Discussion of the Role of and Implications for Continuous Monitored Adaptive Control (CMAC)

Technology-Driven Public-Private Partnership Programs:

How Can Emerging Technologies Help to Support Sustainable Stormwater Infrastructure Investments & Programs

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1:00pm-1:30pm

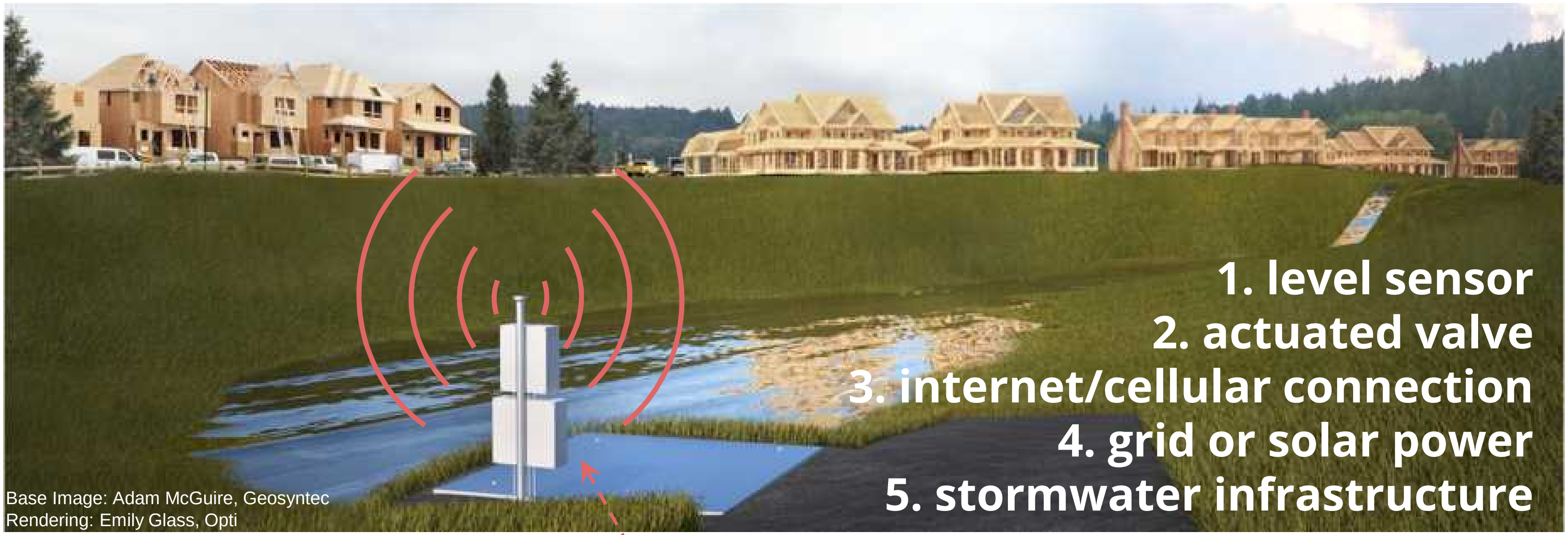
Performance based contracting can allow space for innovation while also reducing risk.

Contract outcomes can be more closely tied to compliance obligations.

What technologies are most promising?

