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The Future of Sewers – Get Smart! Control and Optimization Strategies for the 21st Century

August 13, 2020

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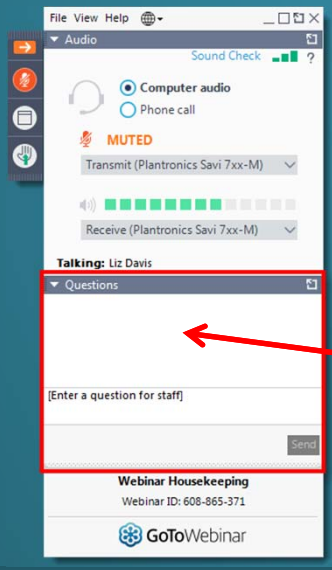
How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

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Today's Speakers

- Eric Harold, *moderator*
- Wolffie Miller and Diana Tao
  - Protecting Community Waterways
- John Abrera, Tasha King-Davis, Joshua Balentine
  - Real-Time Monitoring of Industrial pH Discharges
- Shawn Dent
  - Real Time Modeling, Smart Systems, and System Optimization

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Introduction

Wolffie Miller, P.E.
Project Manager
Louisville MSD

Diana Tao, Eng.
Project Manager
RTC and system optimization expert

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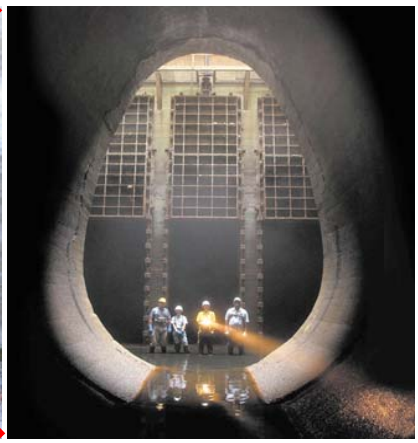
Protecting Community Waterways: Applying Analytics, Optimization, and Real Time Control for the Efficient Operation of Sewer Networks

Csoft®: Innovative Real Time Control (RTC) Solution

6

MSD smart approach for strategic sewer management

- Reduce sewer overflows to rivers: over 2 billion gallons



- Use full system capacity: avoid over $200 million cost

- Protect community health and safety: for 755,000 shareholders and millions of visitors

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MSD mission: protect public health and safety

- Largest nonprofit public utility in Kentucky
- Our shareholders
  - 755,000 residents in Louisville Metro
  - Over 24 million visitors annually
- Core business
  - Wastewater collection and treatment
  - Stormwater management
  - Riverine flood protection
- 650 employees, 24/7 services

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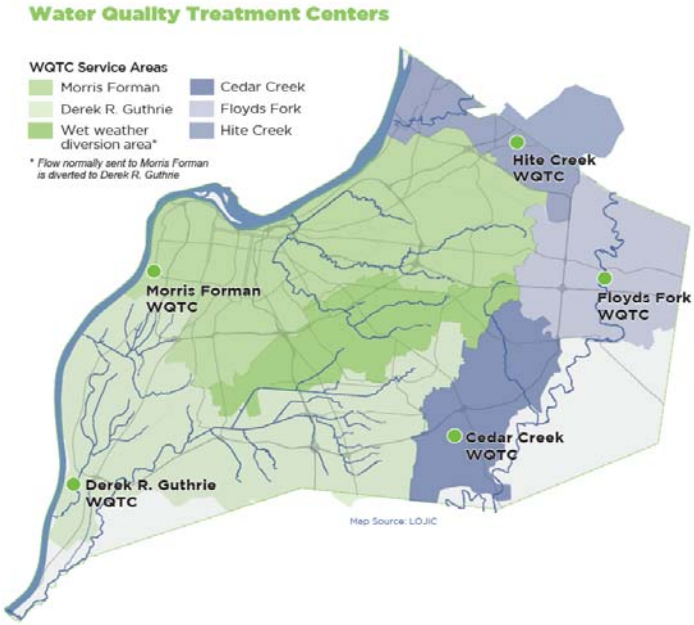
MSD wastewater collection and treatment challenges

- Complex and extensive sewer system
- 5 regional wastewater treatment plants
- 260+ pump stations
- 3,200 miles of sewer



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Improving the waterways: a step-wise approach

✓Step 1: Treat dry weather wastewater before discharge

- Build treatment plant
- Intercept wastewater flow during dry weather conditions

Step 2: Minimize discharge of diluted, untreated wastewater during rain events

- Manage waste flow you cannot see
- React to rapidly changing flow conditions to protect system infrastructure and public health

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Improving the waterways: choosing the best approach

- Construct new storage assets
  - Traditional approach
  - Costly new construction
  - Additional assets to maintain
- Renovate existing assets
  - Think outside the box
  - Maximize use of existing system
  - Enable more affordable rates for 755,000 shareholders
  - Utilize technology and data analytics to enhance sewer management

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Development of the Solution and Innovations: Addressing Challenges for Implementation

