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BLUX

Intelligent Urban Watersheds™

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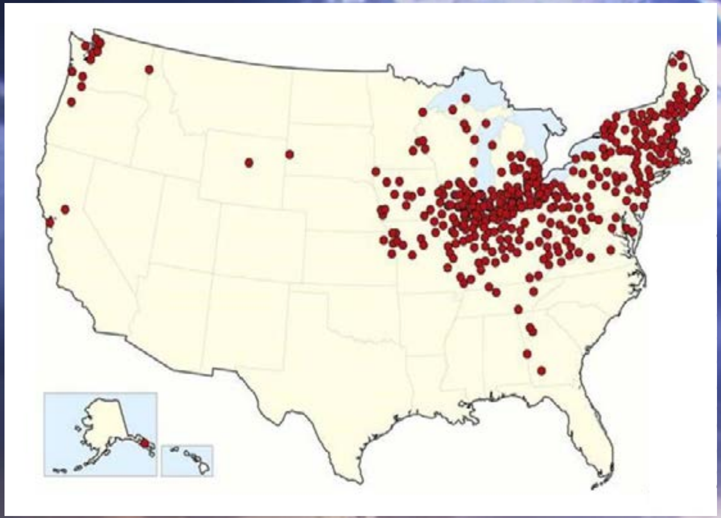
A Symposium in Honor of Dr. Panos Antsaklis

October, 2018

The Problem:
Wet Weather Management



772 cities with 46 million people


Traditional Solutions
Chicago Tunnel and Reservoir Plan
Tunnel: 100 miles, 400 ft. deep, 33 ft. diameter
$3.5 Billion
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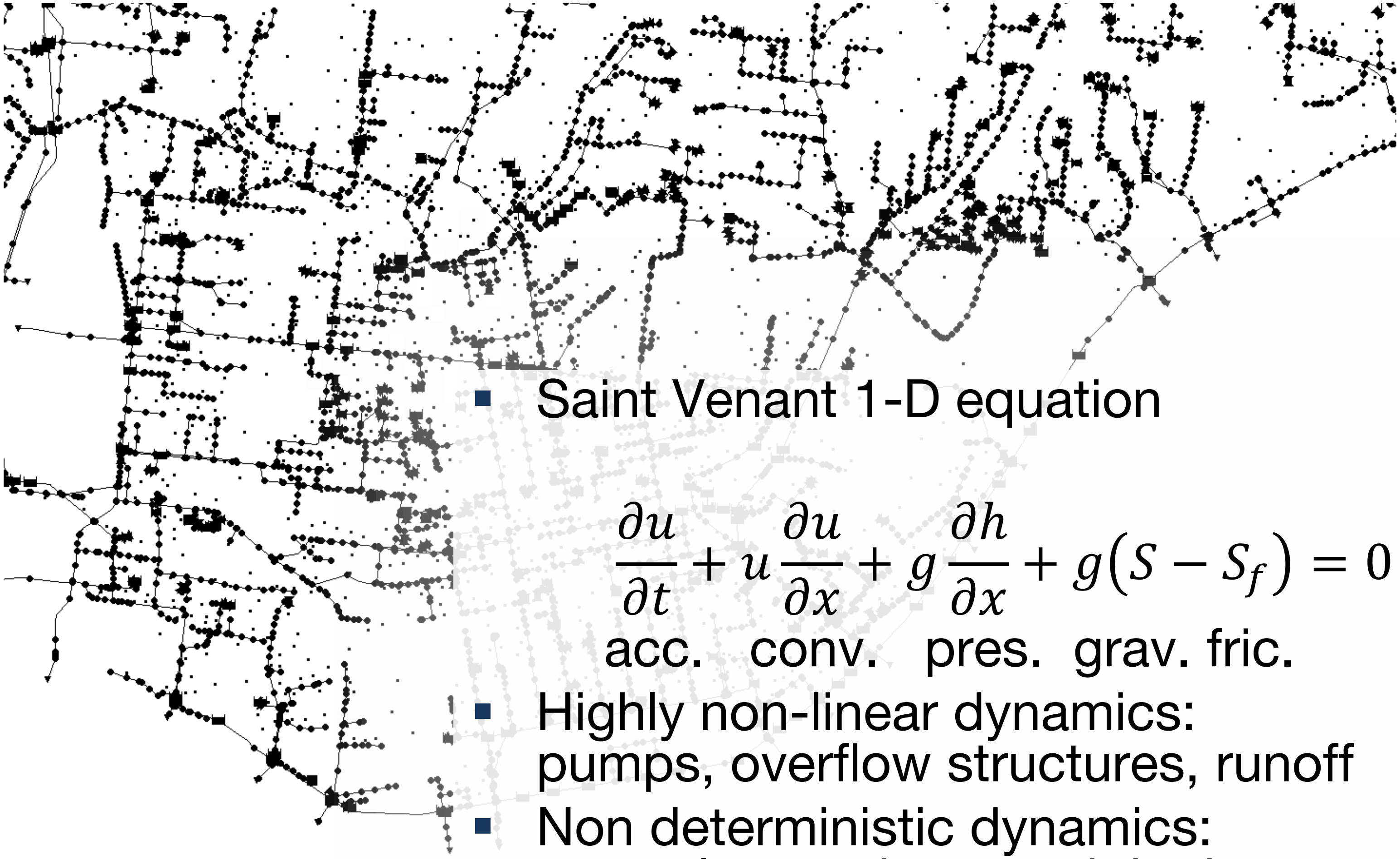
Problem Characteristics



- Saint Venant 1-D equation

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + g\frac{\partial h}{\partial x} + g(S - S_f) = 0$$

acc. conv. pres. grav. fric.

- Highly non-linear dynamics: pumps, overflow structures, runoff
- Non deterministic dynamics: manual operation, precipitation

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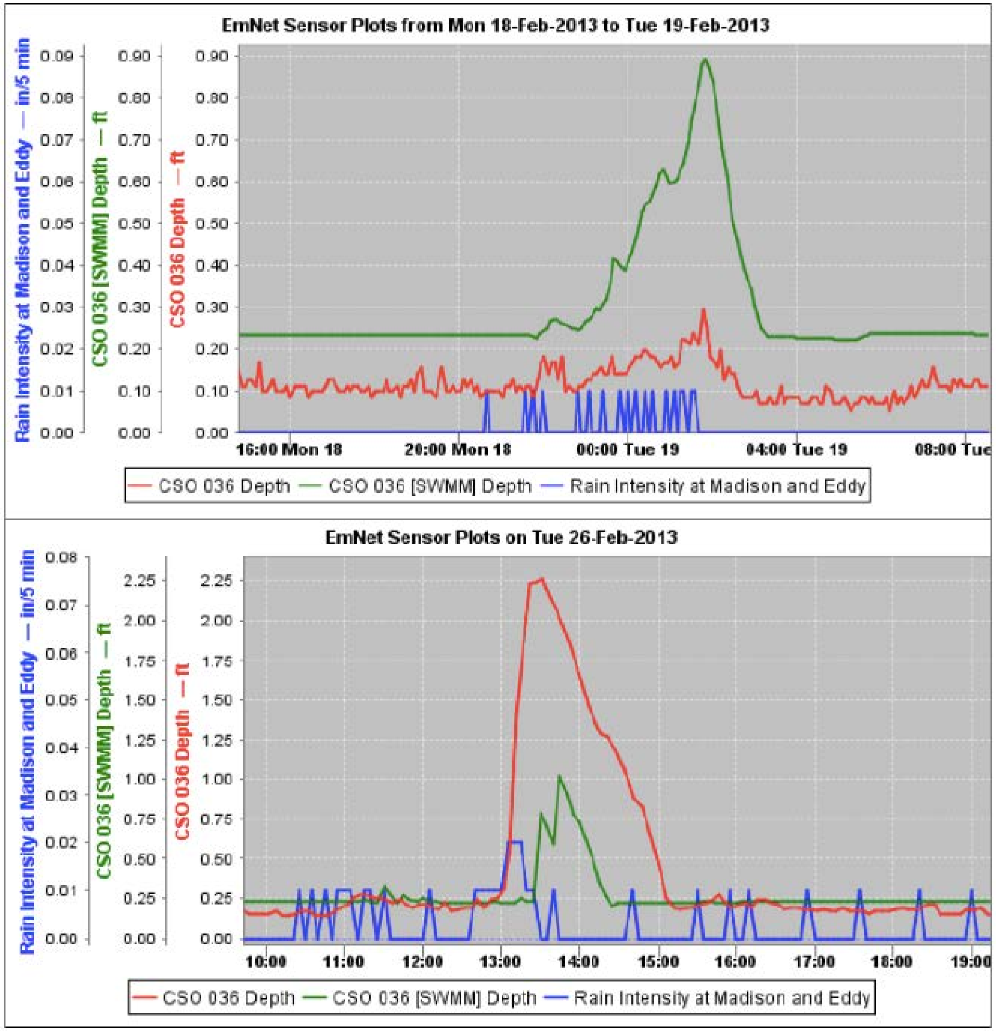
Problem Characteristics