Continuous Monitored Adaptive control (CMAC) Stormwater Management

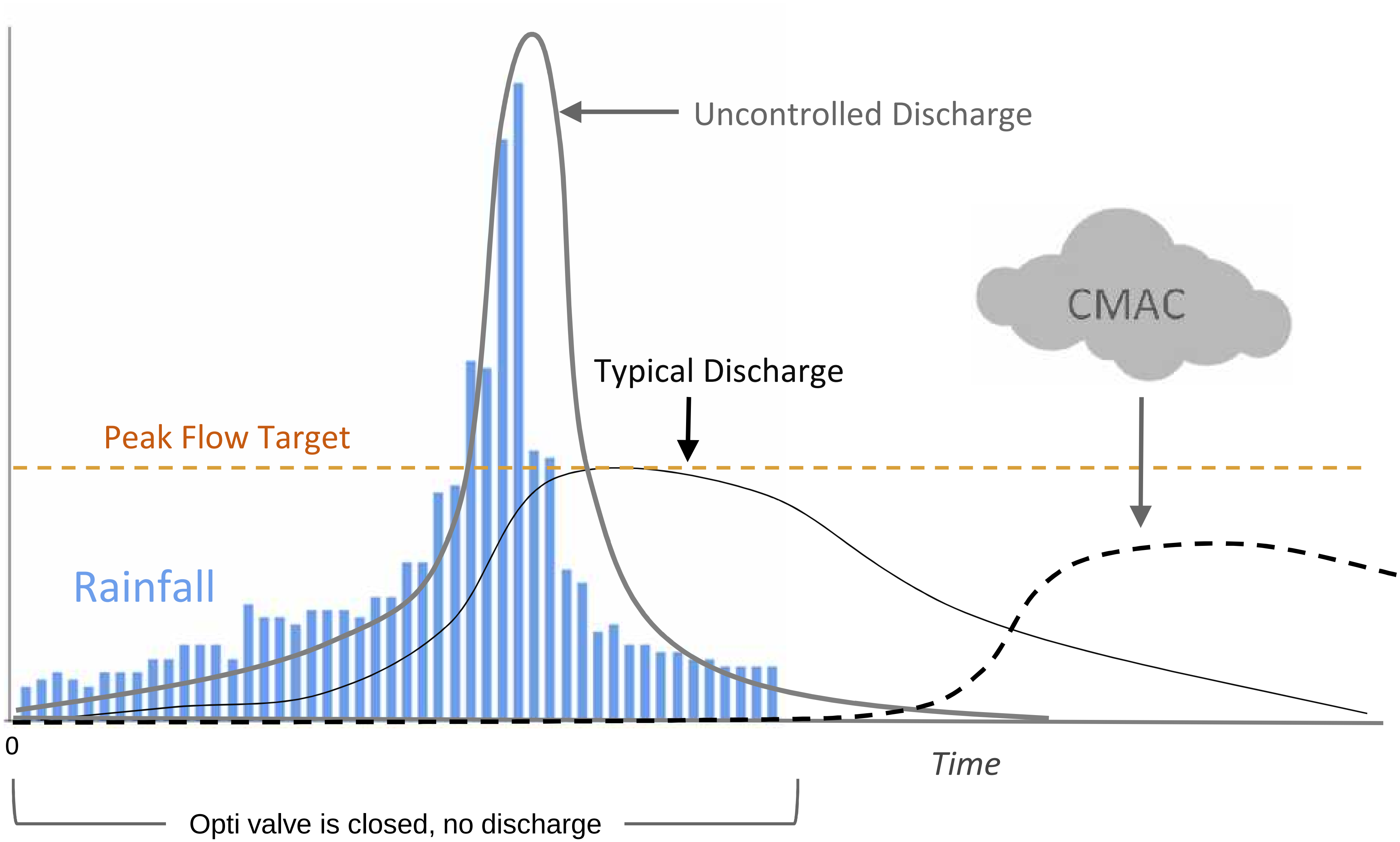
Combine sensor data, weather forecasts, and algorithms
to optimize stormwater infrastructure through active, cloud-based control



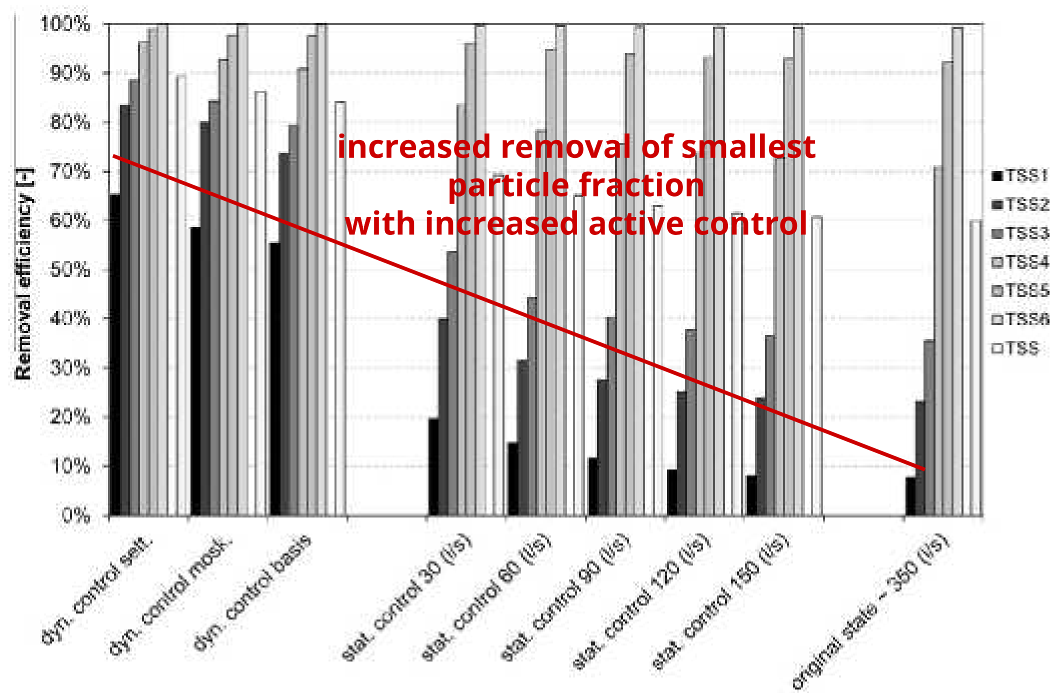
-Cloud architecture
-Robust data security
-Advanced user authorization
-Configurable logic algorithms that optimize complex, multi-variable results
-Online dashboard interfaces
-APIs for data export/analytics

Bethany Creek Falls Project completed in partnership with Clean Water Services, Geosyntec Consultants, and Opti

Optimize Water Quality
One Example of CMAC



Increased control → Increased retention time → Increased WQ benefit



Muchalla et al. 2014

Dry pond to wet pond retrofit (no active control) increased retention time and improved TSS and ammonia-nitrogen removal efficiencies

