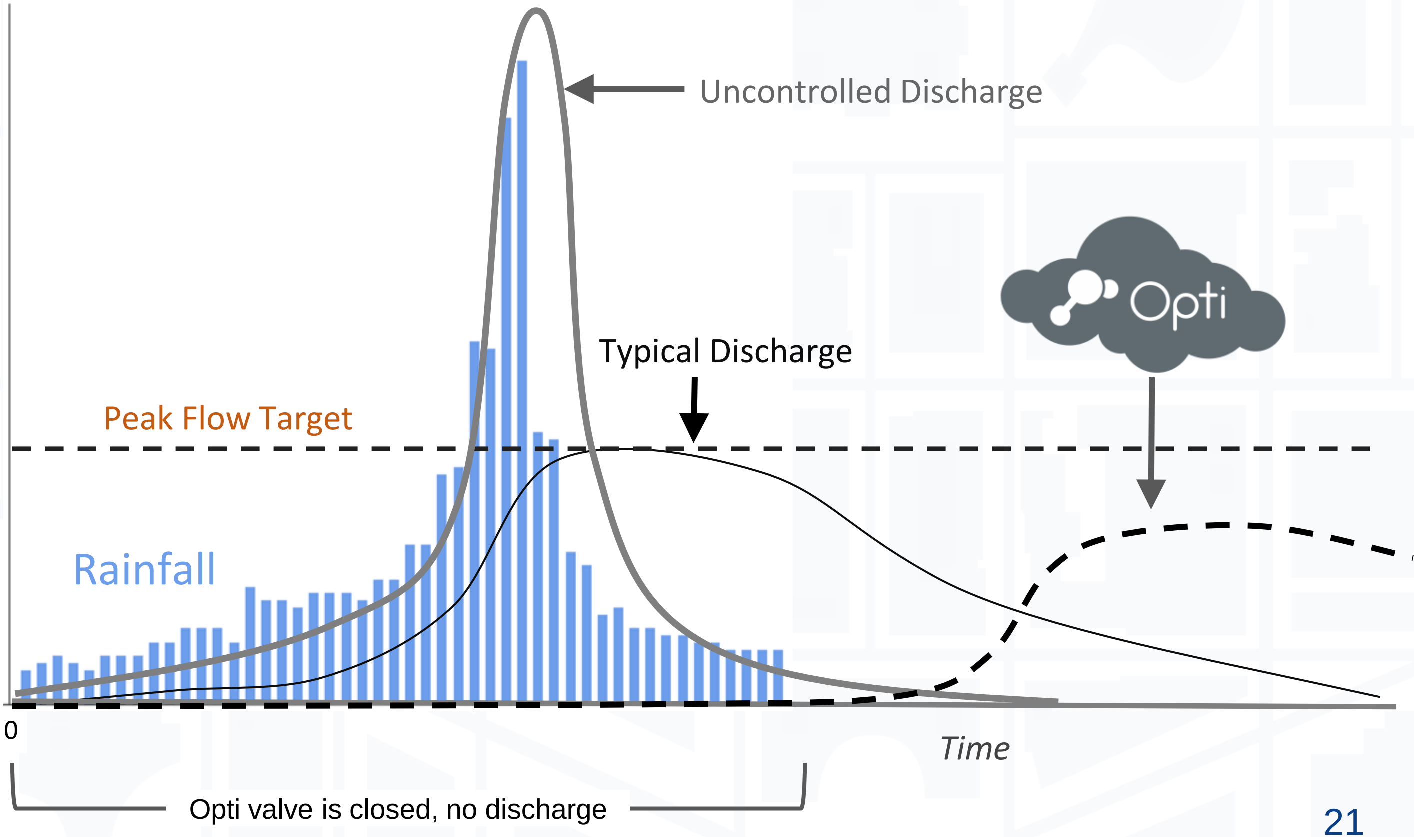
Direct Community Stakeholder Engagement – Public API