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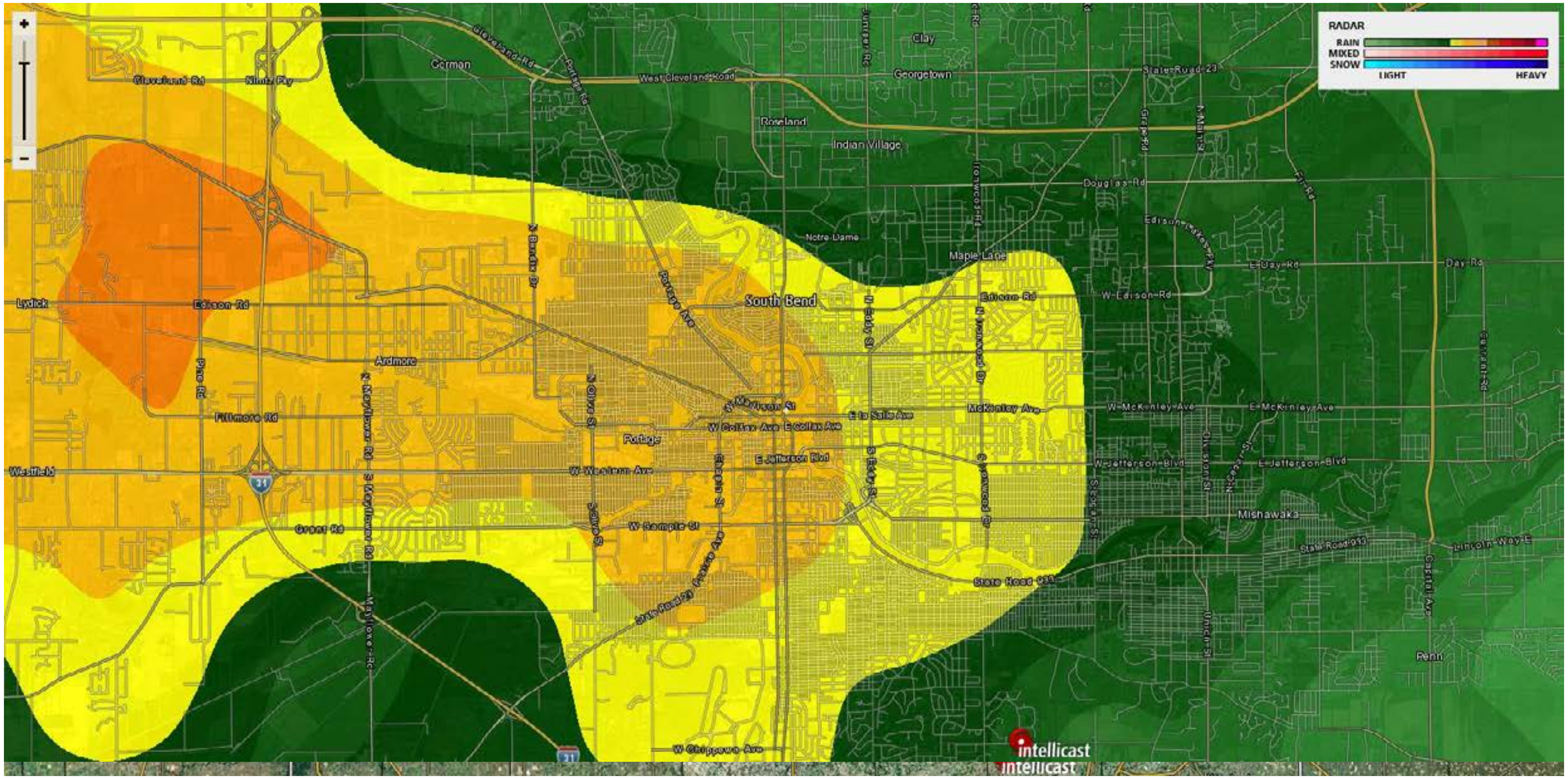
Problem Characteristics



Problem Characteristics

Blue Infrastructure:

Control the urban watershed to improve the environment while saving ratepayers money

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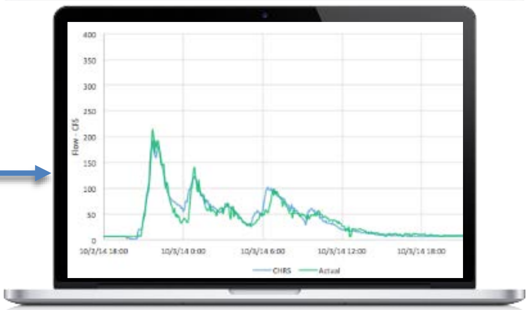
Blue Infrastructure / Smart Infrastructure

Tier 3: Operate the watershed

Implement and run Global RTC
Empower operations with RT-DSS
Maximize Performance and Resiliency

Tier 2: Create Digital Copy

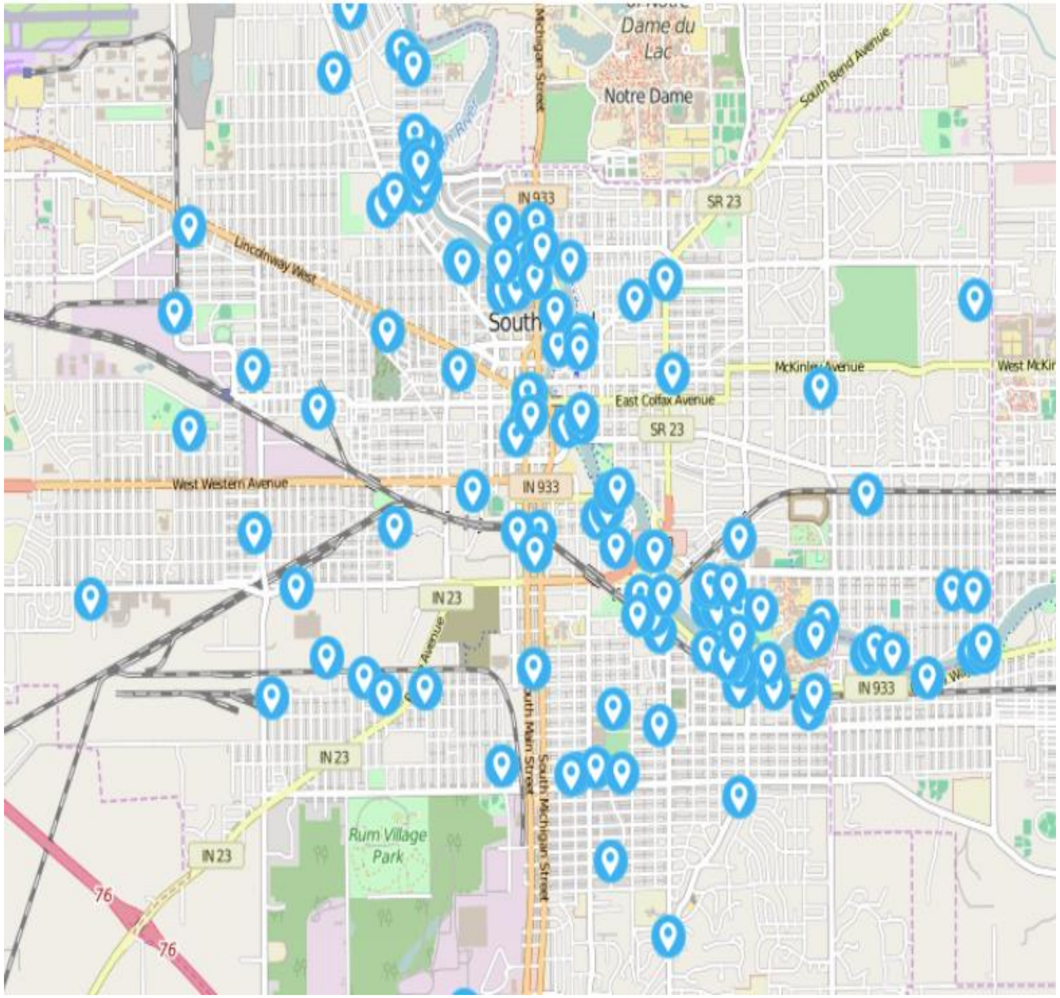
Cognitive Hydraulic Models
Host and run real time models
Compare/contrast sensor and model data