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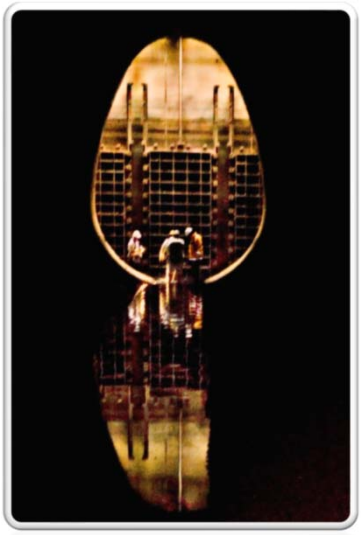
Build Big …. or …. Manage Smart

Challenges

- Reduce sewer overflows
  - Largest combined sewer outfall in the system
  - 76 overflow activations/typical year
  - 2.8 billion gallons (40% system total)/typical year
- Minimize control costs for shareholders



Solution

- Use tunnel already in place
  - 27 feet tall by 17 feet wide
  - 2.8 miles in length
  - Three gates already in place
- Apply Real Time Control
  - Adapt to changing sewer conditions and rainfalls
  - Fraction of cost of building new storage
  - Reduce overflows to 8 activations and 125 million gallons (95% reduction) /typical year

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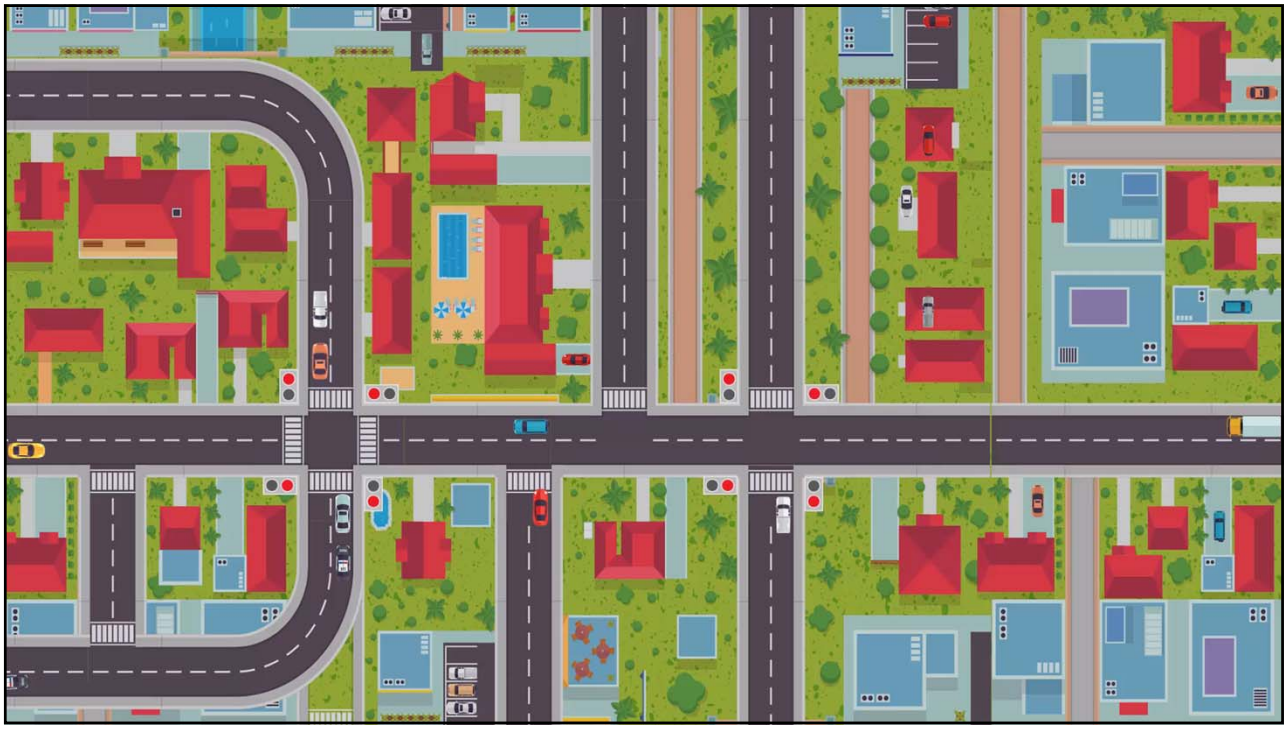