Stormwater and Green Infrastructure Control

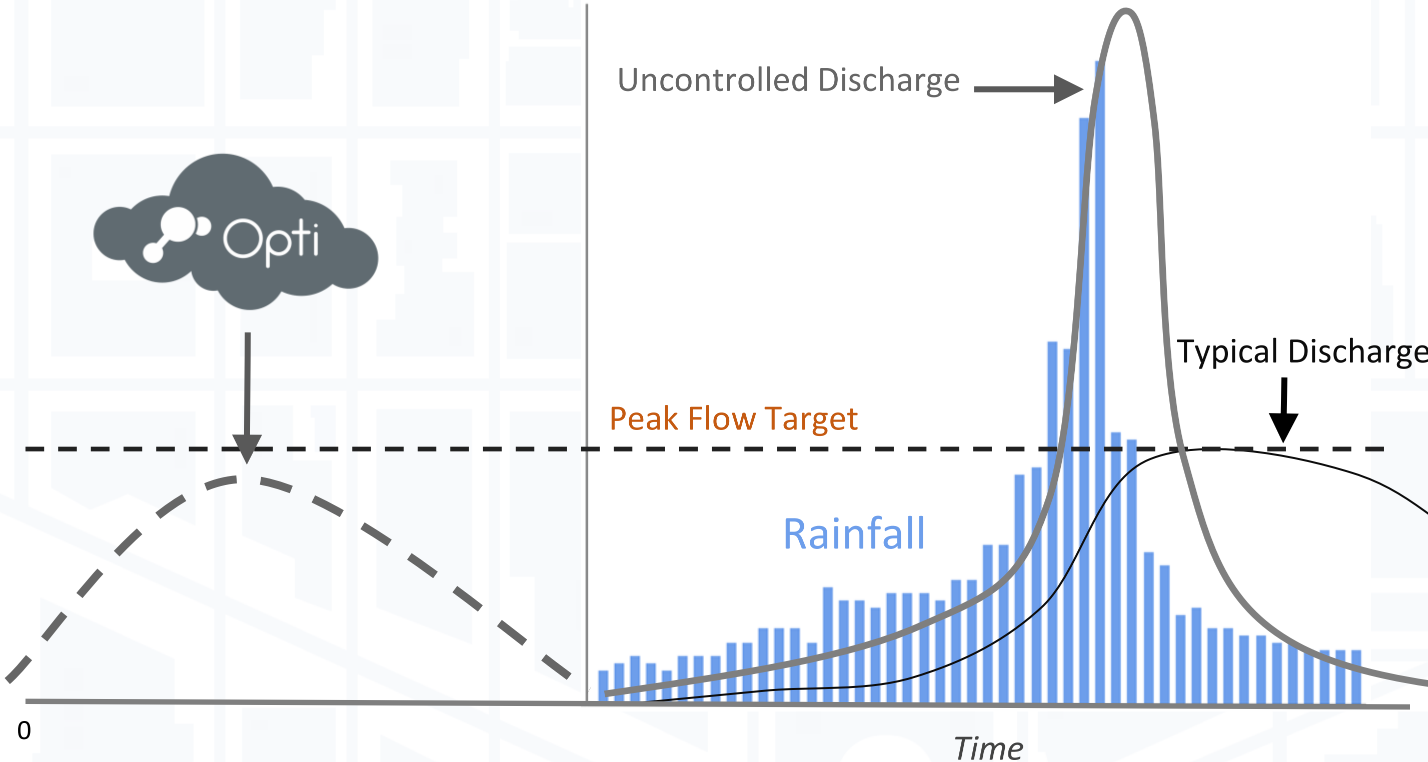
Adaptive Control



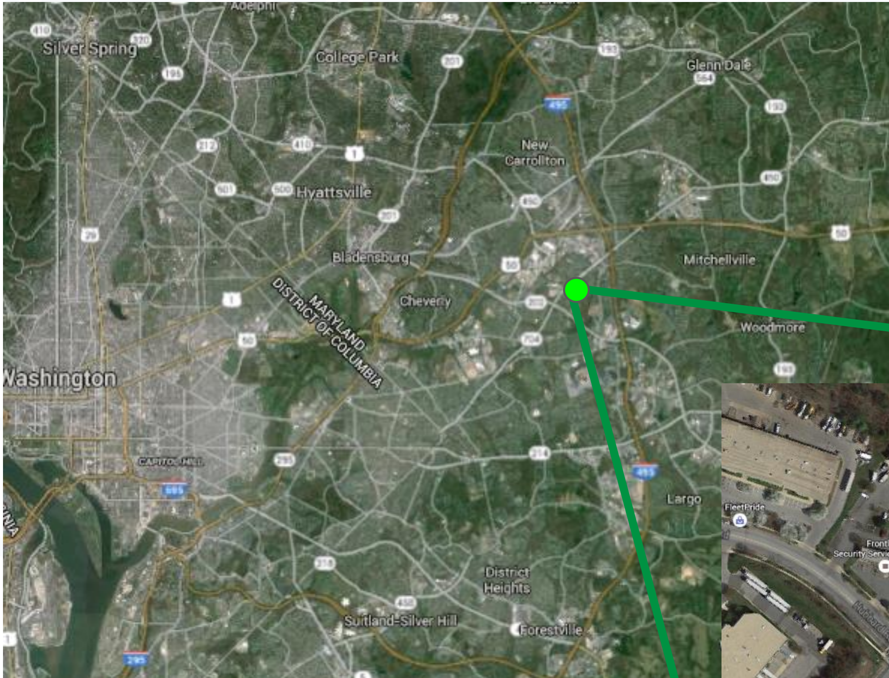
Control the Hydrograph

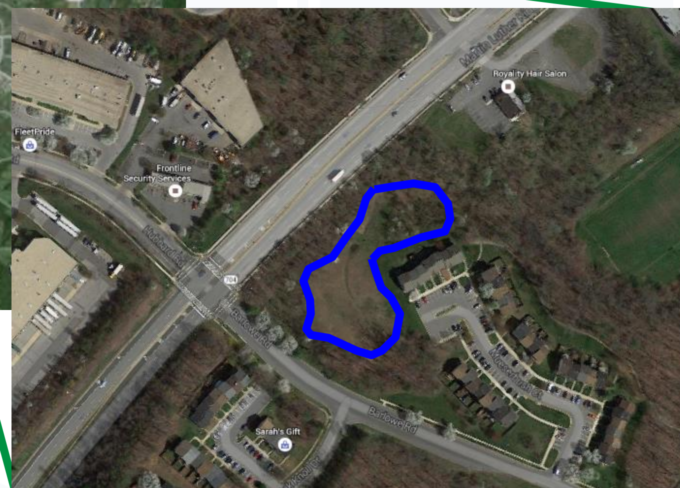


Release water at the right time
As late as before the next event



Case Study:
Nutrient Control in Chesapeak Bay Region





Frost Pond
Prince Georges County, MD
60 Acre Drainage Area
19 Acre Impervious
Approx. 0.5 ac
Dry Pond built in 1988

METROPOLITAN WASHINGTON
Council of Governments

NATIONAL FISH AND WILDLIFE FOUNDATION
NFWF

Frost Pond

Conventional Retrofit
Dig a Bigger Hole!

Storm Water Management Retrofit Evaluation

Pond No.: 02_87216A_01 **Pond Name:** Frost Property Pond # 1 **Date:** 6/7/12

ADC Map: 13D08 **Address:** Mueserbush Court & Barlowe Road **Rating:** C

Pond Ownership: DPWT **Subwatershed:** Washington Metropolitan Area

Lat/Long: 1349326.7108 460068.3144 **Sub-Catchment:** Anacostia River

MDE HUC 12 NO.: 021402050816 **Watershed Impairment:** Yes - Annacostia

Year Constructed: 1988

Notes:

Online pond, though there is enough area to grade wet cells, while maintaining WUS

BMP Description:

Existing BMP Type		Drainage Area (acres)	Pond Surface Area (sq ft)	Impervious Cover (I) Acres	Impervious Cover (I) %	Does Facility Meet MDE 2001 Water Quality Req.	Adequate ROW	Adequate Access
Extended Detention Dry Pond		60.27	28629	19.15	31.77%	No	Yes	Yes

Water Quality Volume (WQv) Required for 'New' Development:

Acre-feet	Cubic Feet	Depth of excavation to provide Wqv[i]	Proposed Retrofit	Notes
1.69	73488	3.21	Wet Pond / Shallow	Create wet pools while maintaining WUS

WQv Calculation:

PE (Rainfall Target, in inches): 1

RV (Runoff Volume) = 0.05_0.009(I), where I is % Impervious Cover:

QE (Runoff Depth in inches to be treated QE = PE*RV)

WQv = (PE)(RV)(A)/12, where A is the DA in acres

[i]Determined by multiplying the pond surface area by a factor of 0.80 to account for side slopes, then dividing by the WQv

Projected Retrofit Cost: $303,153

Excavate 3.21' to create 1.69 ac-ft of storage

Opti Retrofit
Adaptively Control Flow

With a valve and control logic

Created >2 ac-ft of extended detention volume

Lifecycle Costs

Lifecycle Costs

Including Consulting, Design, and Construction

Cost Summary	Opti	Passive	Opti Savings Over Passive (Passive – Opti)/Passive
Total Capital Cost	$26,000	$303,000	**90%+**
Gross Annualized Costs (includes maintenance)	$10,000	$5,000	
Present Value of 25 year Lifecycle Cost	$166,939	$373,470	**55%**

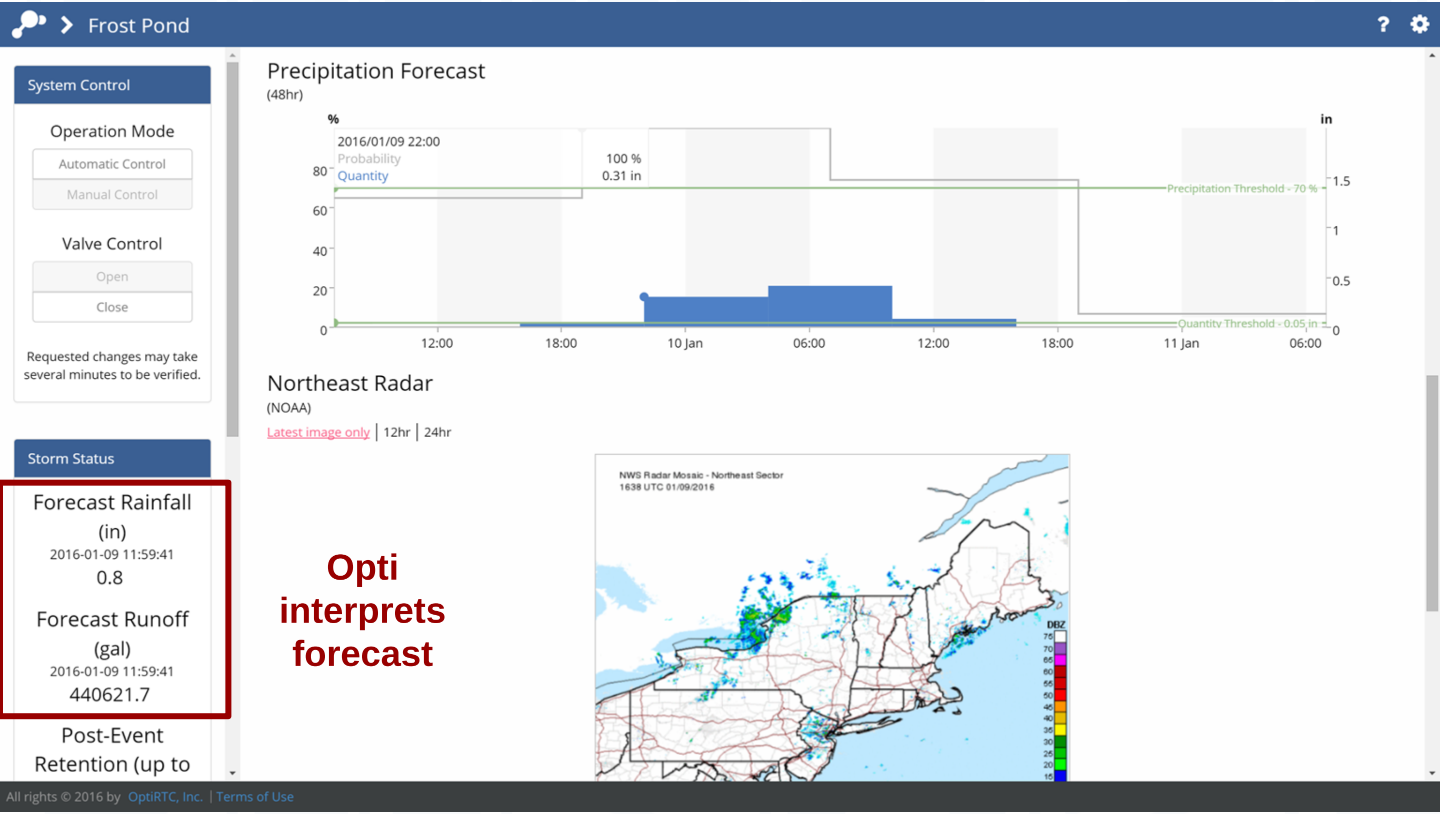
Opti's lifetime cost to treat one impervious acre is **$8,700 compared to $20,000** for a passive retrofit.