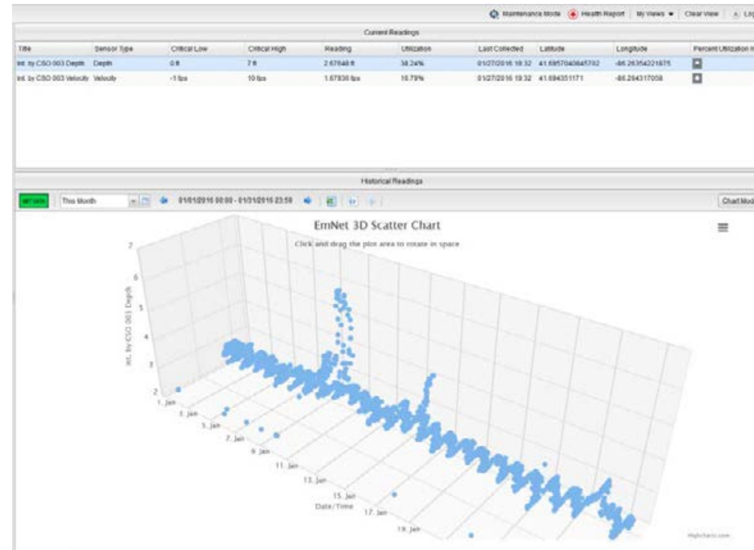


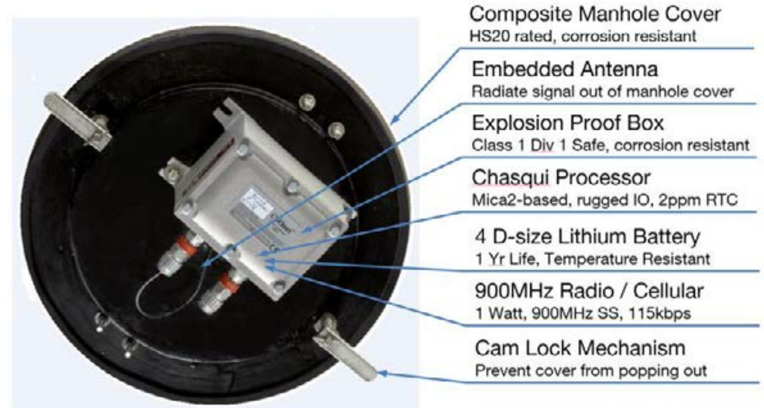
Tier 1: Turn On the Lights ™

Data Collection Software
Database & Data Analytics Tools
Full SCADA Integration

Turn on the Lights







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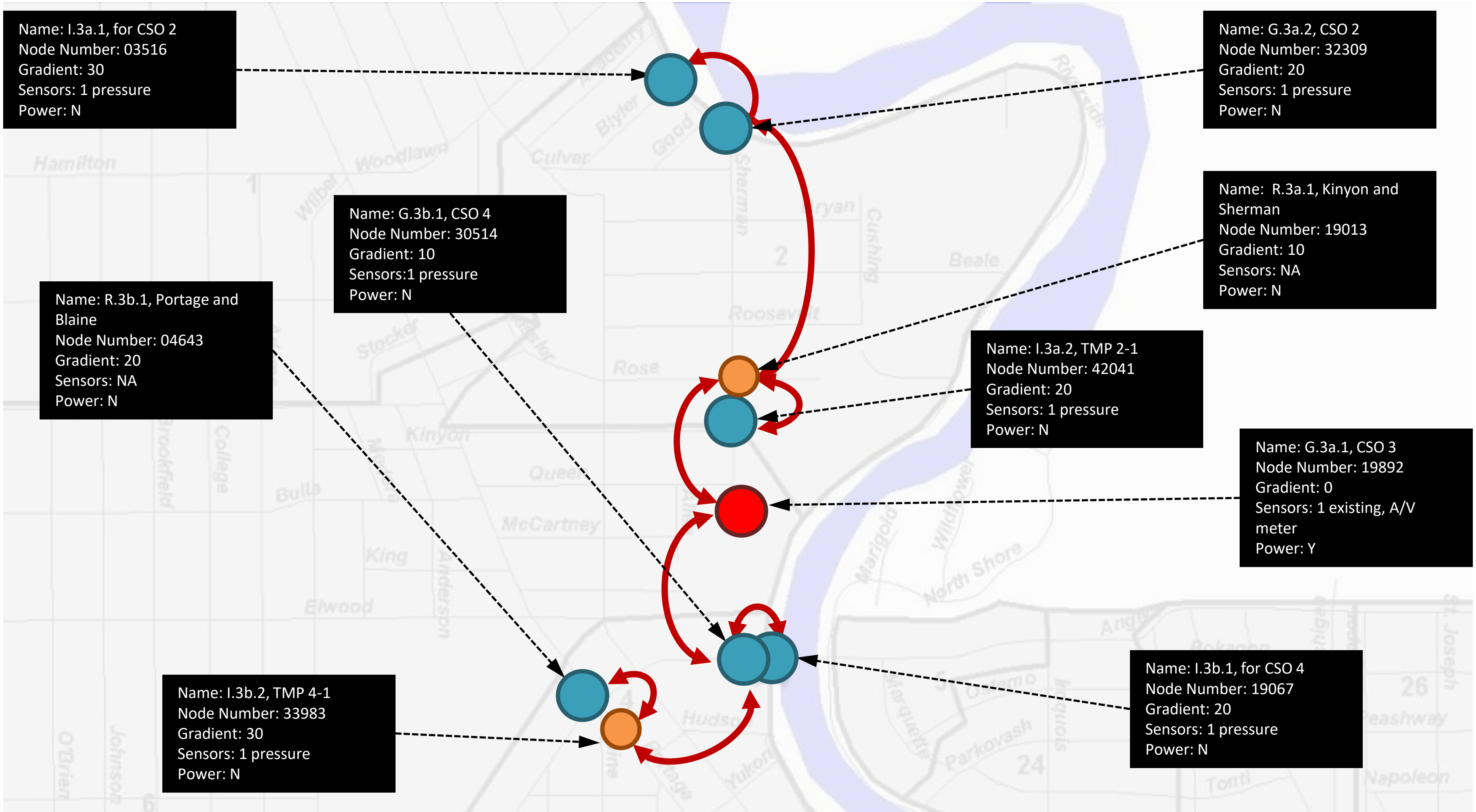

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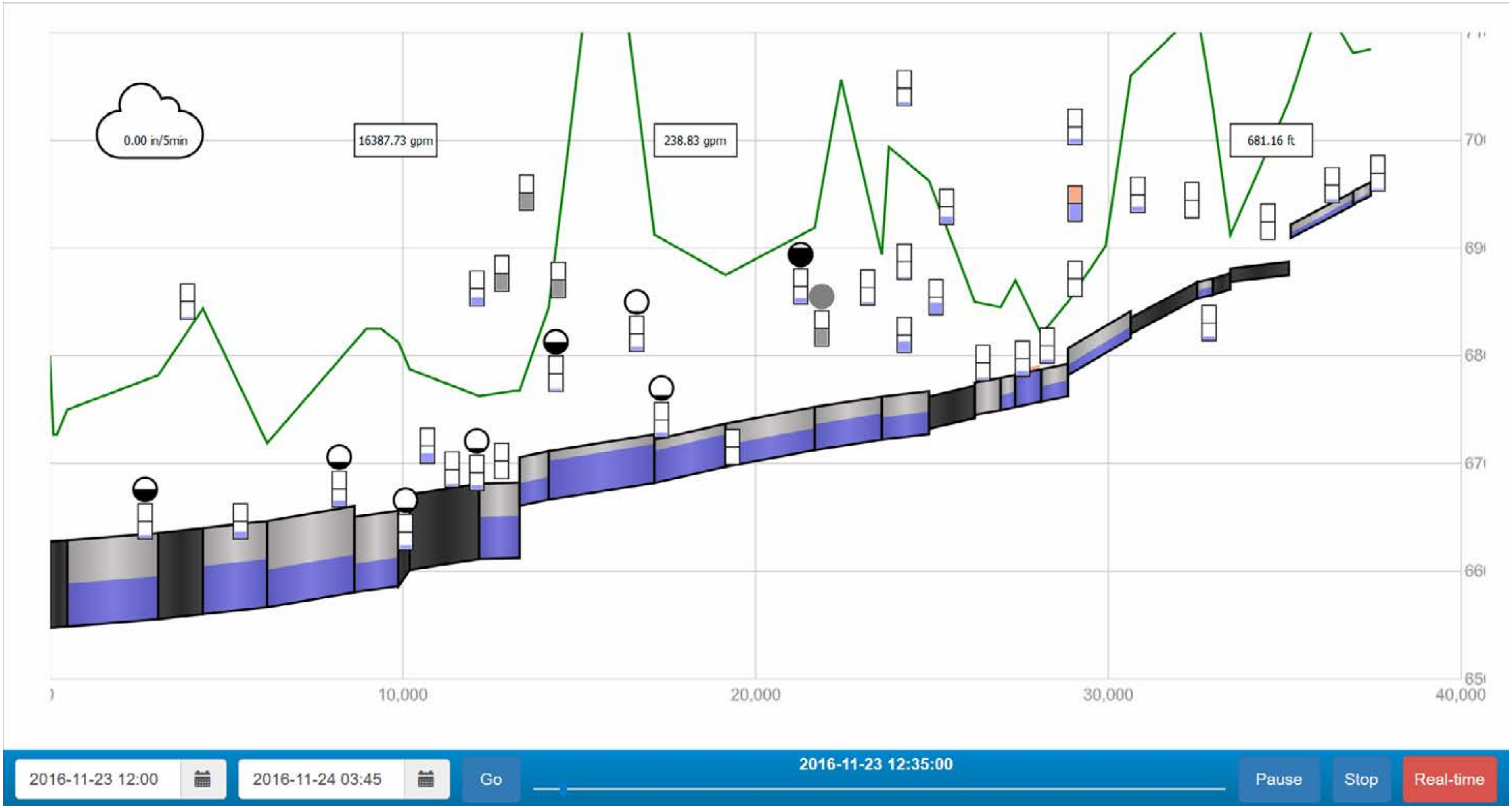

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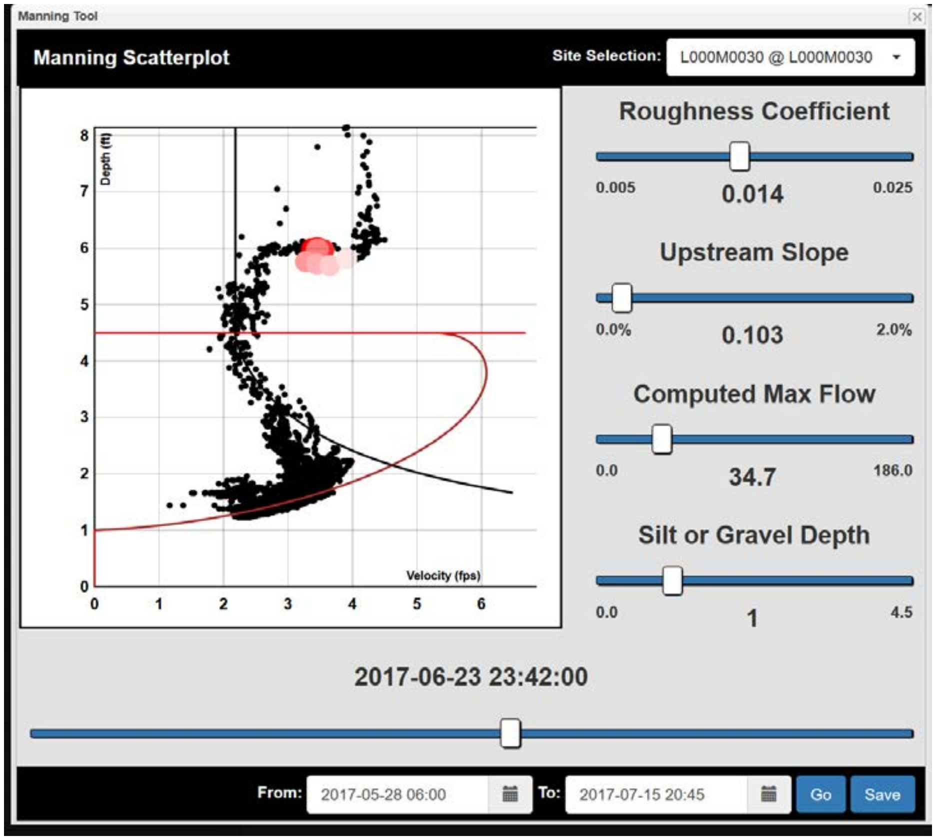