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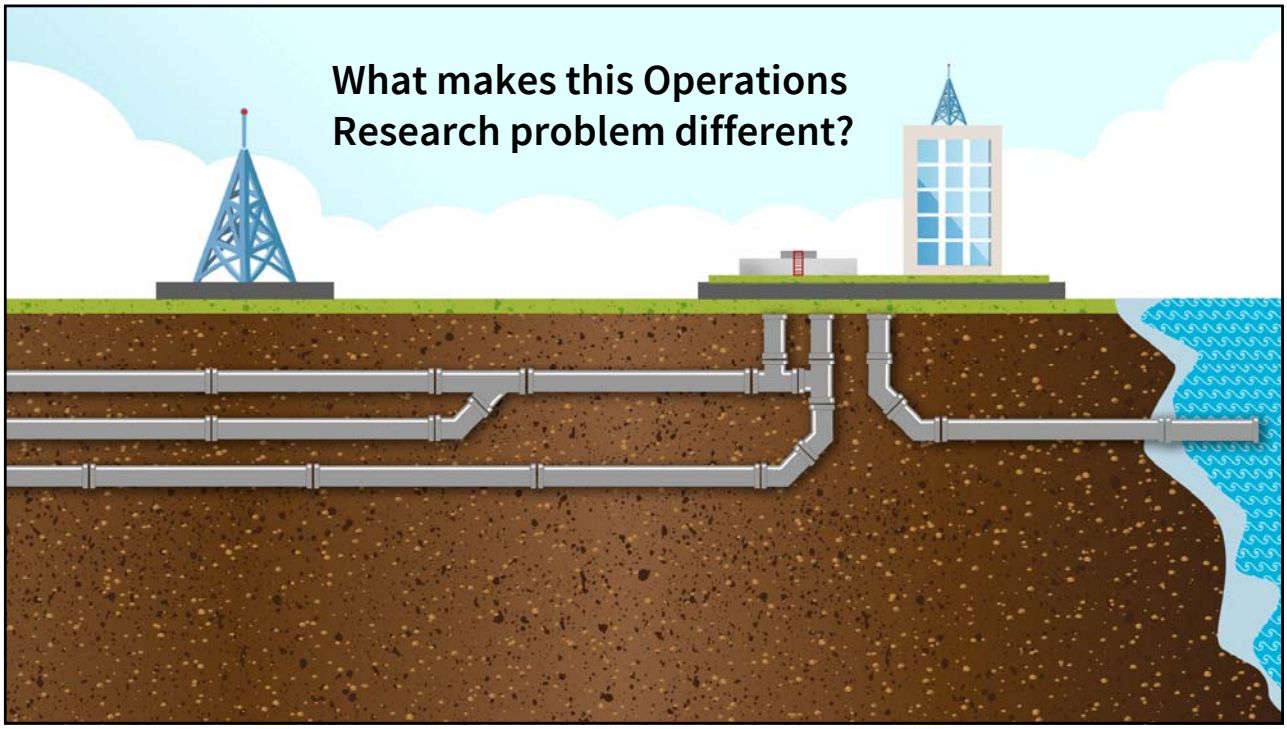

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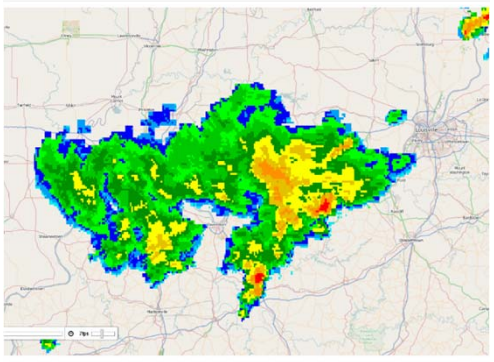
Specific challenges for real time control solutions

Harsh Environment

Highly Variable Precipitation

1" in 3 hour = 330 million gallons



Hydraulics: "Water Waves"

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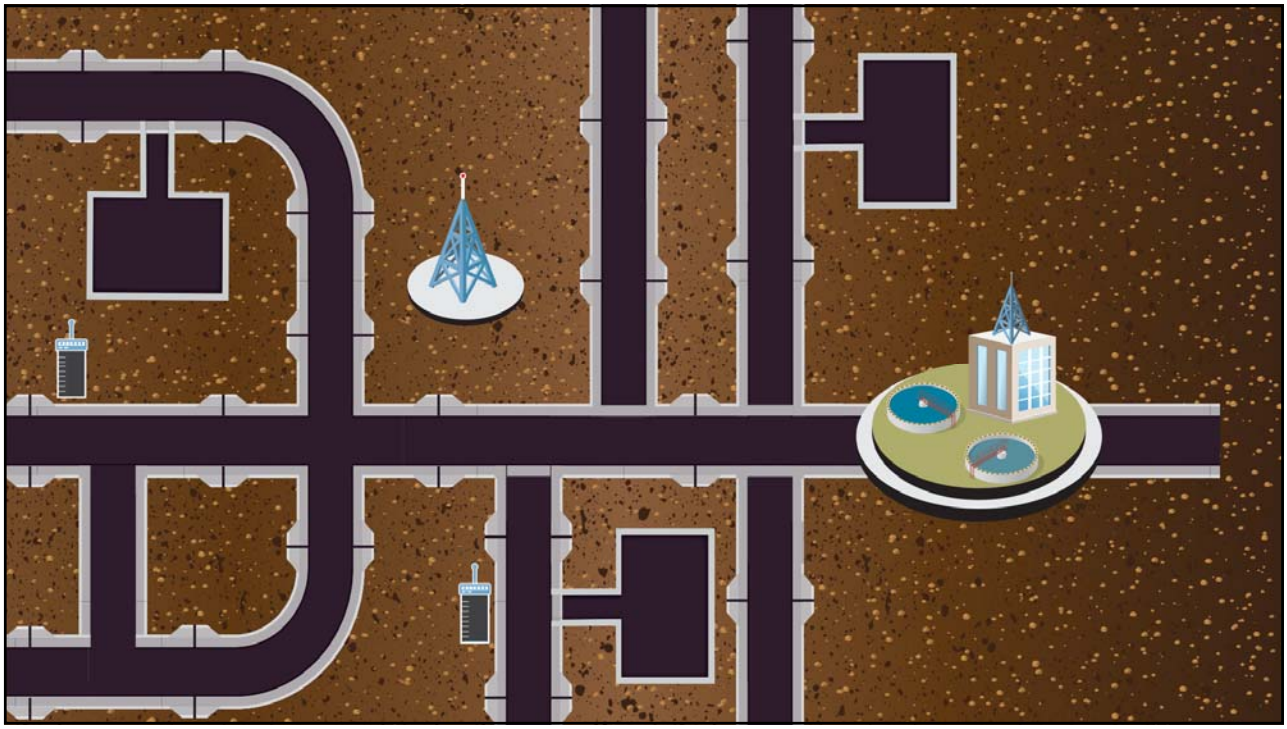