References:
Construction and annual costs from Opti and from a comparison bid for passive retrofit and maintenance of the same pond.
*NPV uses a discount rate of 5%

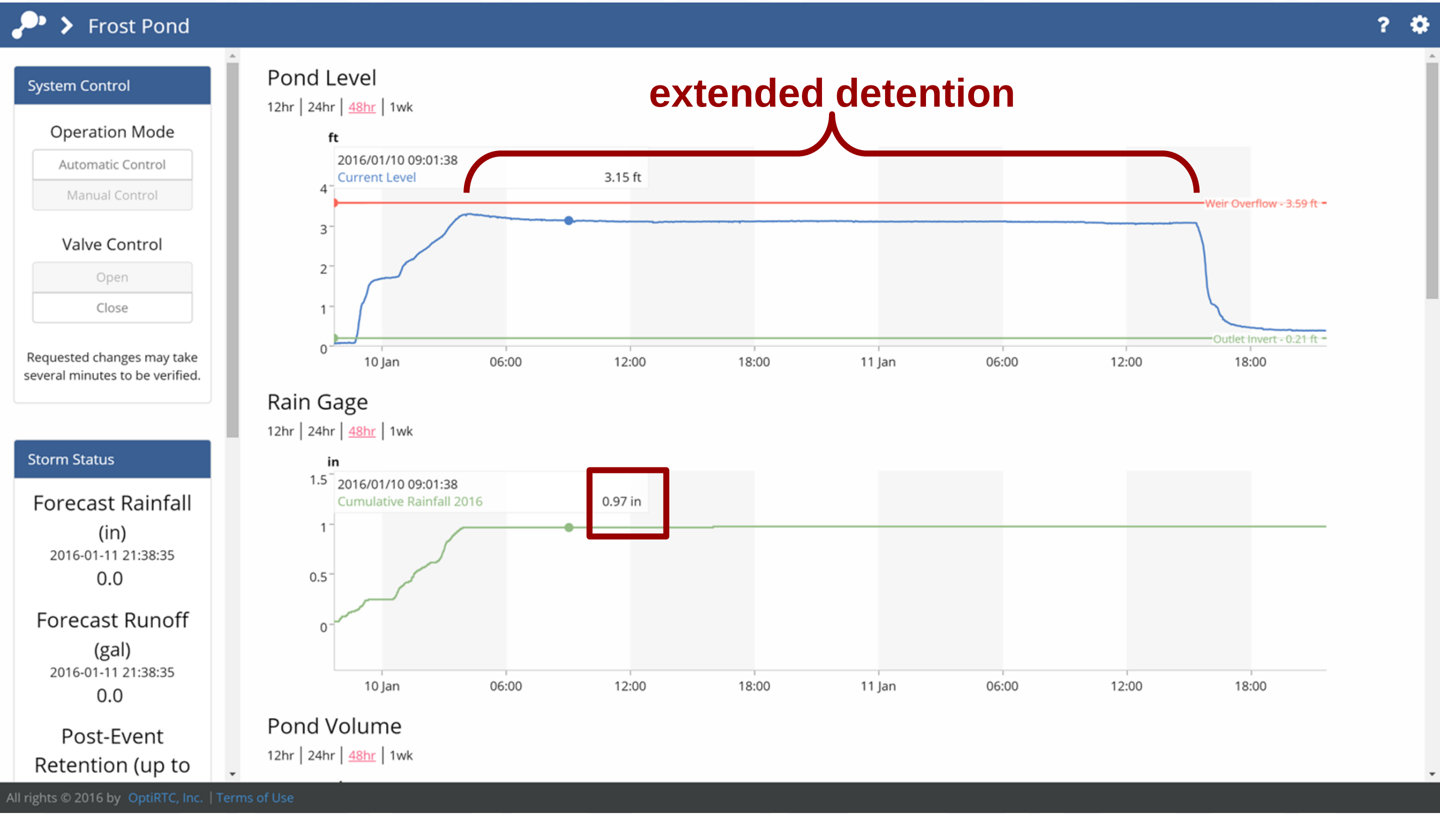
90% reduced capital cost for highly effective water quality retrofit.

What ecosystem services will you deliver with the additional $276K?