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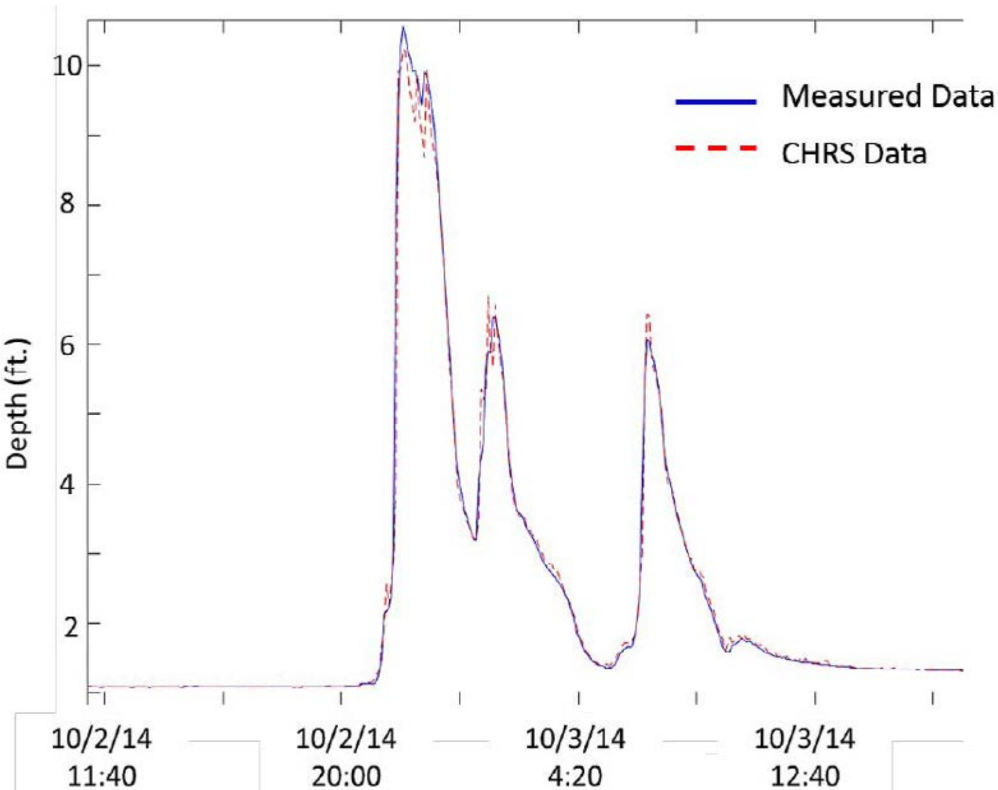
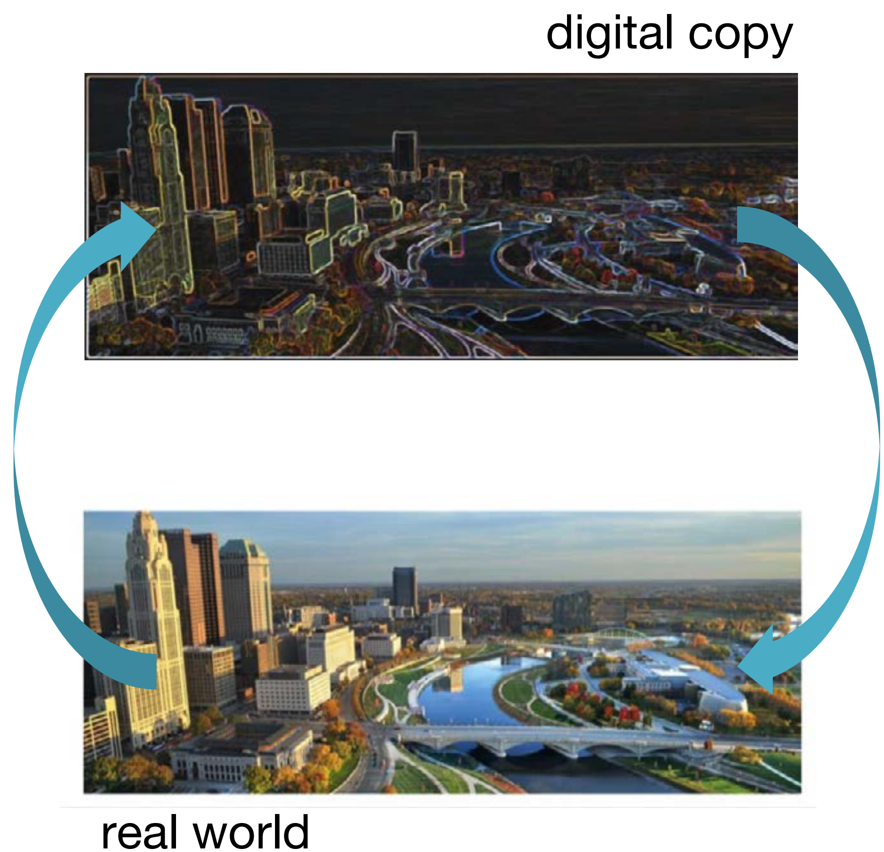
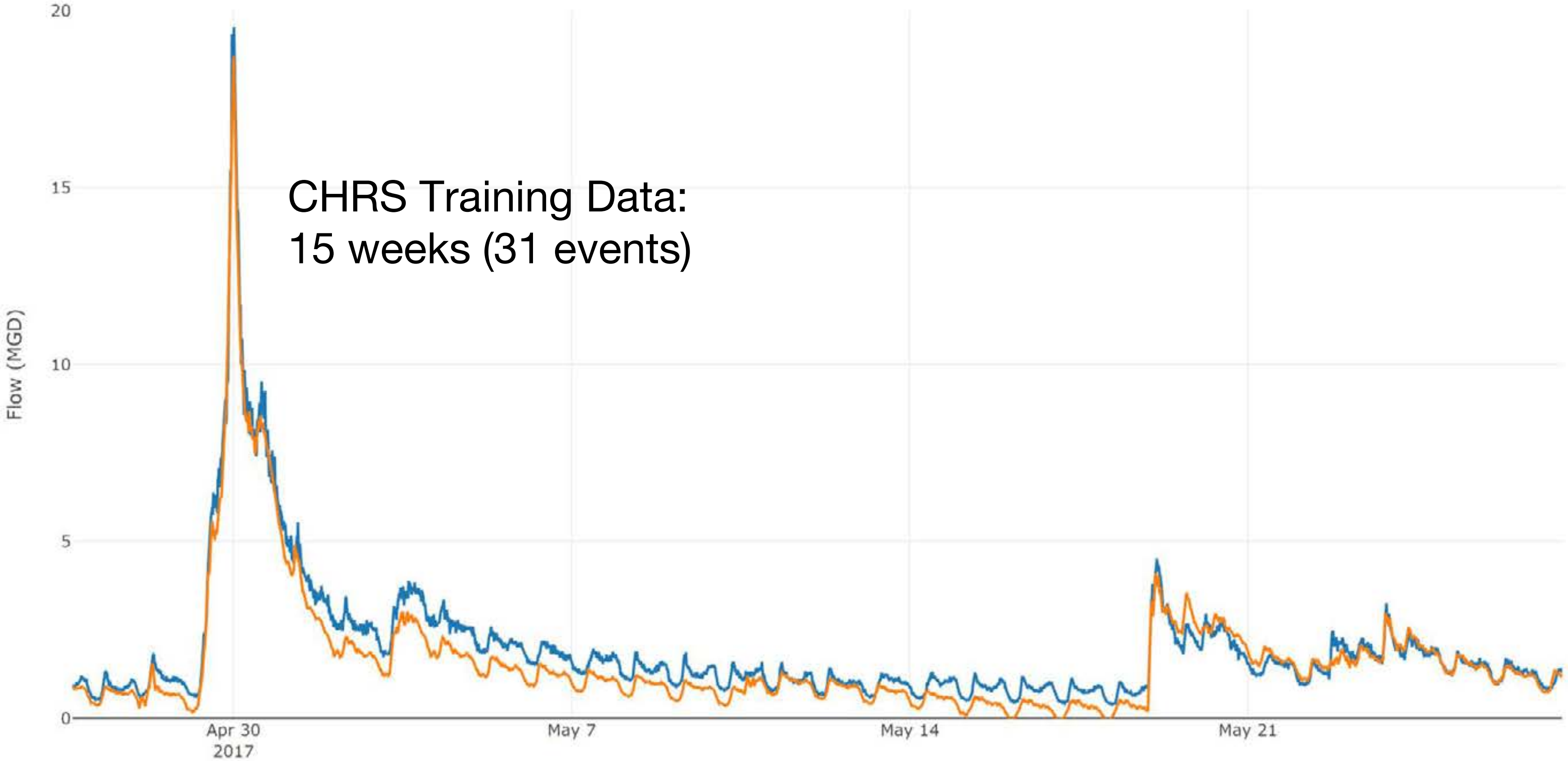
Predict: Cognitive Hydraulic Response System