- **TSS: from 39 to 90%**
- **NH_3-N: from 10 to 84%**

Carpenter et al. 2014
Gaborit et al. 2012

48-60% better removal efficiency of small particles in pond with active, rainfall-driven control
Muchalla et al. 2014

Smaller particles have higher associated phosphorus concentrations than larger particles
Moquecho and Pitt 2005

Continuously Monitored and Adaptive control (CMAC) Retrofits for Approved BMP Types

Not a new technology - relies on existing approved BMPs types for treatment, but has significant additional benefits:

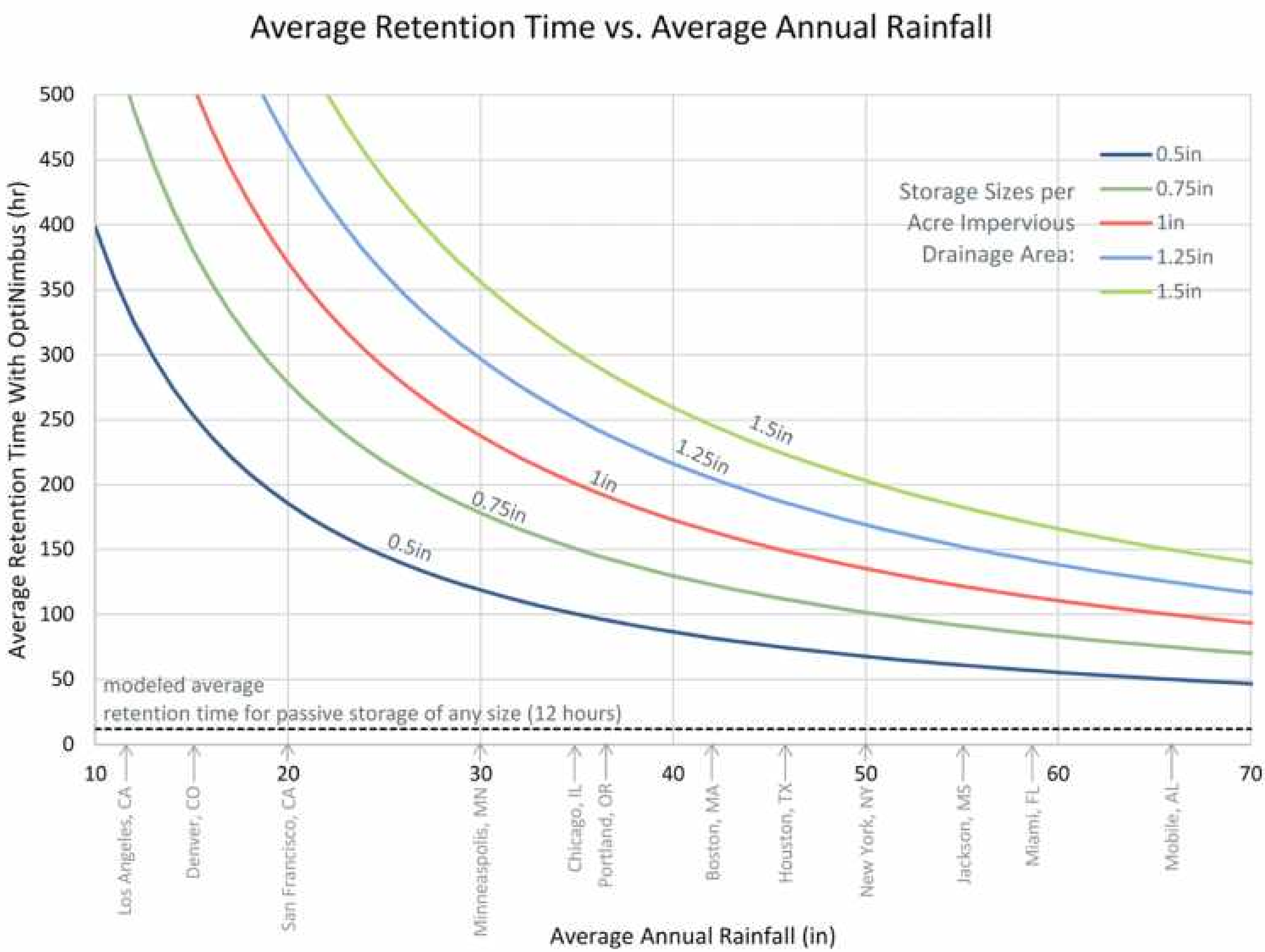
Benefits of Continuous Monitoring

- Direct verification of performance.
- Auditable performance and supporting data without additional cost.
- Increasing uptime of facilities through notification of operational issues.
- Reduce maintenance costs without sacrificing performance.

Benefits of Adaptive Control

- Dramatically improving water quality from facilities by increasing residence time and/or improving unit process effectiveness (e.g., settling, denitrification).
- Reduce the frequency of flooding events.
- Enabling robust adaptable construction designs that are less dependant on site specific conditions.
- Allowing for updated operation to adapt systems to for future climatic conditions or changes in site characteristics.
- Utilizing an entire facilities storage volumes for the full range of storm event sizes.
- Intelligently detain flows in combined sewer systems for release during non-critical periods.
- Restoring pre-development hydrology (i.e., flow-duration matching) by actively modulating release rates based on forecast information.
- Increasing the volume retained on site.
- Maintaining ecological base flows.
- Allowing for changes to operation without major redesign or reconstruction.