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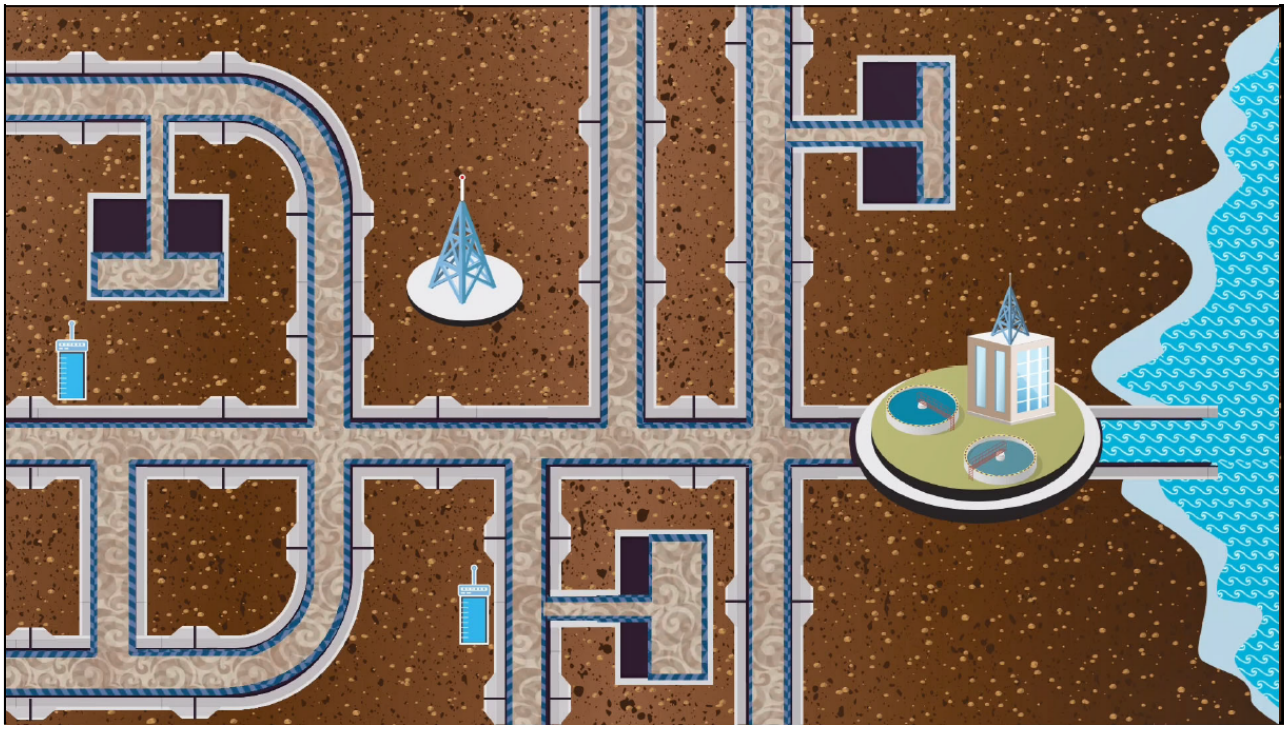

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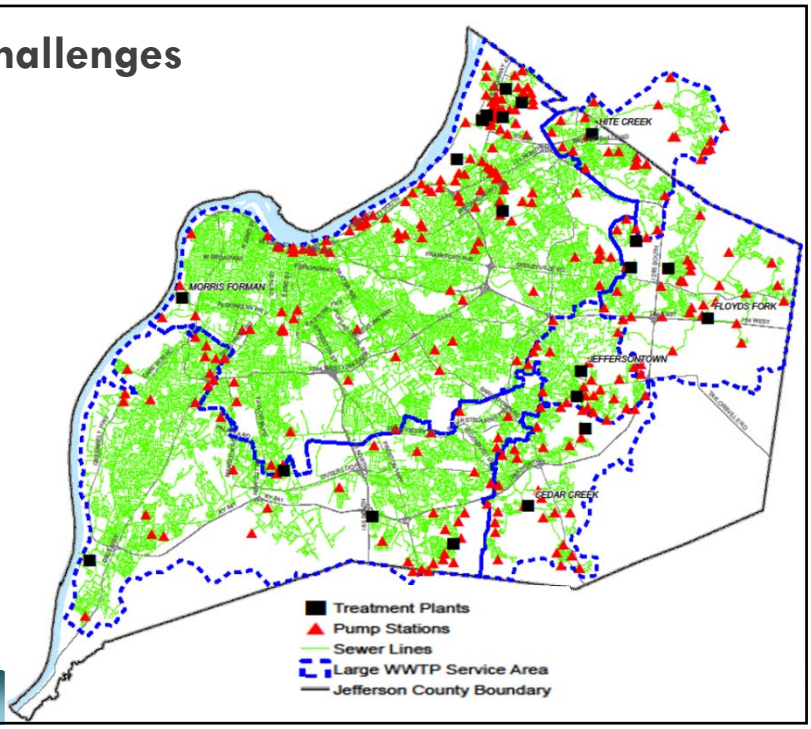
Many operational challenges