BLU Predict: Cognitive Hydraulic Response System



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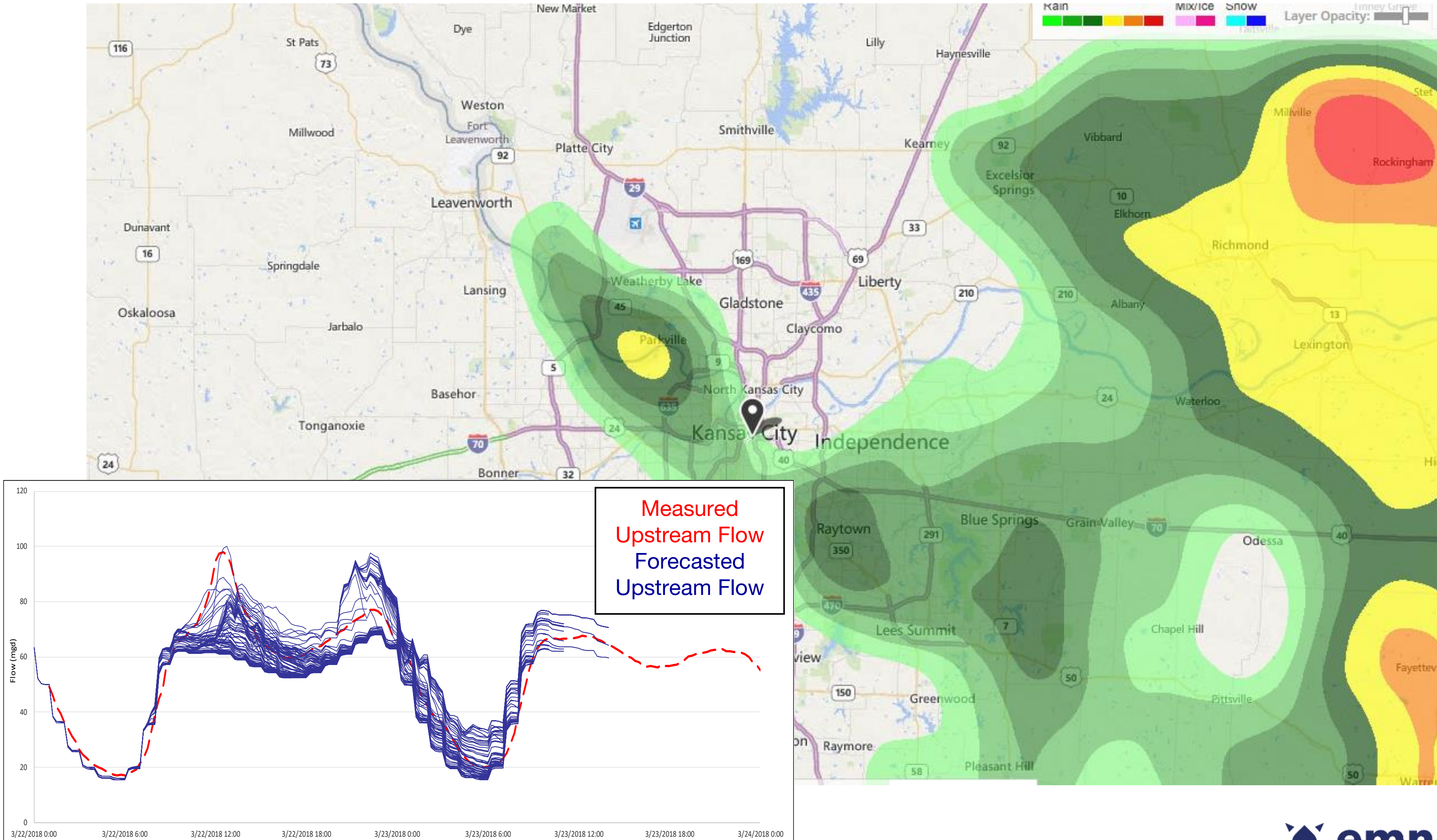

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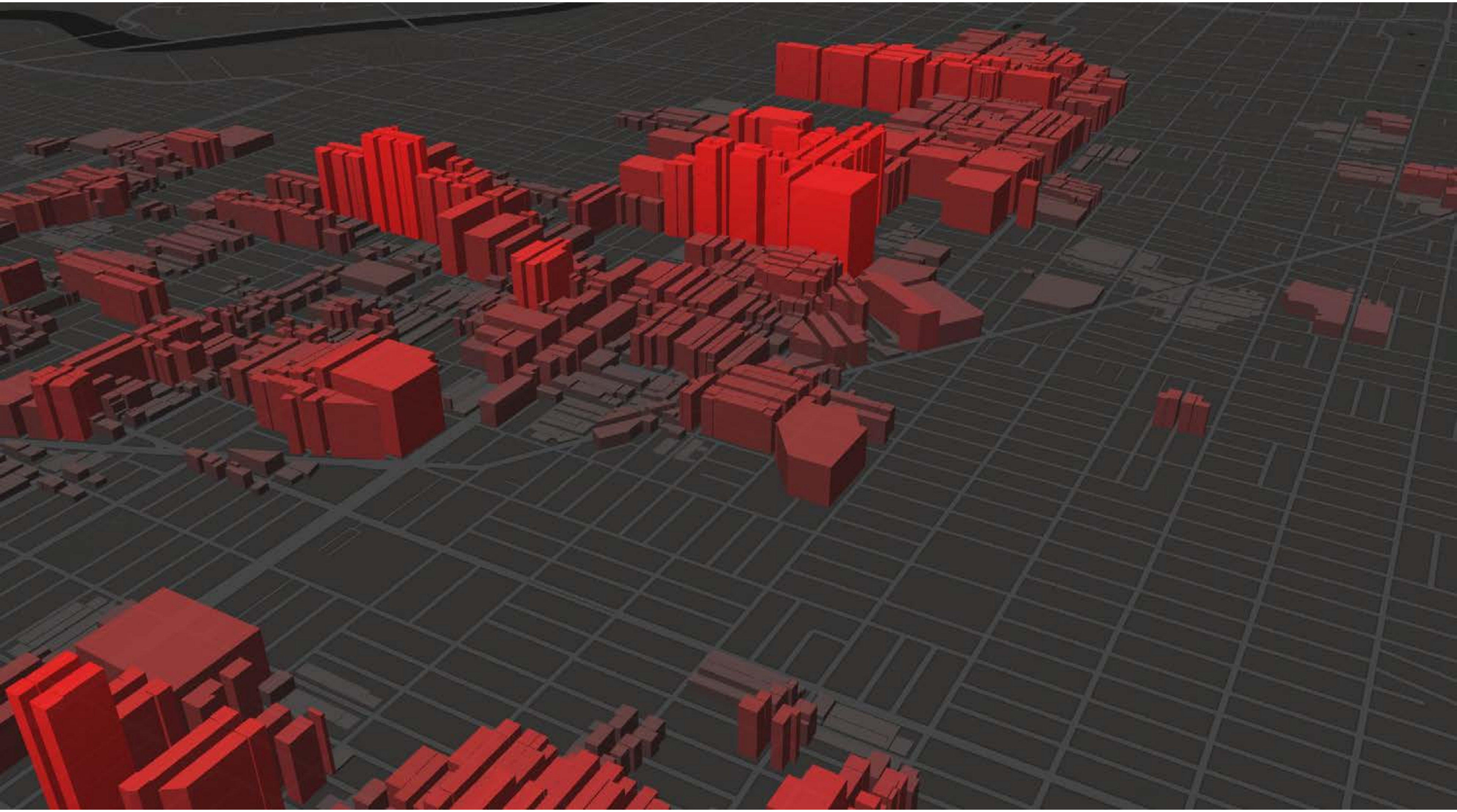
Predict: Cognitive Hydraulic Response System



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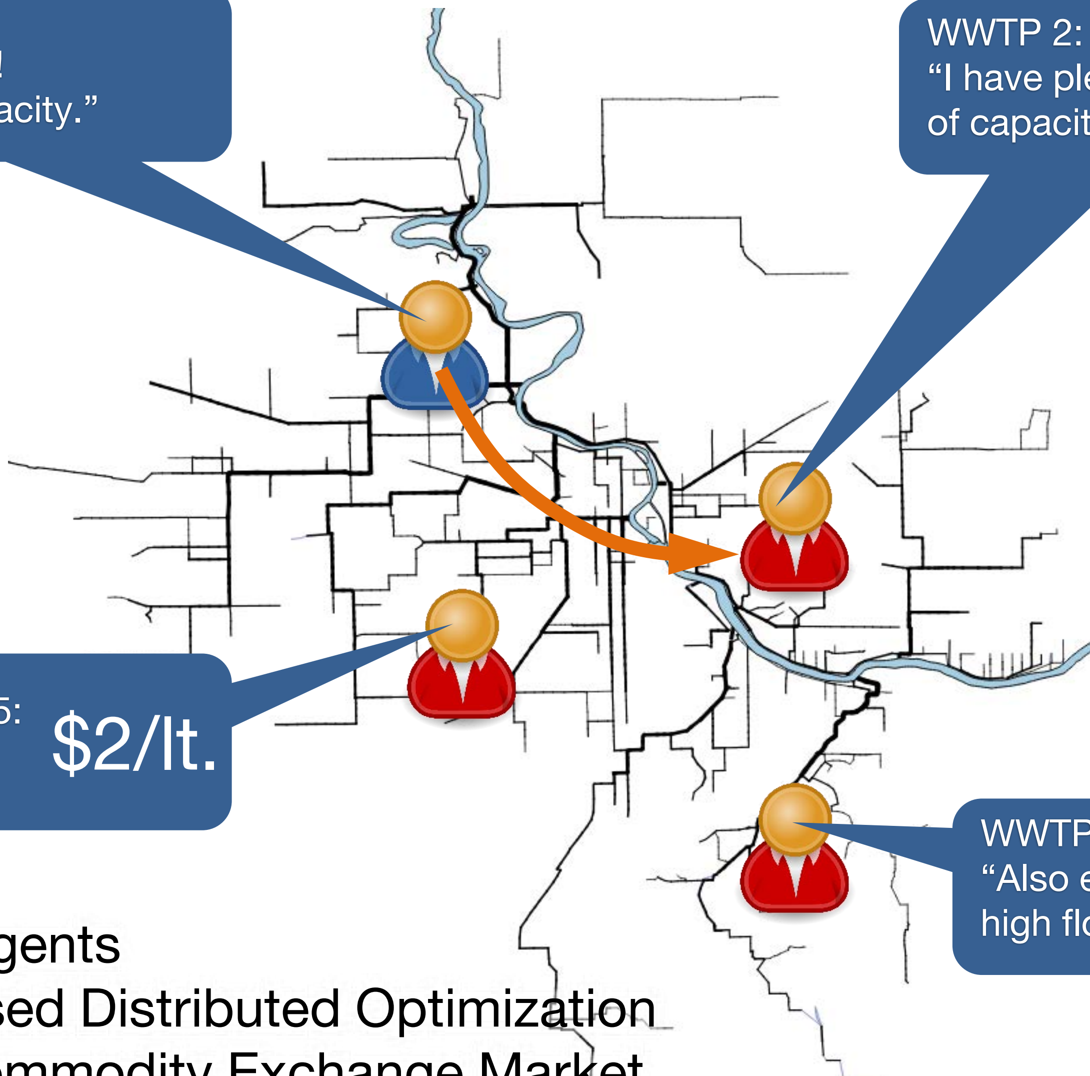
Operate the Urban Watershed