Preparing for Rain: Pre-Event Forecast

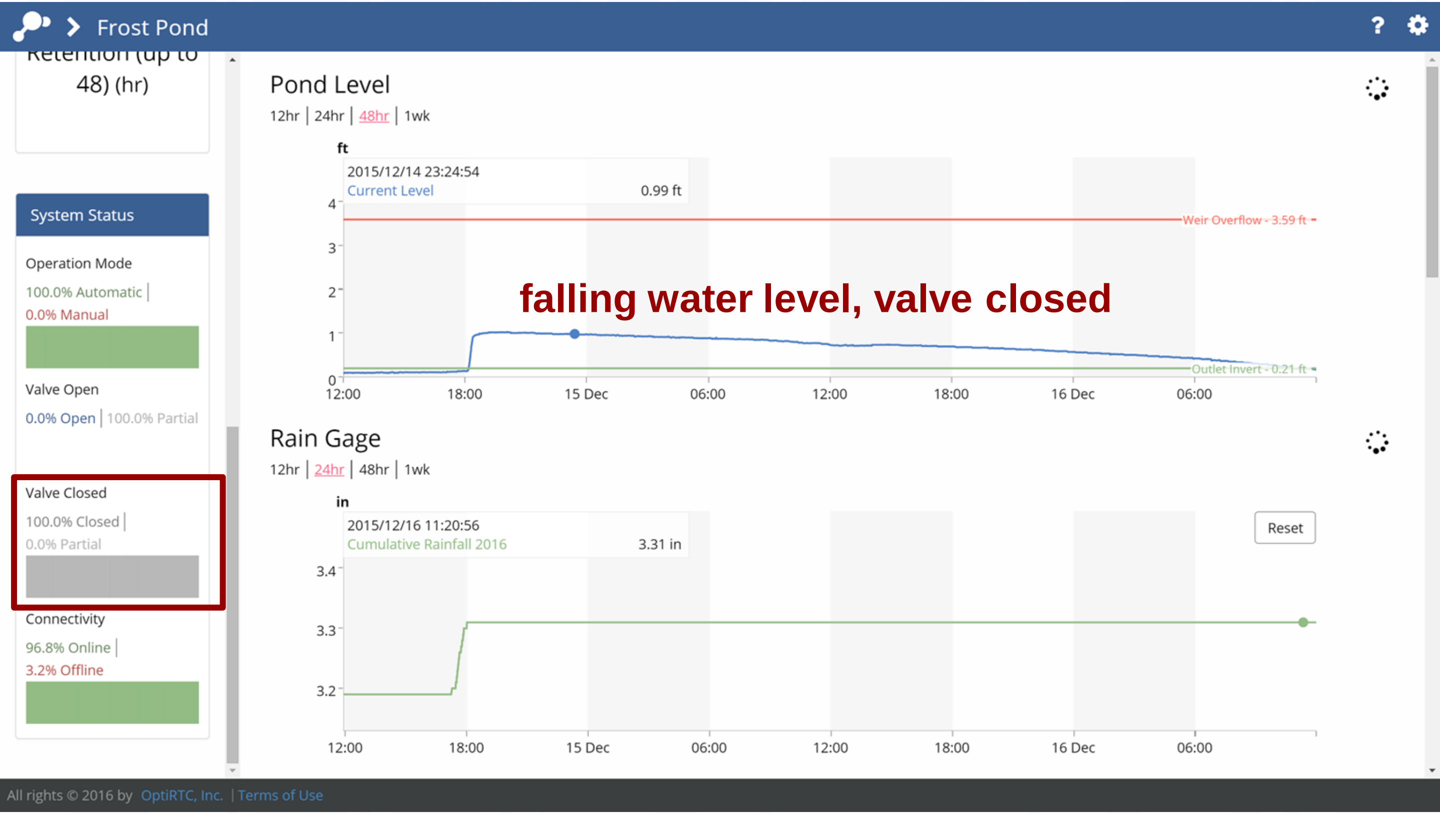


Example Storm:
January 9 to 11, 2016

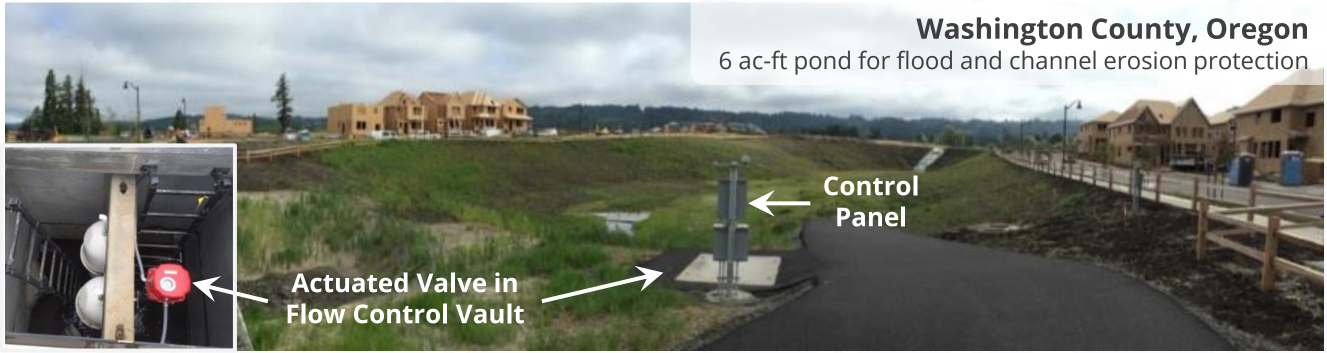


Downstream benefits for range of events

Small Event with 100% Infiltration



Washington County, OR
Water Quality and Flow Control

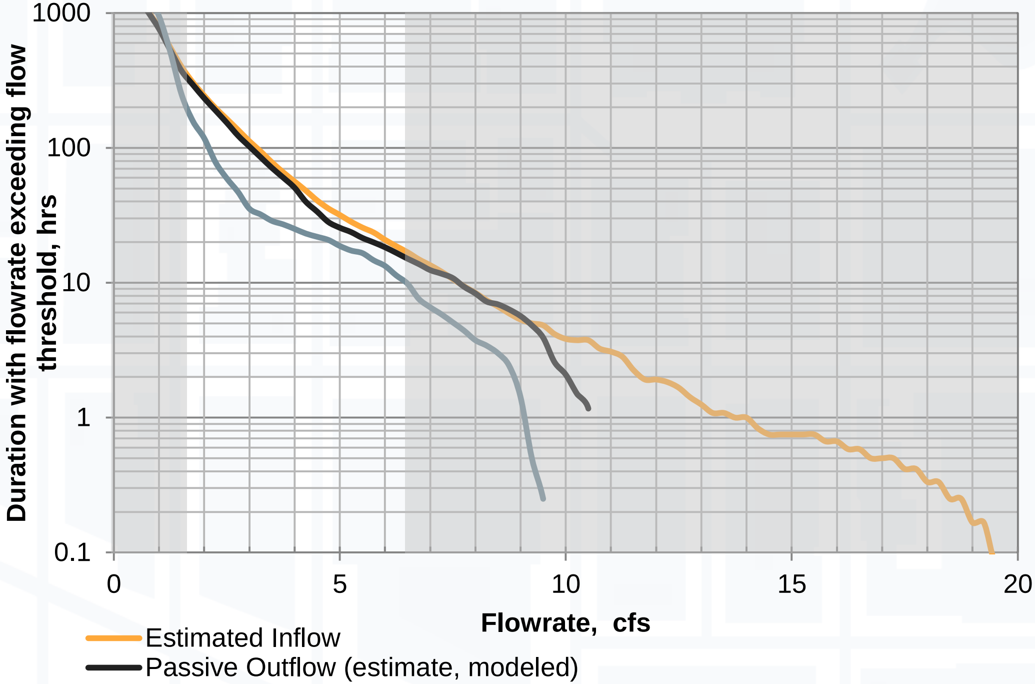


CleanWater Services

Geosyntec consultants

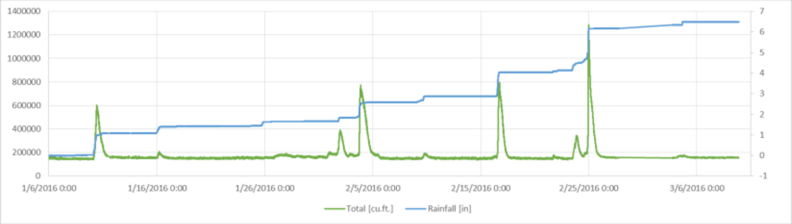
Opti

Flow Duration Control



Clean Water Services
Geosyntec consultants
Opti

University Pond – Montgomery County
Q1 - 2016



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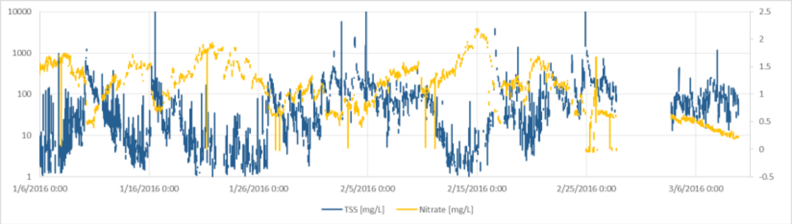
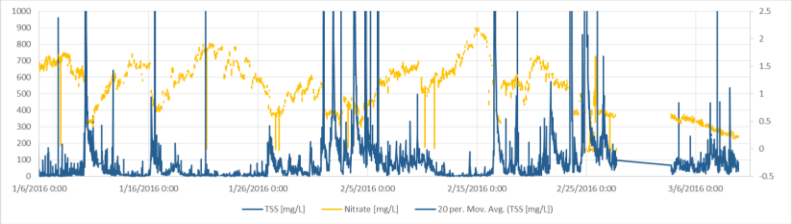
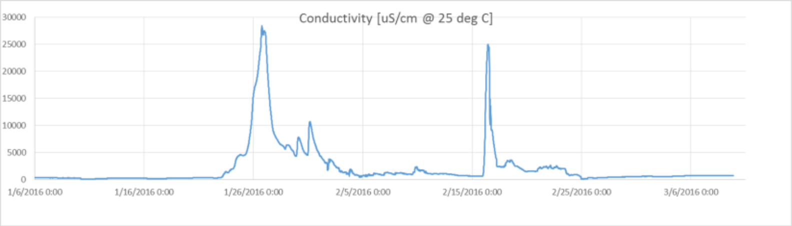


TSS and Nitrate (log scale)