- Highly complex and interconnected network
- Spatial and temporal variability of flows
- Changing conditions at any time



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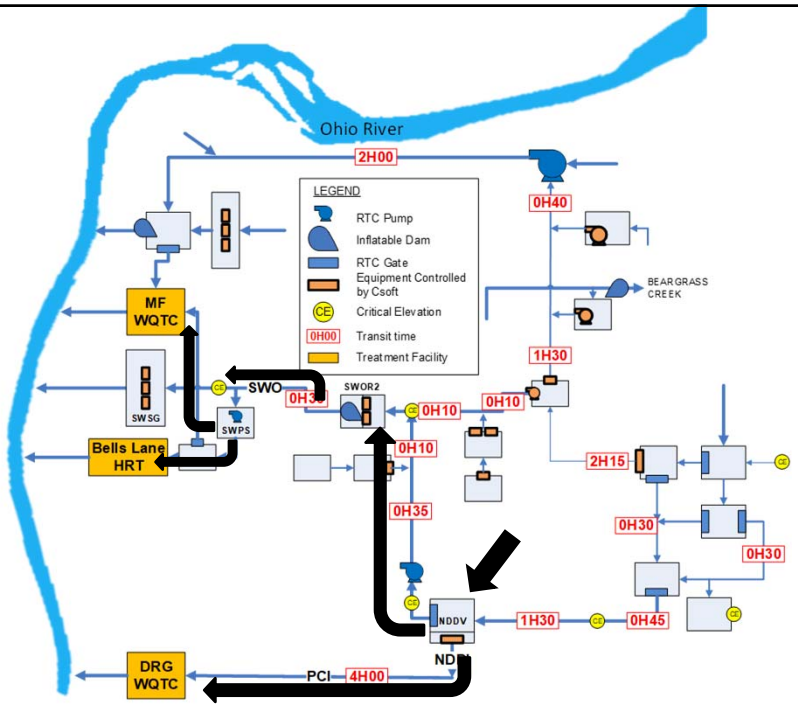
Routing possibilities and risks

- Optimize flows to treatment plants
- Minimize risks
  - Meet permit requirements
  - Minimize overflows
  - Prevent basement backups



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Optimization constraints and challenges

- Represent how sewers work in the real world
  - Avoid risks
  - Respect system capacities and critical levels
- Real time control loop in 5 minutes
  - Real time data acquisition and validation
  - Real time model simulation
  - Optimization in less than 1 minute
  - Application of control set points at facilities

Importance of avoiding risk

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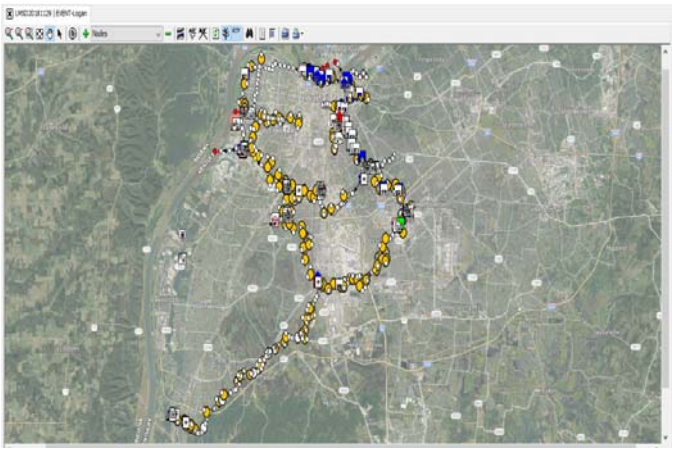
Represents sewers in the real world

- Represents hydraulic behavior with mixed integer linear programming (MILP)
- Compatible for real time operation

Mixed Integer Linear Programming



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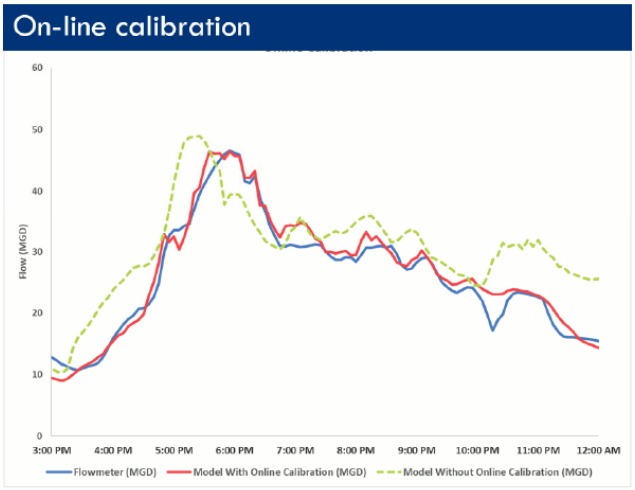
Represents sewers in the real world