- Software Agents
- Market-Based Distributed Optimization
- Emulate Commodity Exchange Market

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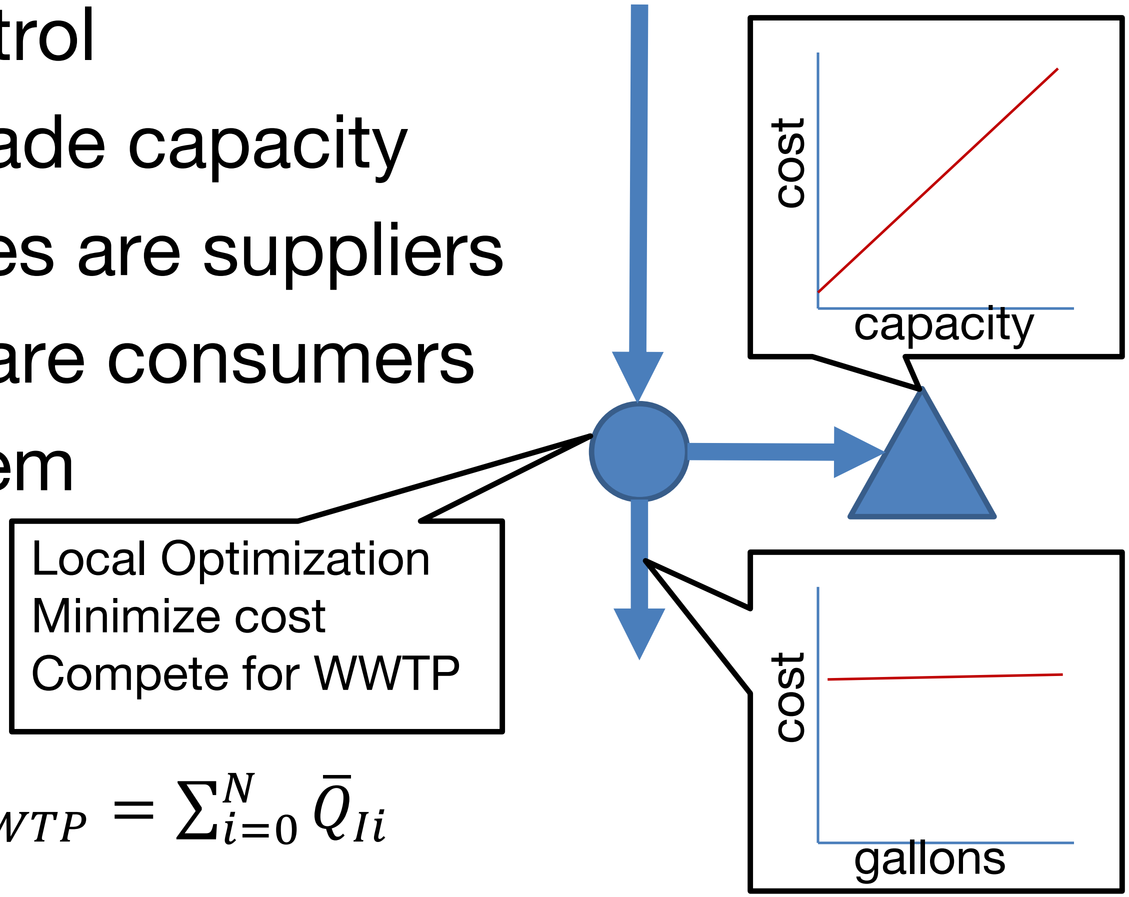
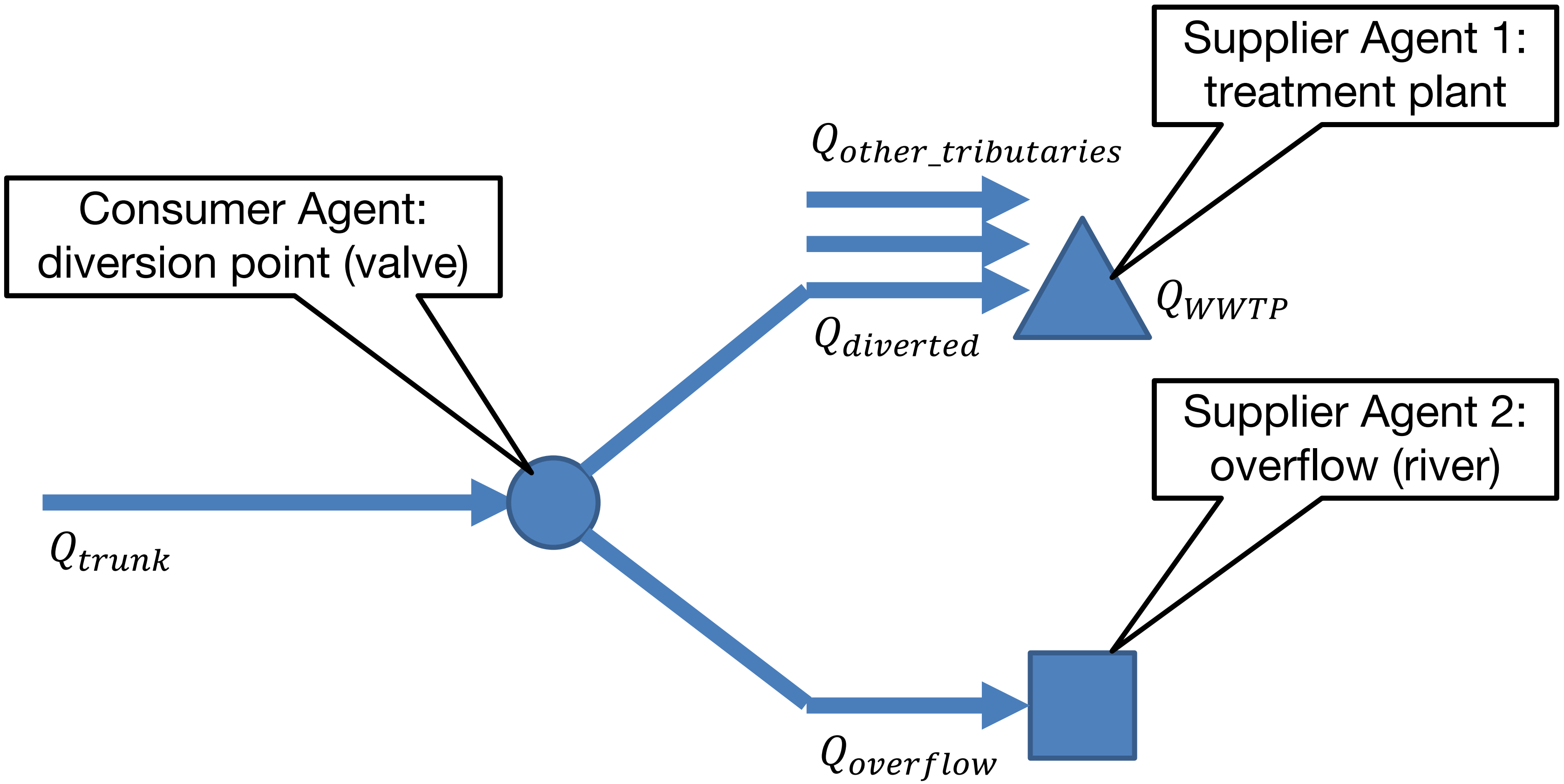
- Agent-Based control
- Network nodes trade capacity
- Downstream nodes are suppliers
- Upstream nodes are consumers
- Consensus problem