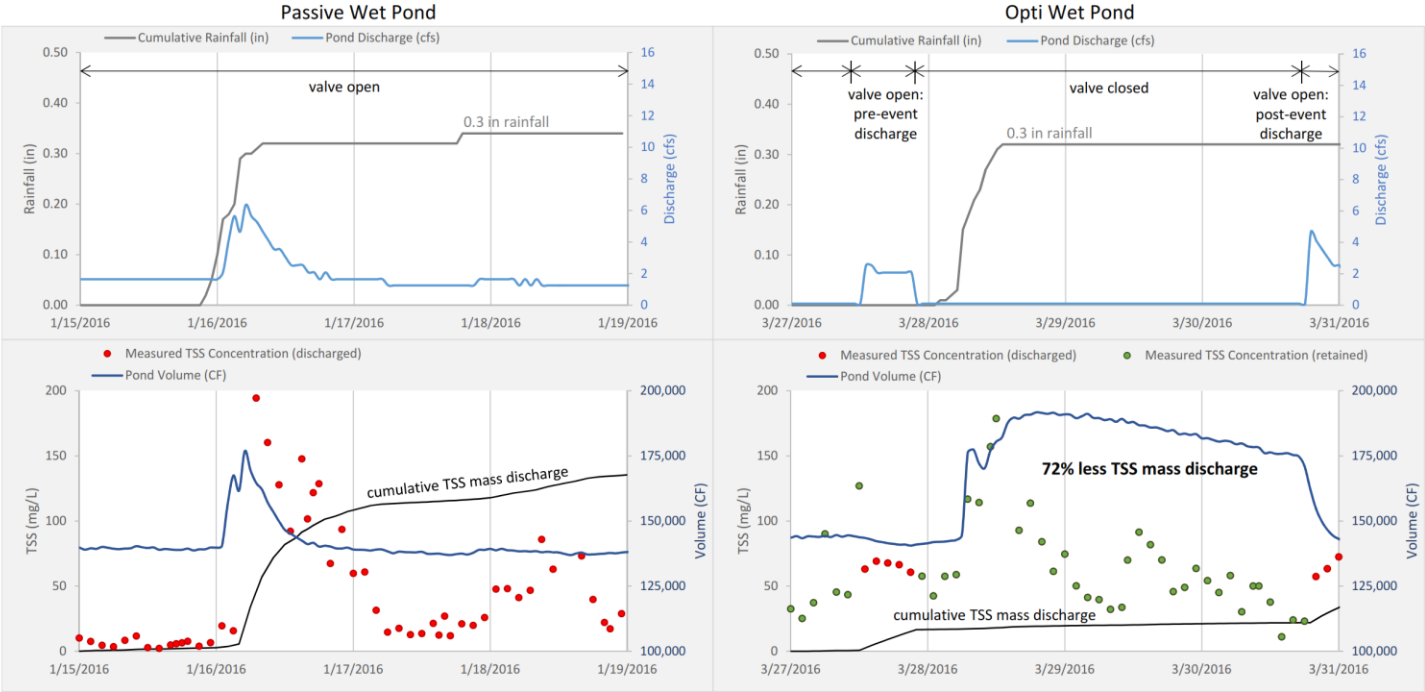


TSS and Nitrate (linear scale)



Conductivity

Real-time TSS Monitoring of Passive vs. Adaptive Control in Maryland

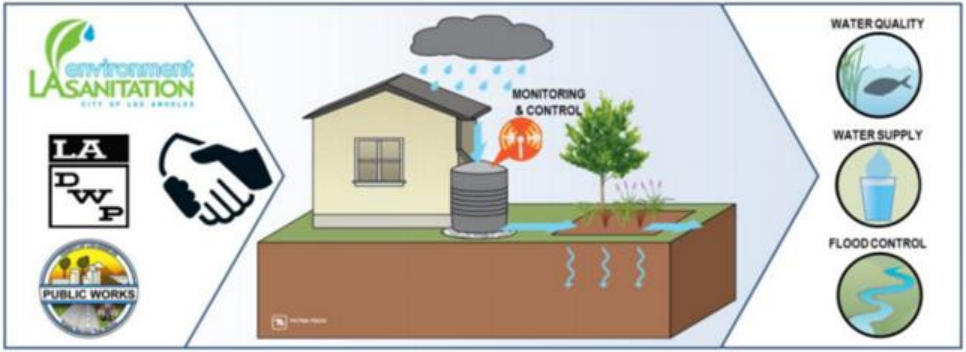


Same facility, Similar storms - 72% reduced mass of TSS discharged with adaptive control.

Los Angeles

Multi-Agency Collaborative, Phase 2

Collaborative Governance Around a Pilot-to-Scale Initiative



AGENCIES

- City of Los Angeles Sanitation
- Los Angeles Department of Water and Power
- Los Angeles County Department of Public Works

LOCATION

City of Los Angeles and Los Angeles County

KEY OUTCOMES

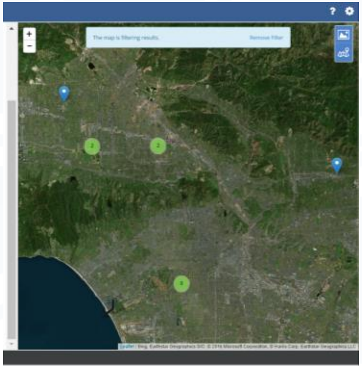
- **Water quality improvement** (EWMP compliance)
- **Local water supply augmentation** (Stormwater Capture Master Plan and One Water synergy)
- **Flood control and nuisance flood mitigation** (Los Angeles County Flood Control Act implementation)

Los Angeles

Water Collected From Roof

Water used for irrigation
Discharged in advance of the storm

Goal: 1,000s of cisterns throughout LA



Collaborative LA Project

Monitor and Adapt

1. Continuously monitor and understand performance
2. Adapt operation based on performance data
3. Adapt future designs based on data
4. Iterate

Reduce risk and increase certainty of improving water quality and hydrology.

Dramatically reduce cost.

Use assets effectively.

Questions

Appendix

Modeling

Nationwide Modeling Study

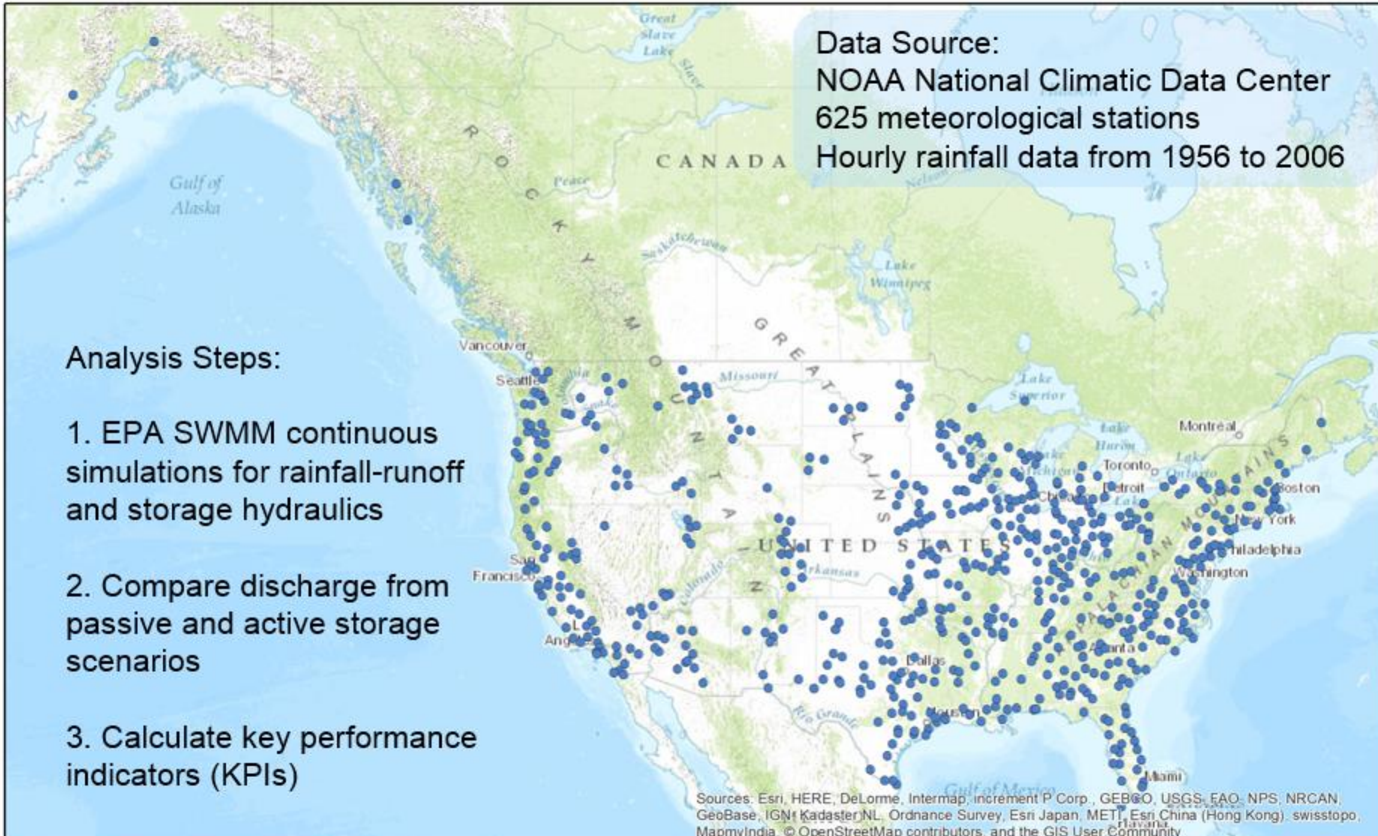
Data Source:
NOAA National Climatic Data Center
625 meteorological stations
Hourly rainfall data from 1956 to 2006