Update MILP model with real information

- Blue – monitored sewer data in real time
- Dashed green – without online calibration
- Red – with online calibration



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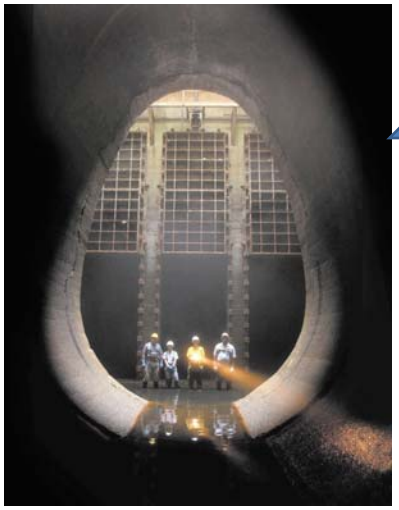
Gaining operator confidence and acceptance

- Progressive optimization
  - Operators start with low set points
  - Gain confidence over time
  - Raise set point without adverse impacts to customers
  - Skeptics to believers



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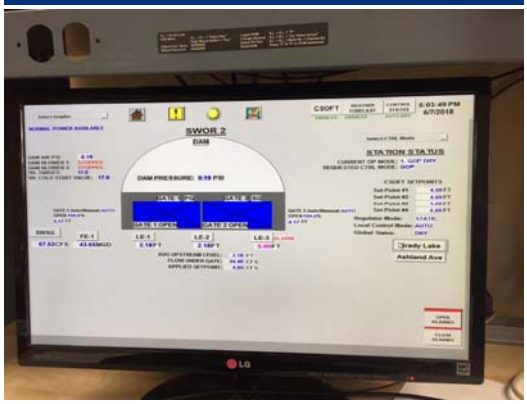
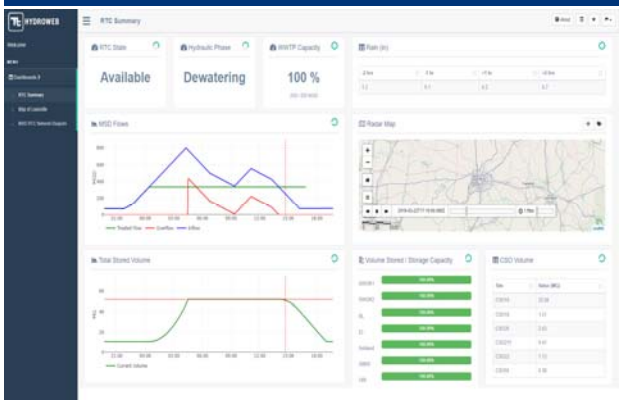
Operations Research guides implementation

- Provides operational tools

Manual override



Key Performance Indicators



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Implementation and Operator Acceptance

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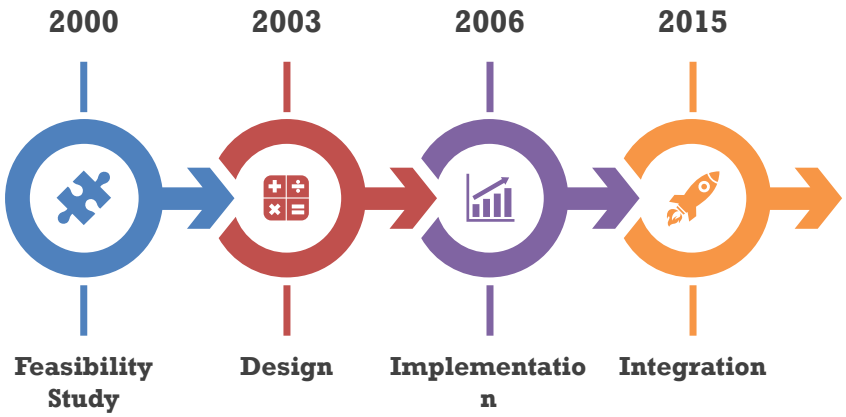
Phased approach to development and implementation of real time control with Csoft®



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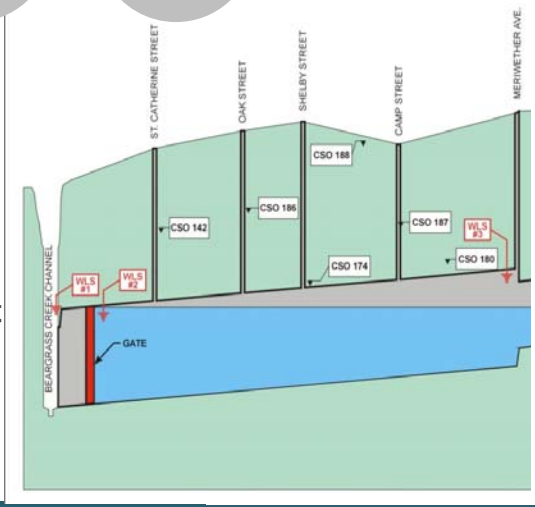
Real Time Control Feasibility Study