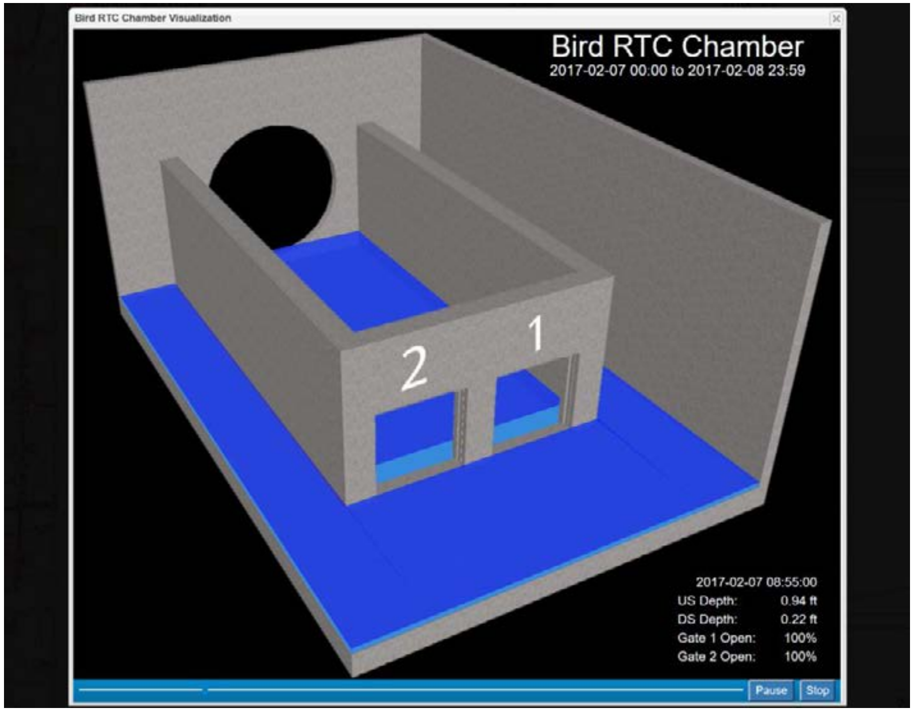


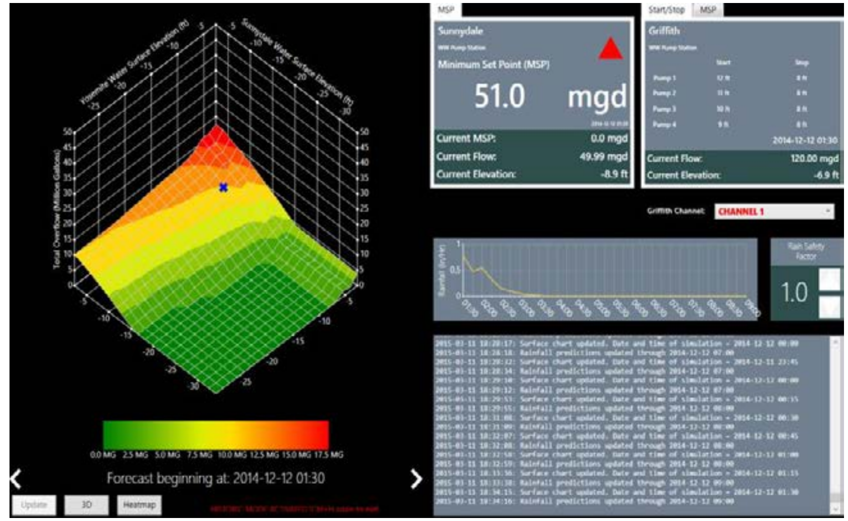
$$Q_{WWTP} = \sum_{i=0}^{N} Q_{Ii}, \bar{Q}_{WWTP} = \sum_{i=0}^{N} \bar{Q}_{Ii}$$

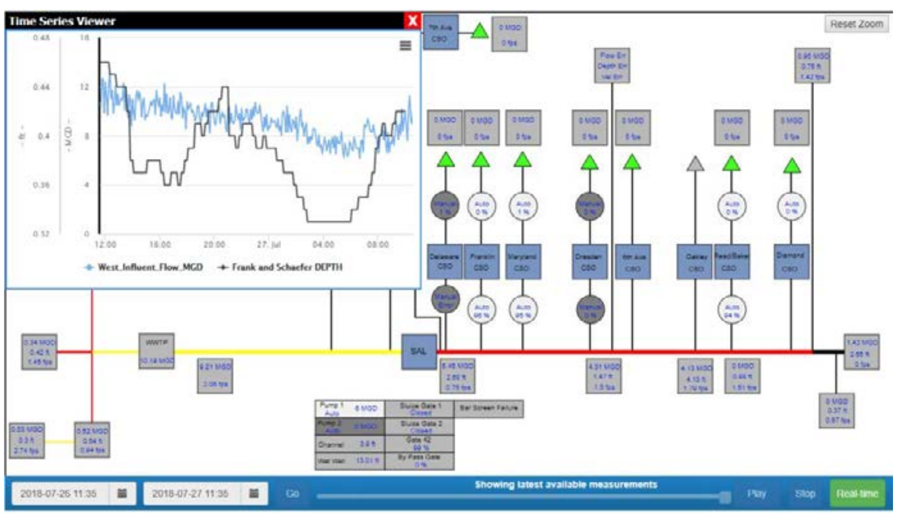
$$Q_{CSOi} = \begin{cases} 0, Q_{Ti} < \bar{Q}_{Ii} \\ Q_{Ti} - \bar{Q}_{Ii}, O.W. \end{cases}$$

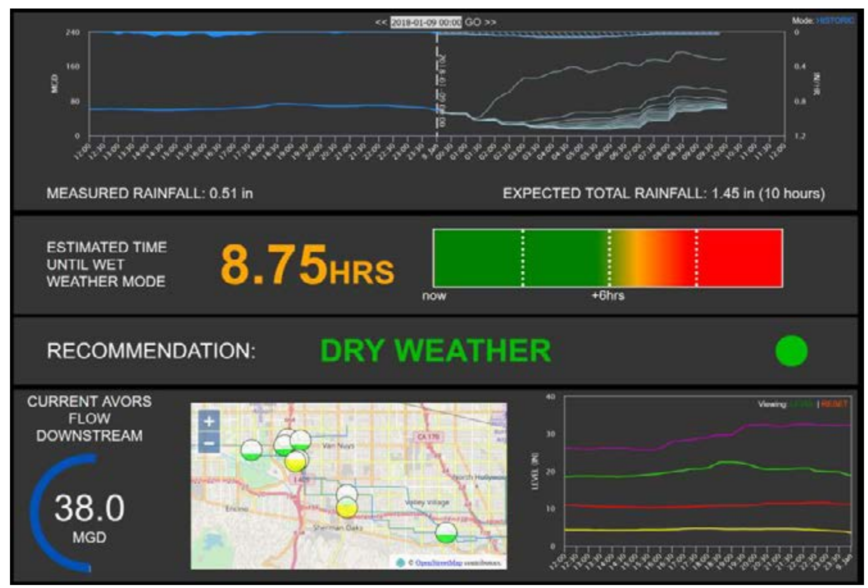


$$min(Q_{overflow}) \text{ subject to } Q_{WWTP} \leq \overline{Q_{WWTP}}$$









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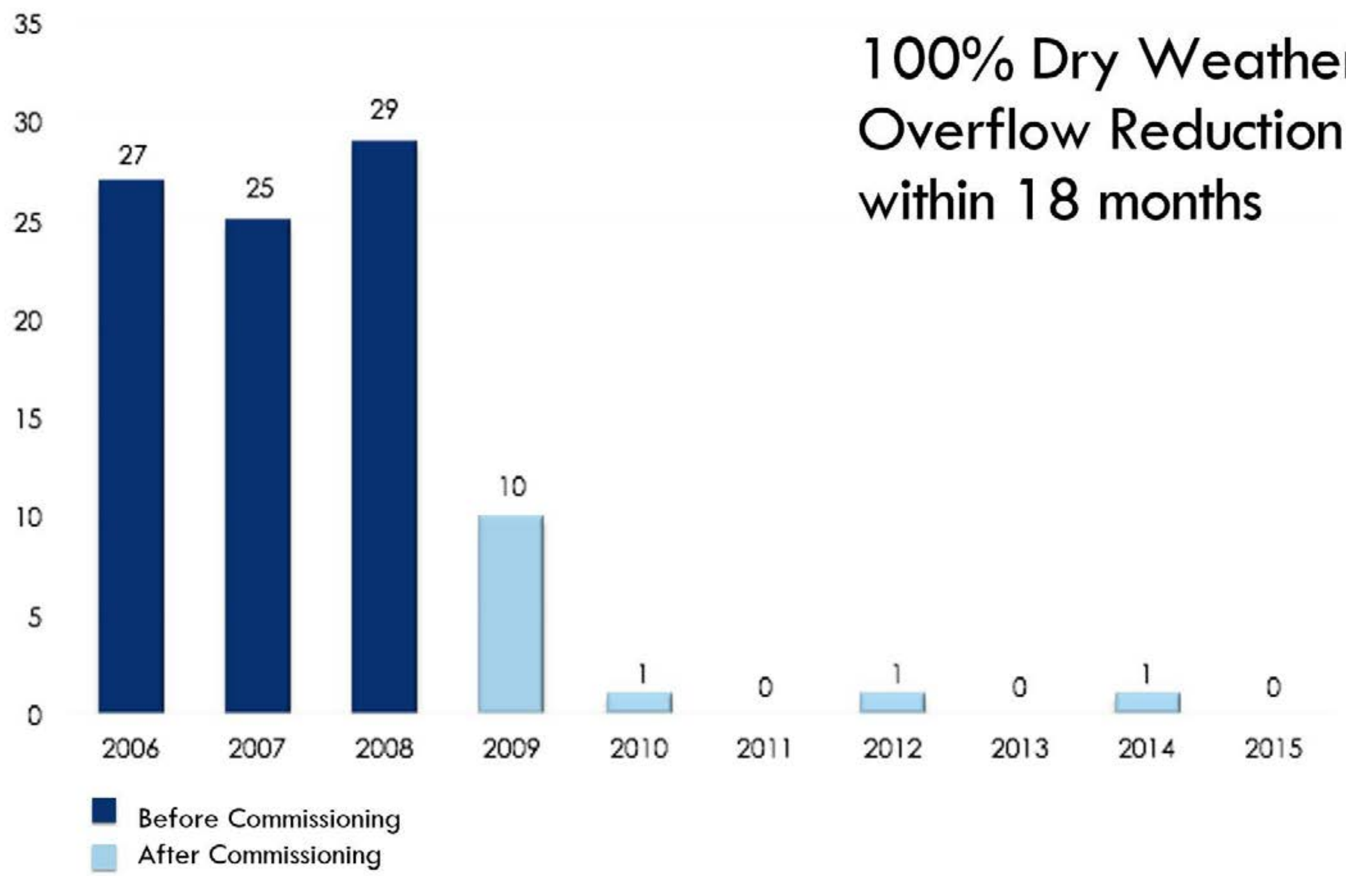
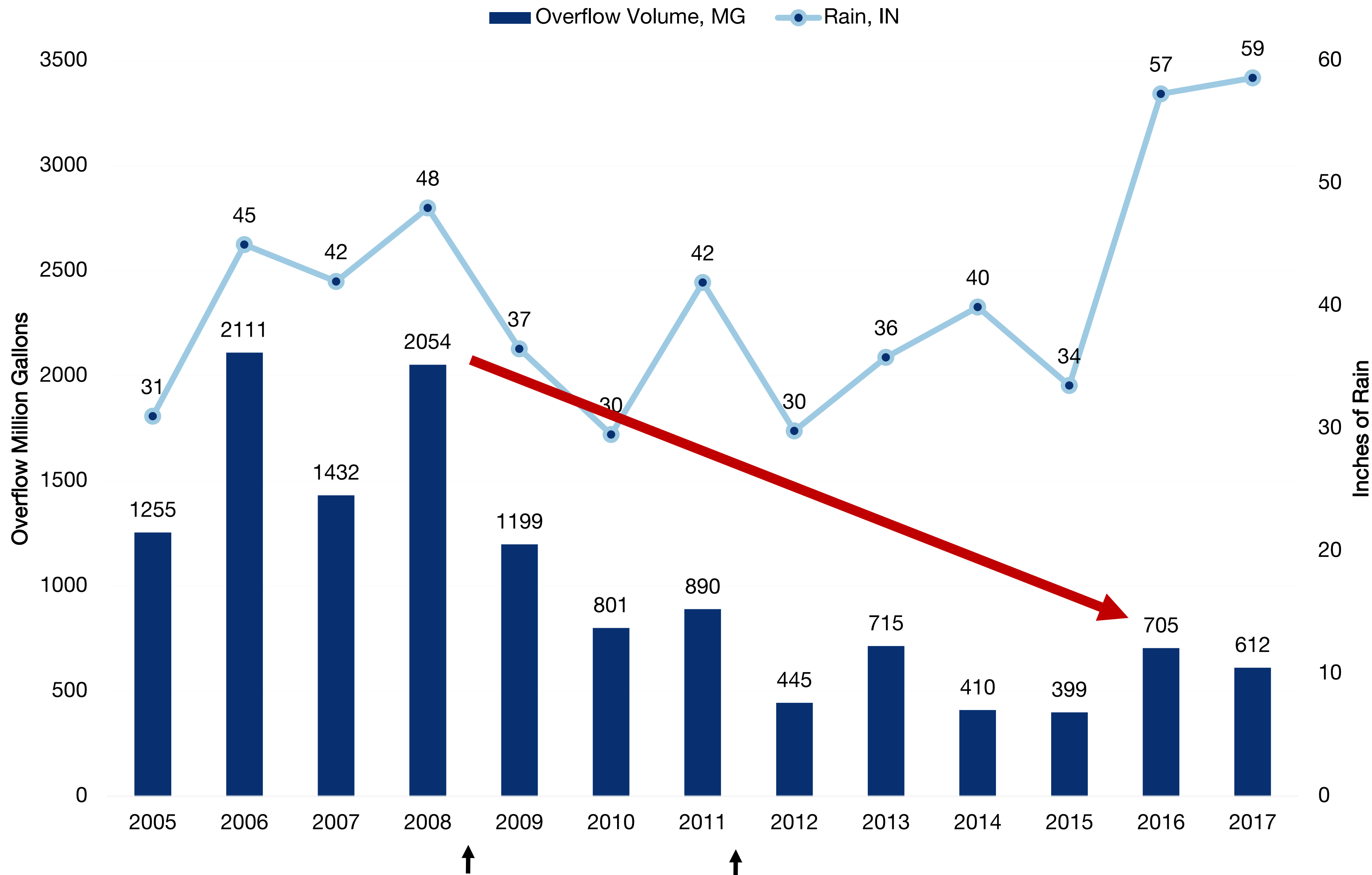
Results