Analysis Steps:

1. EPA SWMM continuous simulations for rainfall-runoff and storage hydraulics

2. Compare discharge from passive and active storage scenarios

3. Calculate key performance indicators (KPIs)



Summary Statistics for 1-in Storm

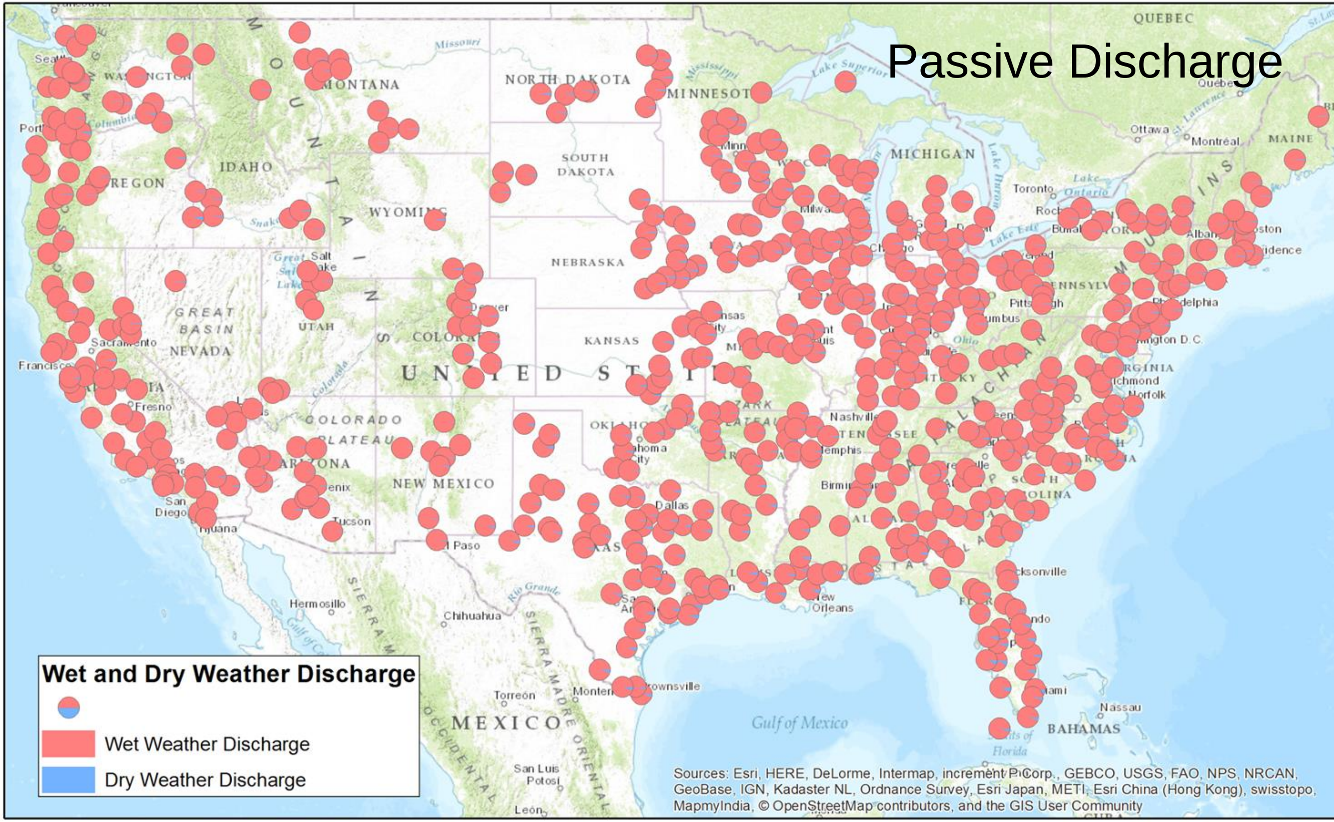
Median values for all 625 stations

Simulation	Metric	Passive Storage	Opti Active Storage
Water Quality: Maximize Retention Time	Long term average retention time	12 hours	196 hours
	Average water available for use[1]	0	590,000 gal/acre/year
	Average wet weather storage utilization	26%	68%
	Percent time runoff retained	3%	59%
CSO/Flooding: Minimize Wet Weather Discharge	Average wet weather discharge	0.052 cfs	0.021 cfs
	Average wet weather discharge during inflow > 0.25 cfs	0.265 cfs	0.171 cfs
	Wet weather capture	2%	61%
	Percent time runoff retained	2%	91%

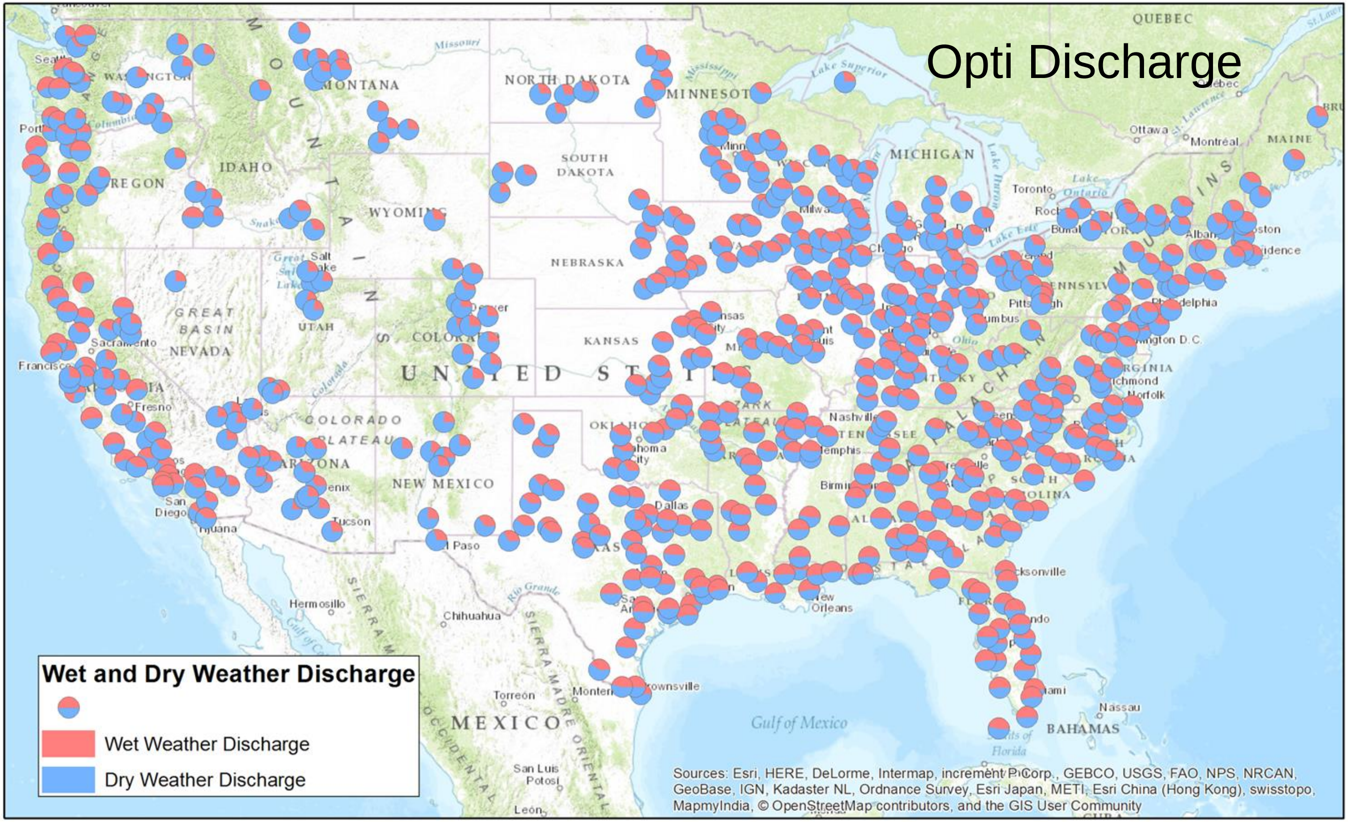
Note: median values shown for 1 inch storage size