- Unit cost $0.006 to $0.021 per gallon of combined sewer overflow reduction
- 4 to 10 times lower than the average unit construction cost of traditional storage



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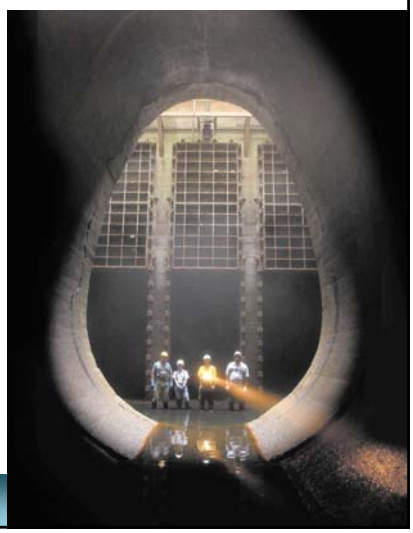
Phase 1 Implementation Strategy

- Retrofit 5 existing facilities
- Expected overflow reduction of approximately 600 million gallons per year



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Implementation and Integration

- Rapid deployment, rapid results (2003-2006)
- Embracing full-scale implementation
- RTC with Csoft® integral of overflow abatement
- Adapting and learning from operation results
- Cost avoidance of more than $200 million

600 million gallons overflow reduction = 1,000 Olympic pools of sewage captured in the first year!

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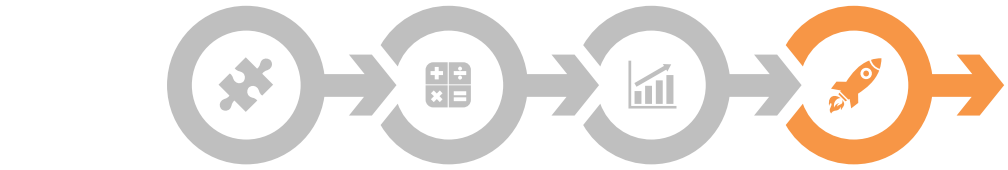

MSD/Csoft ® Evolution

- Long-term investment of infrastructure
- Integrated into every new facility
- Reduced overflows from 6.5 billion gallons to 340 million gallons
- Provides resiliency

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Foster culture change for operations research success

- Top-down leadership for total system optimization with RTC
- Involve operation staff in solution development
- Communicate the vision
  - **Reduce billions of gallons of overflows to the waterways for millions of visitors**
  - **Save hundreds of millions of dollars for 755,000 shareholders**
  - **Manage the sewers intelligently and safely for 650 staff during everyday and critical conditions**
- Adaptive planning and building on to system

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LOUISVILLE MSD OPERATION AND ENGINEERING STAFF

"Back when we were implementing RTC and rolling it out, we had a lot of pushbacks from operators because they felt like automation will take their job, but I saw the benefits of taking these sites and implement RTC into it to where you can have things work automatically and make decisions based on real life information…"

"If it weren't for RTC, we would have to station an operator at this site to manually control the gates…with RTC and automation, we can remotely move these gates, depending on the rainfall sizes."

"Real Time Control makes me and the district very proud. We frequently joke around that RTC is the sexiest thing we do at MSD. We are using technology, not too many people are, to control and to protect our environment. And this is pretty cool."

HTTPS://YOUTU.BE/7E_MLJ8MX9Q

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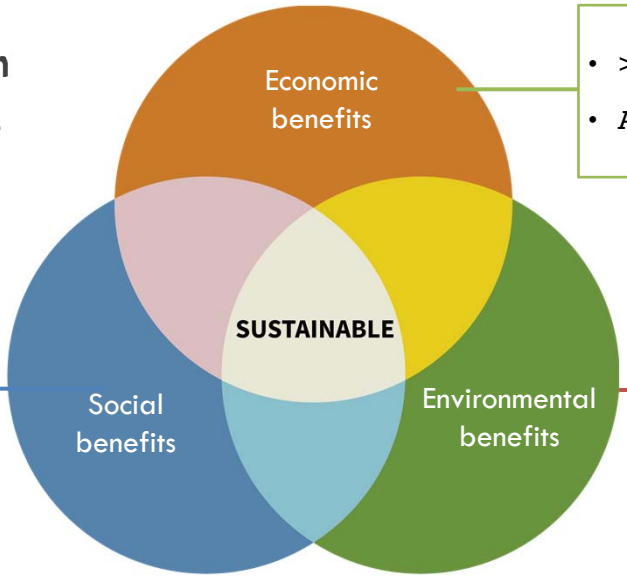
https://youtu.be/7e_mlj8mx9q

Sustainable triple bottom line benefits



- >$200M to reinvest
- Affordable sewer rates

- Protect public health and safety
- Improve quality of life and community development
- Provide workforce opportunities

- Reduced billions of gallons of overflow to rivers
- Access to clean waters for recreation

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- With Csoft® application cities avoid over a billion U.S. dollars in capital costs
- 830 river communities in the U.S. could benefit