100% Dry Weather Overflow Reduction within 18 months

Results

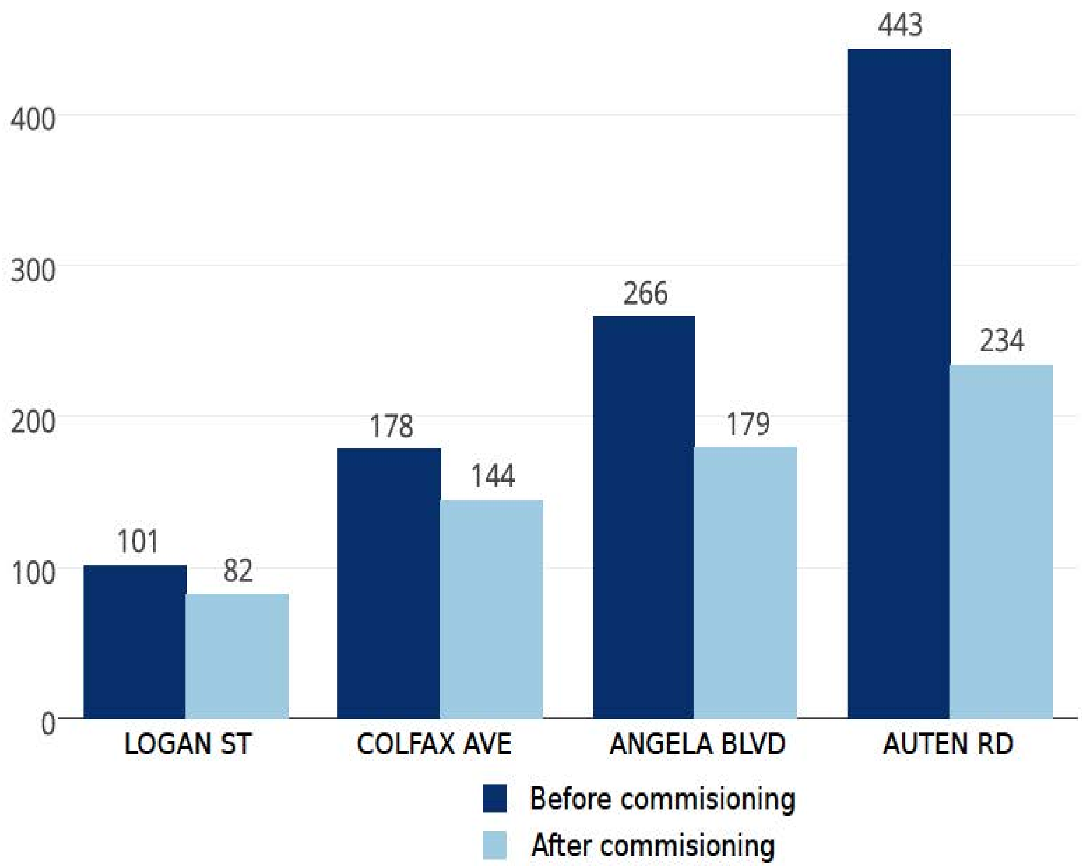


Real Time Monitoring System Implementation

Real Time Control System Implementation

Results

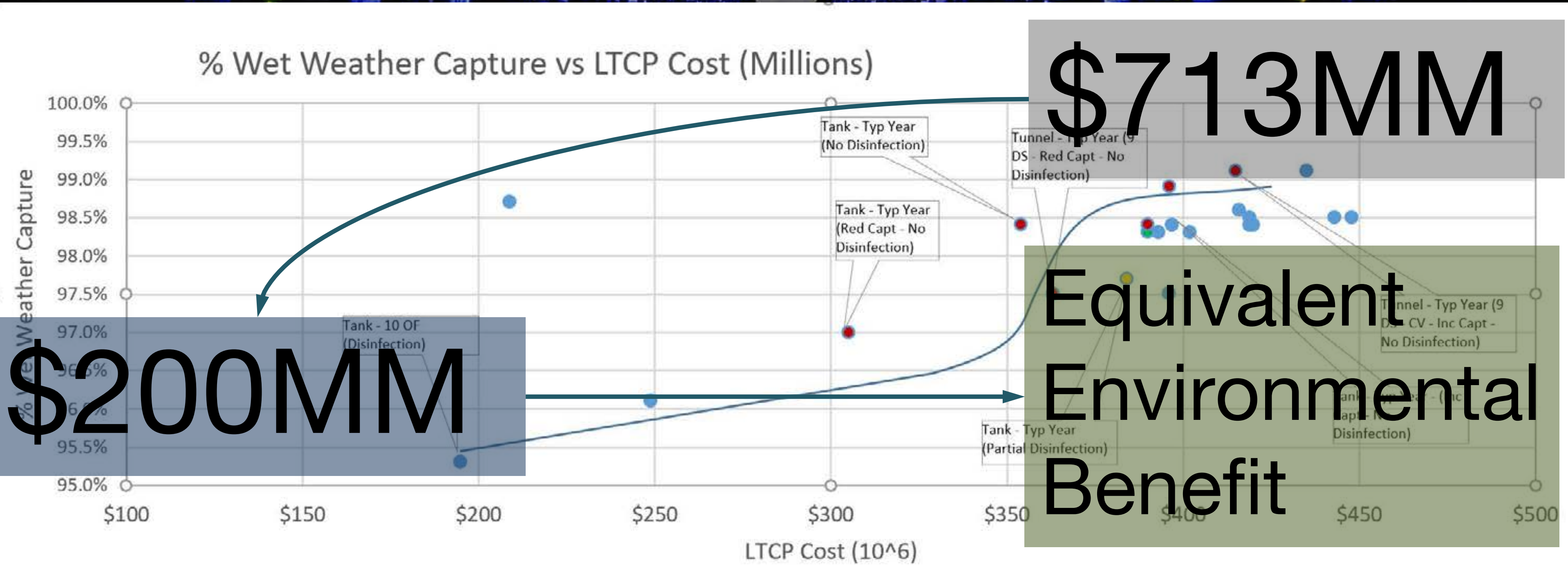
Median E. coli concentration [cfu/100 mL]



55% reduction in E. coli contribution

Revising the Wet Weather Plan: OptiSWMM

Use the cloud to try every possible grey, green, and smart infrastructure option.



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Thank You!

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