Average Retention Time by Annual Rainfall



Each NCDC station modeled has an average annual rainfall

The results show a very strong correlation between long term average retention time and average annual rainfall for each site

This plot shows the regression lines for each storage size, allowing for estimating possible retention times based on average rainfall, with Opti active discharge

Passive discharge scenarios achieve only 12 hours retention time, on average, because most storms to not fill the storage unit

Some CMAC Facility Types

Conversion Types

- Dry Pond to Wet Pond
- Wet Pond to Wet Extended Detention Pond

Enhancements

- Wet Extended Detention Ponds
- Bioretention
- Wetlands
- Demand Dependant Cisterns to Fully Utilized Cistern
- Infiltration Facilities
- Many others…

Let’s look at a specific example.

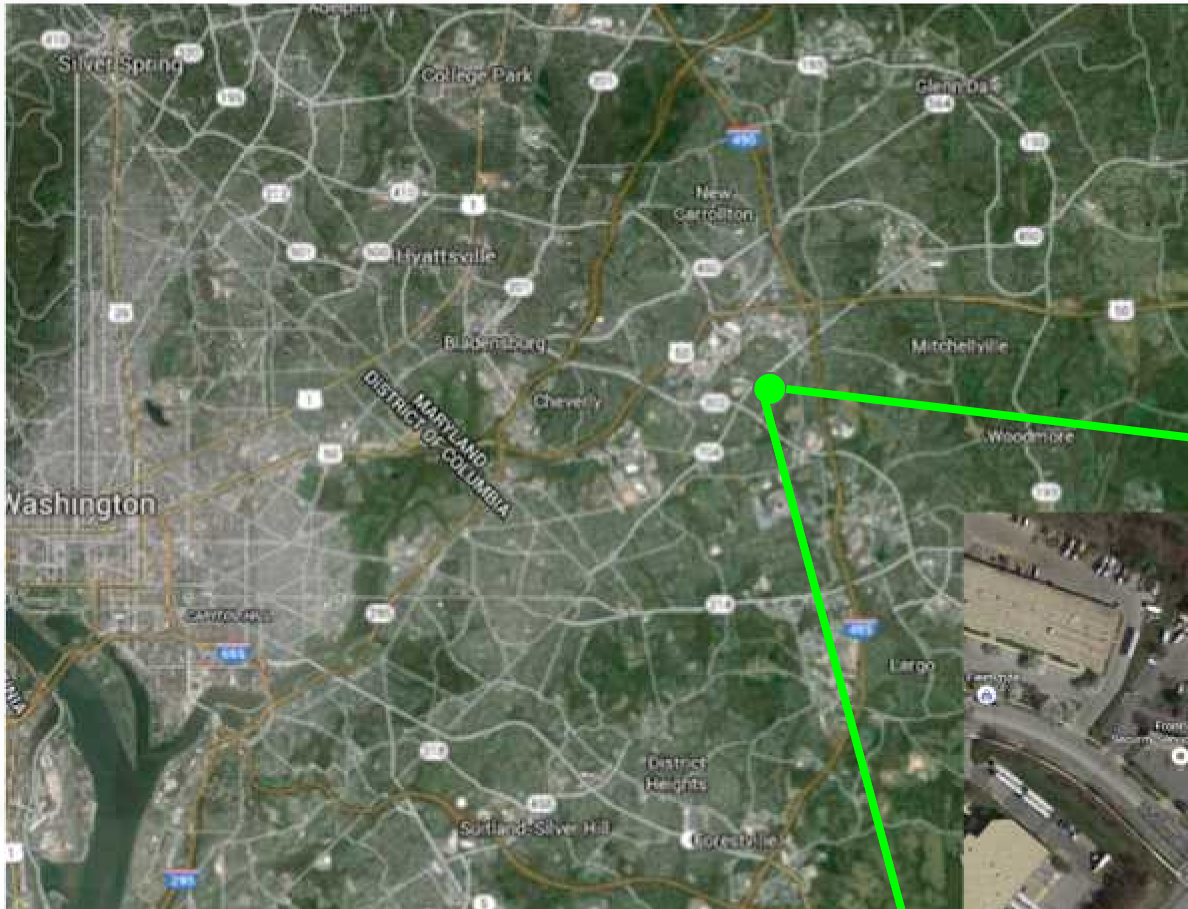
Frost Pond - Prince George's County, MD

NFWF and Washington Council of Governments funded project in the Anacostia Watershed to address nutrients through retrofit of existing facilities with CMAC.

Three sites: Prince George's County, MD; Montgomery County, MD; Washington, DC

Frost Pond in Prince George's County has been fully deployed and is operational.