1: No withdrawals were simulated. In the passive system, no water was available for use because the outflow valve was always open. In the Opti system, water captured and not released during wet weather was considered available for use. The value shown is the annual average capture volume.

Volume Discharged During Wet vs. Dry Weather

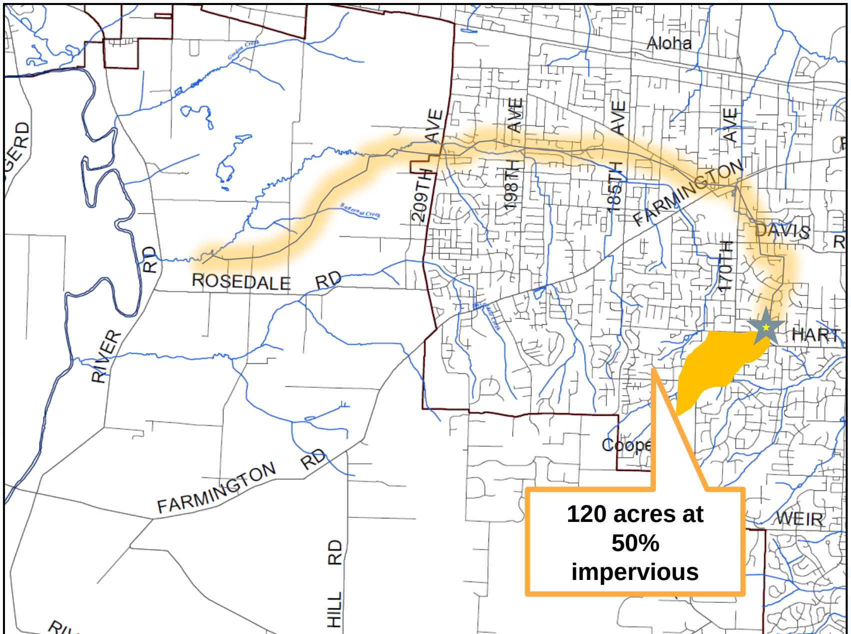


Volume Discharged During Wet vs. Dry Weather



Additional Case Studies

Case Study: Butternut Creek, Portland OR – Hydromodification



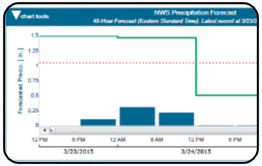
Case Study:
Butternut Creek, Portland OR – Hydromodification

Before

After

Flow Control – Simplified Logic

Watch and prepare in advance of forecasted event

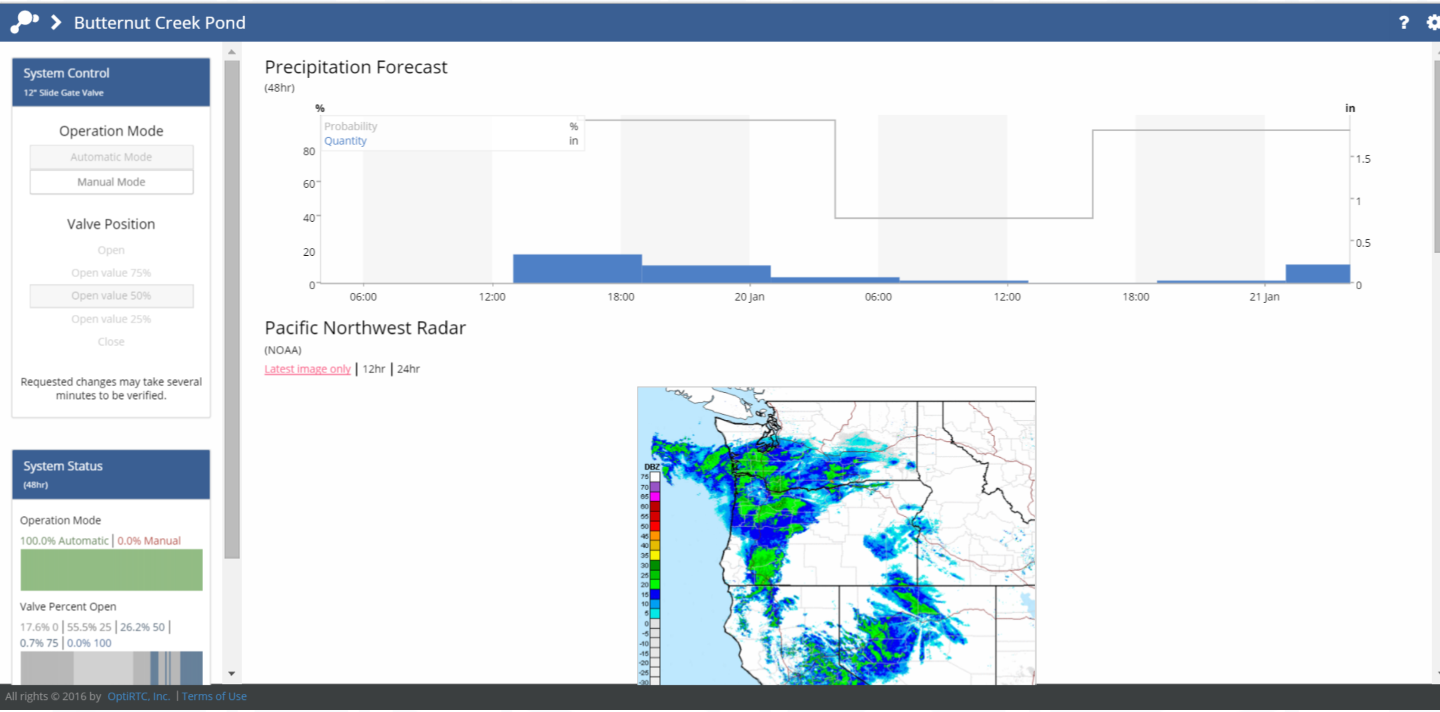


Release at minimum rate before and during event, if needed, to make capacity available