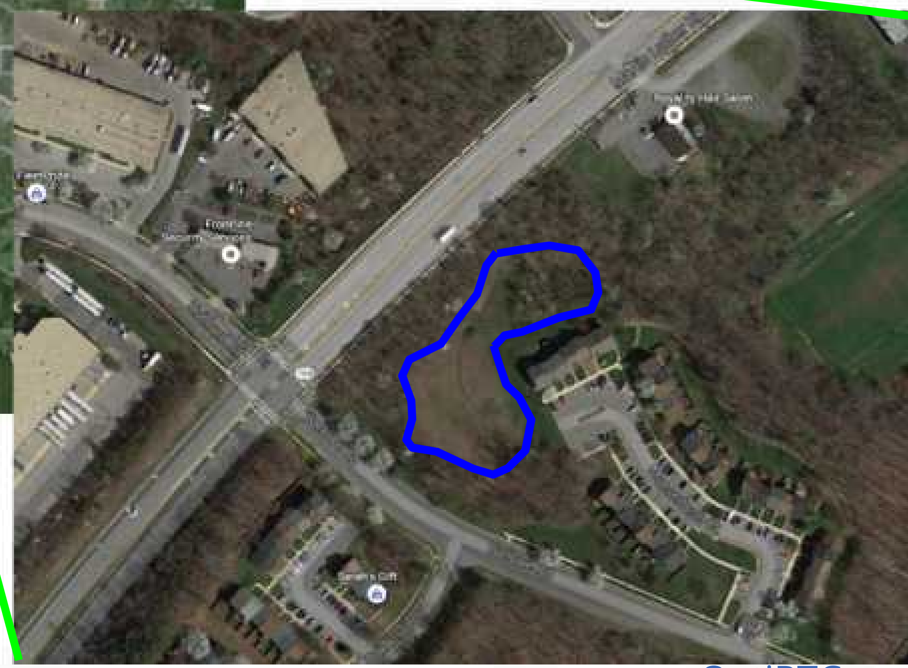
Location of Frost Pond - Glenarden, MD



60.27 Acre Drainage Area

19.15 Ac Imperviousness

Approx. 0.5 ac Dry Pond built in 1988



Frost Pond - Glenarden, MD

Frost Pond - Conventional Retrofit

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[1]	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

[1]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

Conventional Retrofit - Excavate 3.21' to create 1.69 ac-ft of storage

Frost Pond - Conventional Retrofit

Cost Breakdown Worksheet:						
Pond No.: 02_87216A_01					Date:	6/7/2012
Item	Unit cost ($)		Est. Quantity		Sub-Total($)	Notes
Clearing/Grubbing/Disposal*	$7,000	ac	0.79	ac	$5,521	
Erosion/Sediment Control	$8,000	ac	0.79	ac	$6,309	
Excavation/On-Site Disposal	$60	cy		cy	$0	
Excavation/Off-Site Disposal	$100	cy	2721.79	cy	$272,179	
Amended Soil Mix	$110	cy		cy	$0	
Gravel Media	$60	cy		cy	$0	
PVC Underdrain (6 in)	$25	lf		lf	$0	
Concrete Pipe Work	$200	lf		lf	$0	
Concrete Manhole	$3,000	ea		ea	$0	
Concrete Riser	$5,000	ea	1.00	ea	$5,000	
Concrete Barrel	$250	lf	16.00	lf	$4,000	
Drain/ED Valves	$900	ea		ea	$0	
Rip-Rap (Class 1)	$60	sy	20.00	sy	$1,200	Stabilization within BMP
Geo-Tex Fabric	$3	sy		sy	$0	
Reinforced Concrete	$1,000	cy		cy	$0	
Landscape/Reforestation	$5,000	ac	0.79	ac	$3,943	
Misc.	$5,000	ea	1.00	ea	$5,000	Forebay Weir/berm
				Total	$303,153	

* Multiplied Pond Surface area by 1.2 to account for access roads, embankments, and adjacent areas.

Conventional Retrofit - $303,153

Frost Pond - CMAC Retrofit

Creates >2 ac-ft of WQV from CMAC

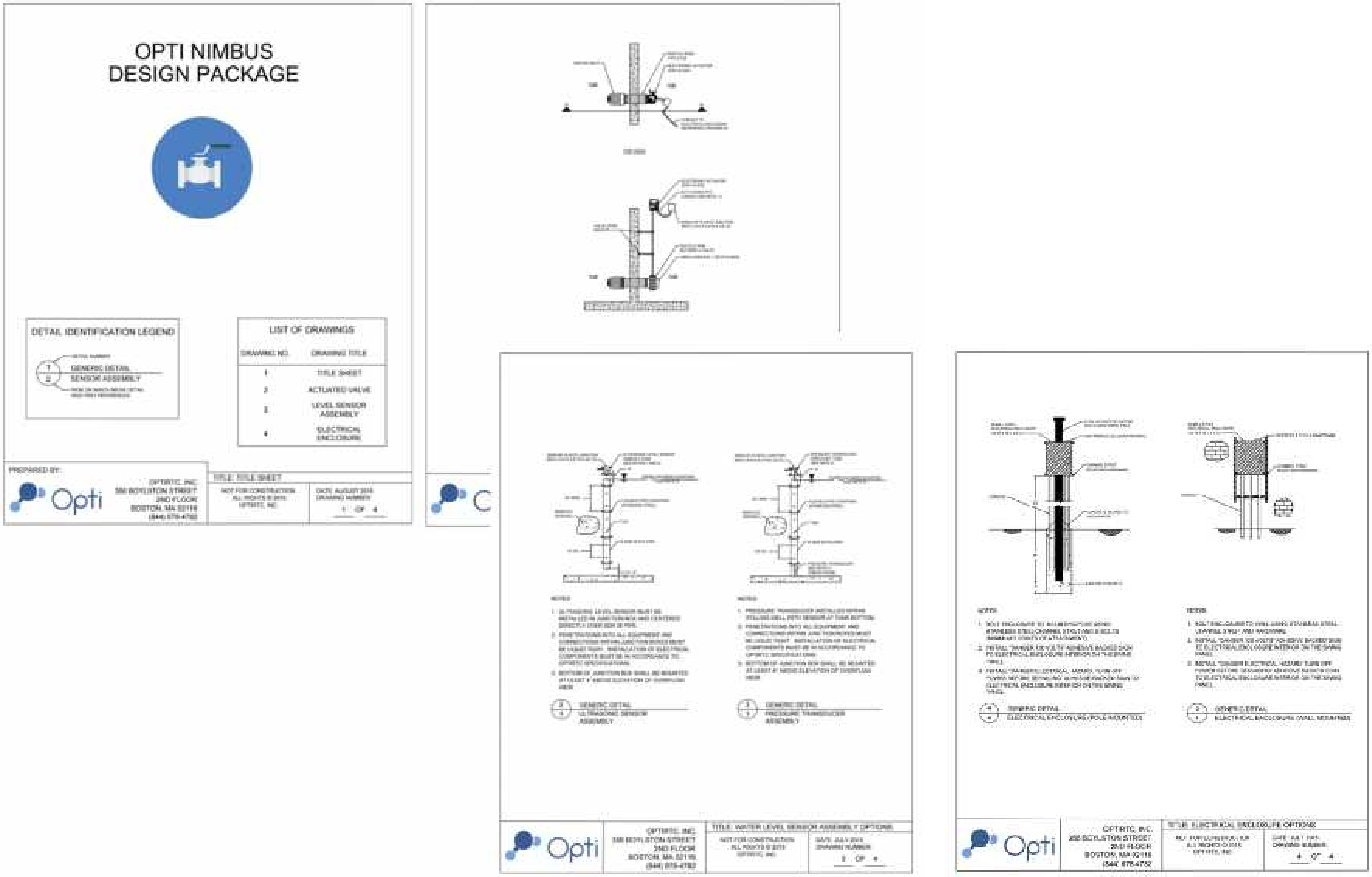
Frost Pond
Summary of ROI Calculations

Lifecycle Costs - Including Consulting, Design, and Construction

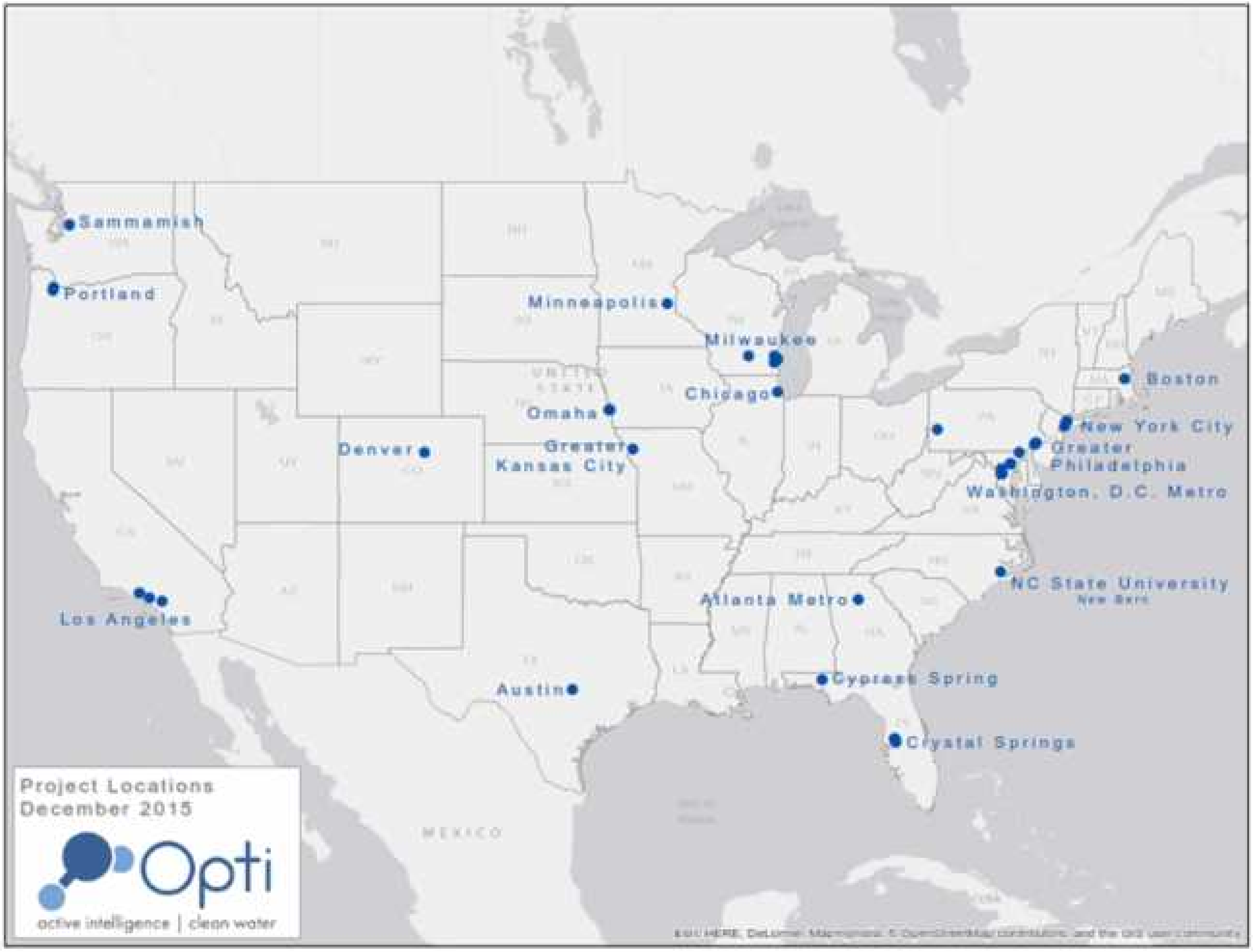
Cost Summary	Opti (Actual)	Passive (From Contractor Bid)	Difference (Passive – RTC)/Passive
Total Capital Cost	$26,000	$303,000	>10 times less expensive
Annual O&M Including CMAC Services	$10,760	$760	
Present Value of 25 year Lifecycle Cost	$177,650	$313,700	43%