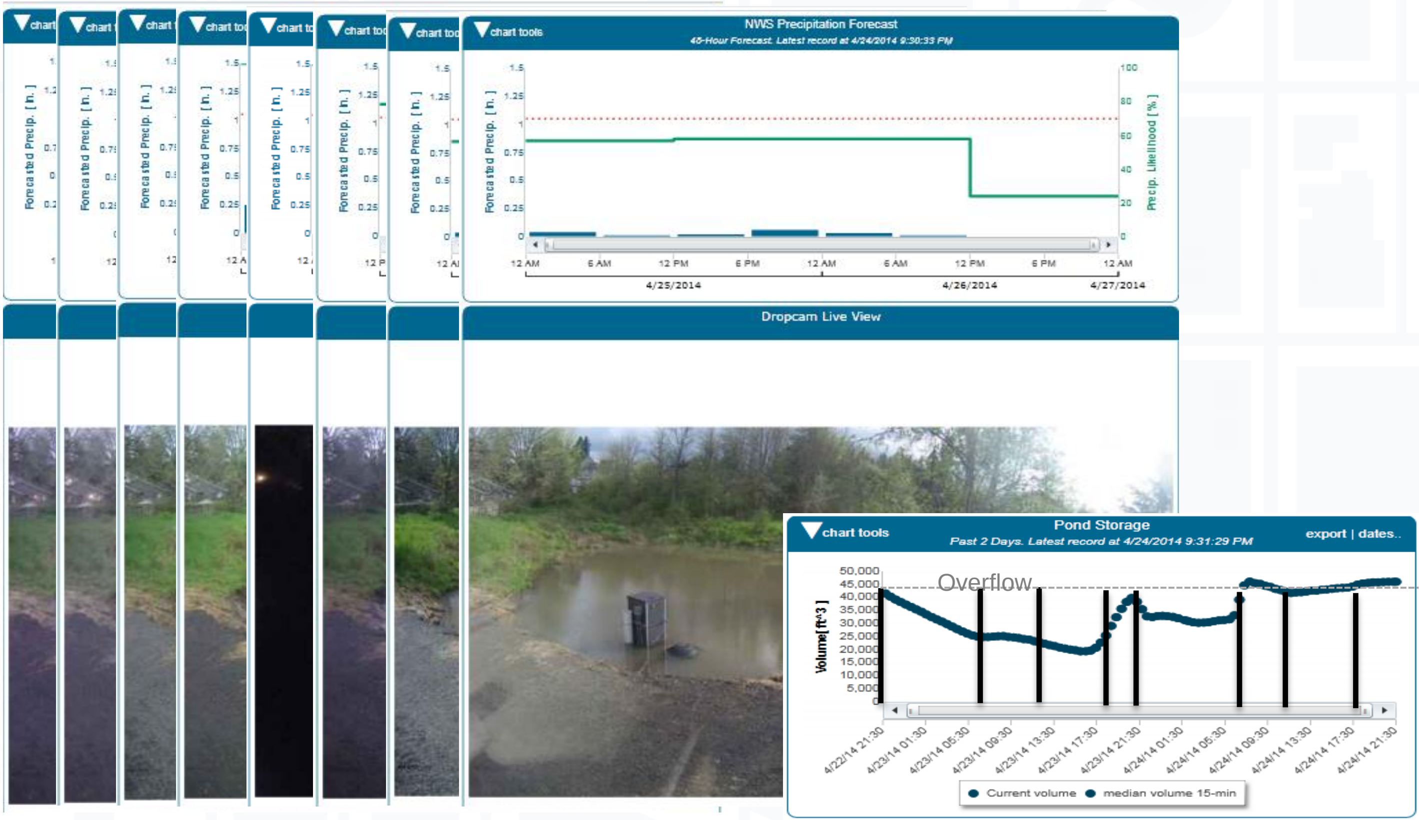
Return to target dry weather state within allowable timeframe

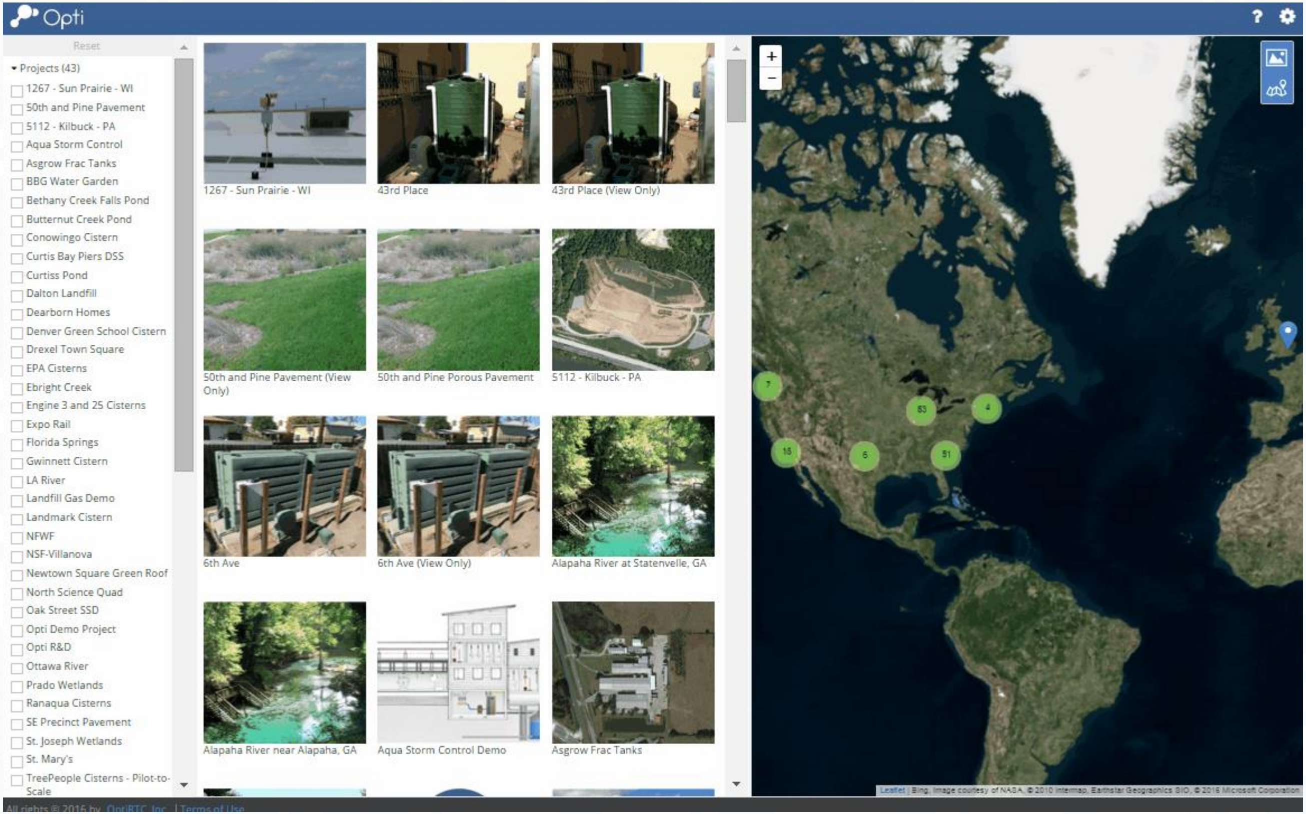
Continually adapt to current conditions and forecast

Flow Control – Web Dashboard



Flow Control – Example Storm




Opti
Reset
Projects (43)
1267 - Sun Prairie - WI
50th and Pine Pavement
5112 - Kilbuck - PA
Aqua Storm Control
Asgrow Frac Tanks
BBG Water Garden
Bethany Creek Falls Pond
Butternut Creek Pond
Conowingo Cistern
Curtis Bay Piers DSS
Curtiss Pond
Dalton Landfill
Dearborn Homes
Denver Green School Cistern
Drexel Town Square
EPA Cisterns
Ebright Creek
Engine 3 and 25 Cisterns
Expo Rail
Florida Springs
Gwinnett Cistern
LA River
Landfill Gas Demo
Landmark Cistern
NFWF
NSF-Villanova
Newtown Square Green Roof
North Science Quad
Oak Street SSD
Opti Demo Project
Opti R&D
Ottawa River
Prado Wetlands
Ranaqua Cisterns
SE Precinct Pavement
St. Joseph Wetlands
St. Mary's
TreePeople Cisterns - Pilot-to-Scale
1267 - Sun Prairie - WI
43rd Place
43rd Place (View Only)
50th and Pine Pavement (View Only)
50th and Pine Porous Pavement
5112 - Kilbuck - PA
6th Ave
6th Ave (View Only)
Alapaha River at Statenvelle, GA
Alapaha River near Alapaha, GA
Aqua Storm Control Demo
Asgrow Frac Tanks