References:
O&M Costs from MDE (http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Documents/FINAL_PhaseII_Report_Docs/Final_Documents_PhaseII/Appendix_C_PhIIWIP_Cost_Funding_Studies_101512.pdf)
Construction Costs from Opti and from a comparison bid for passive infrastructure.

Efficiency - Standard Design Packages



Project Locations

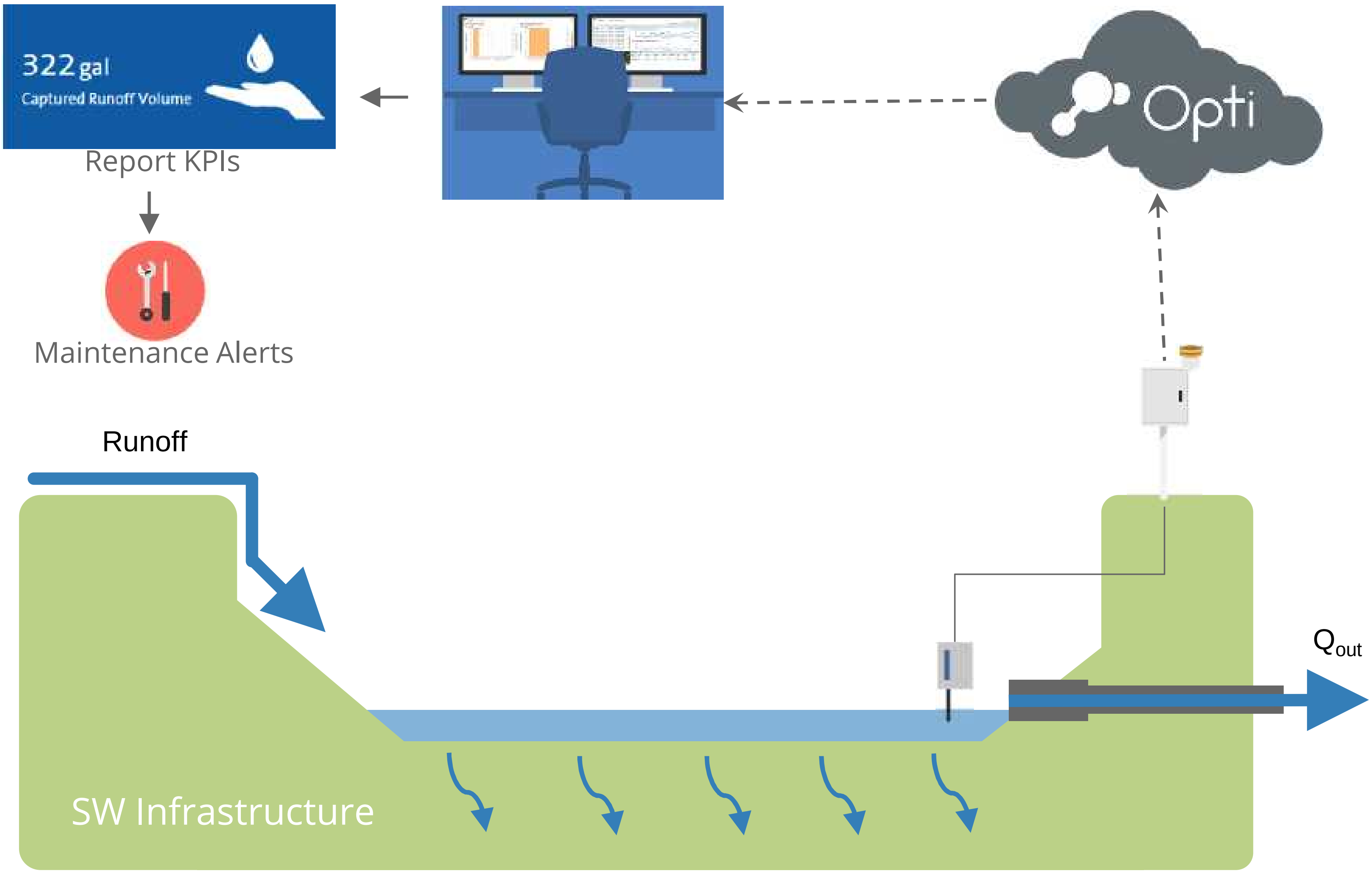


Over 100 Deployments Nationwide

Adaptive control optimizes the function of existing and new stormwater assets and dramatically improves ROI.

Applys also to:
Combined Sewer Overflows, Flow Control, Flood Control, and Stream Restoration.

Continuous Performance Monitoring



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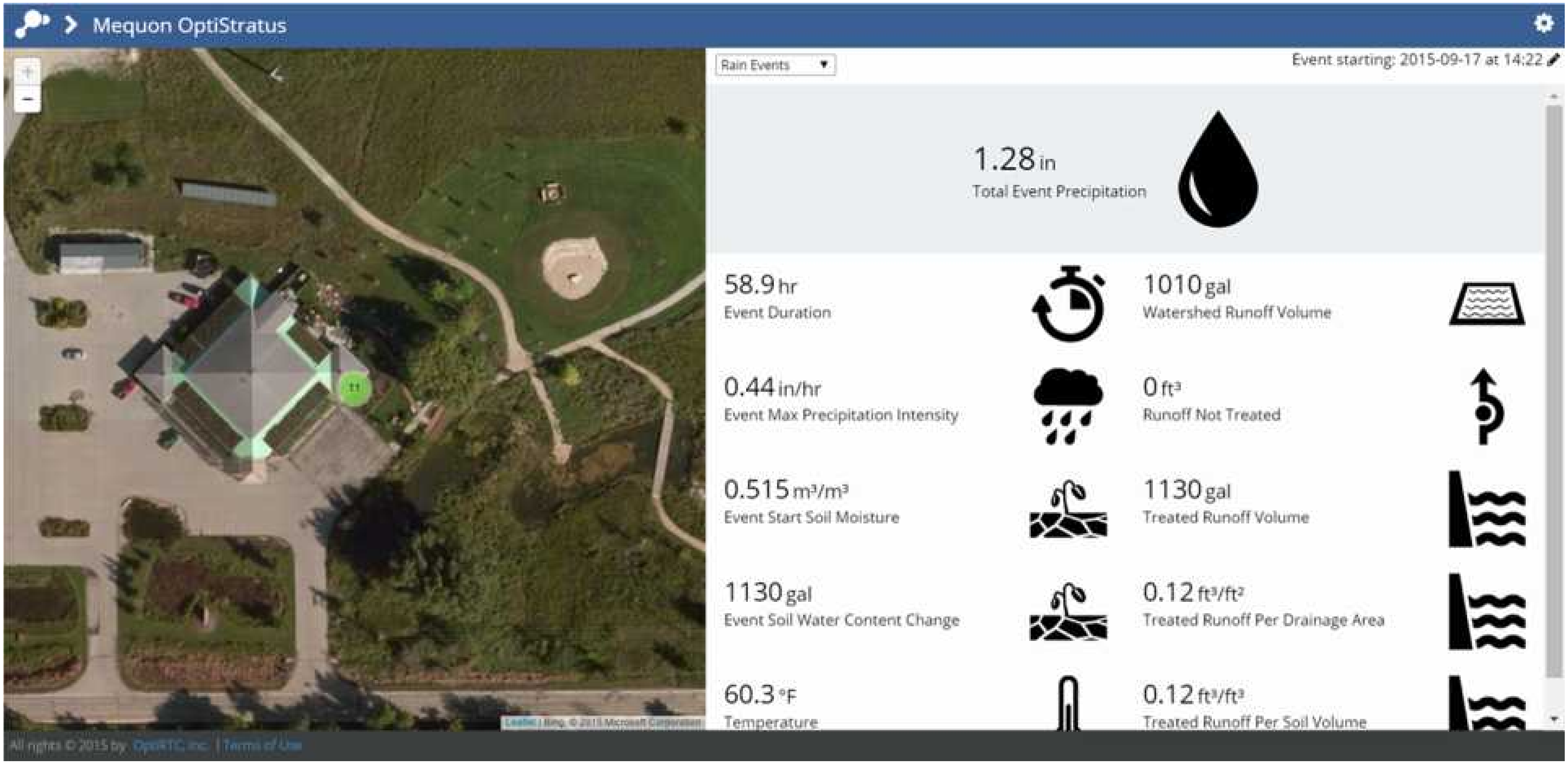
Continuous Performance Monitoring



Quantitative and Verifiable Reporting Data

Continuous monitoring reduces uncertainty and allows for improved pricing and risk reduction by better quantifying performance risk as well as compliance risk.

Directly informs future capital expenditures and can reduce maintenance costs.

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