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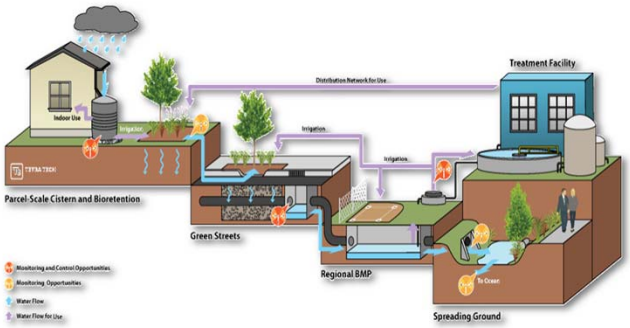
Apply to extremes of water management – droughts and floods

- Application to optimize storm harvesting for capture and reuse in California
- Application to provide flood warning and stormwater control in Quebec



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Today's Presenters

John Abrera, P.E.
National Integrated Digital Applications Lead
Brown and Caldwell

Tasha King-Davis, P.E.
Administrator of Environmental Compliance
City of Memphis

Joshua Balentine, EIT
Industrial Pretreatment Program Technical Lead
Brown and Caldwell

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Real-Time Monitoring of Industrial pH Discharges in Collection Systems

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Presentation outline

- Introduction and how data can improve enhanced source control
- Why Memphis turned to digital solutions
- Industrial Pretreatment Programs and how to supplement with digital solutions

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John Abrera
Brown and Caldwell

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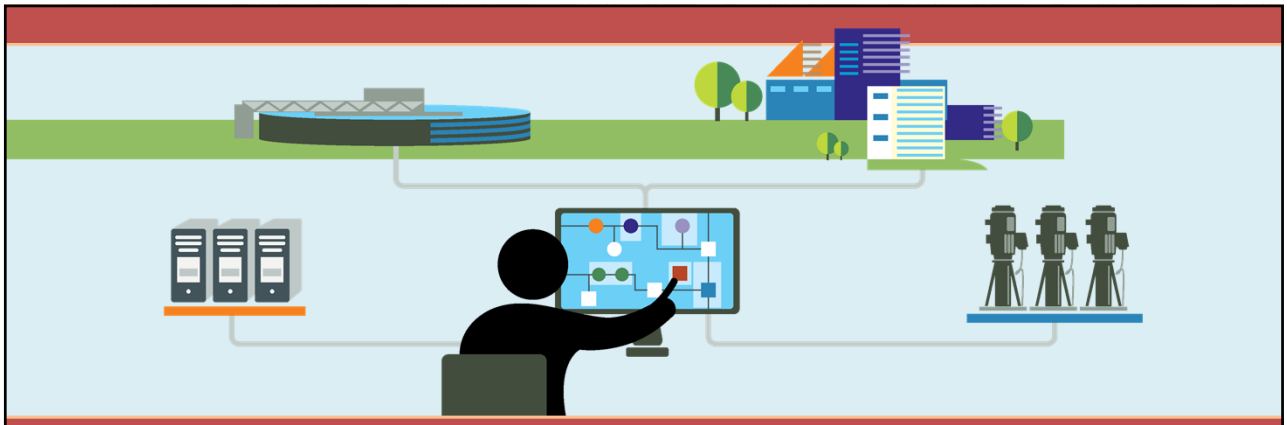

How data can improve enhanced source control

Brown AND Caldwell

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Low and High pH Impacts to Sewer System

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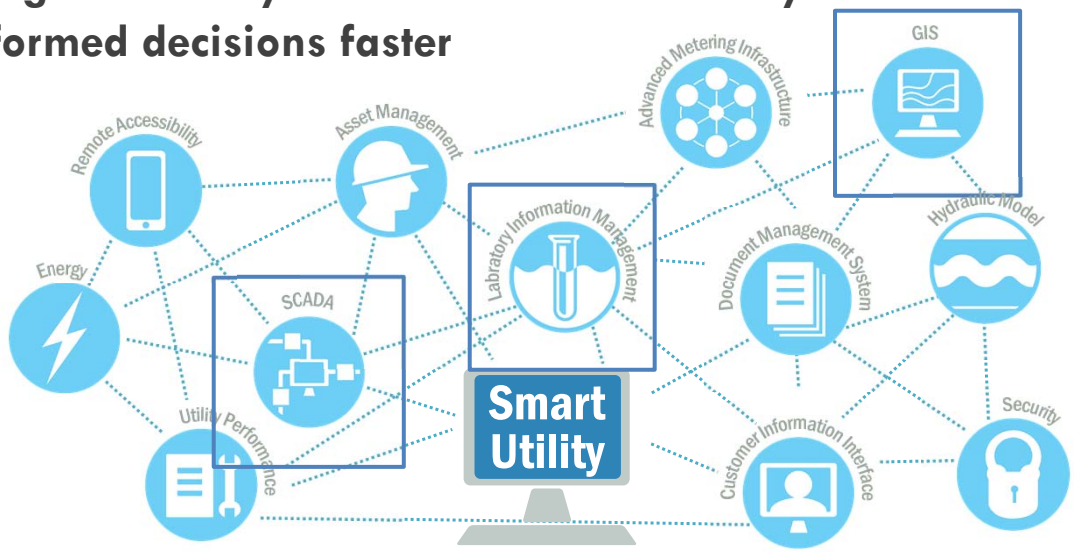
Integration of systems and real-time analytics to make informed decisions faster



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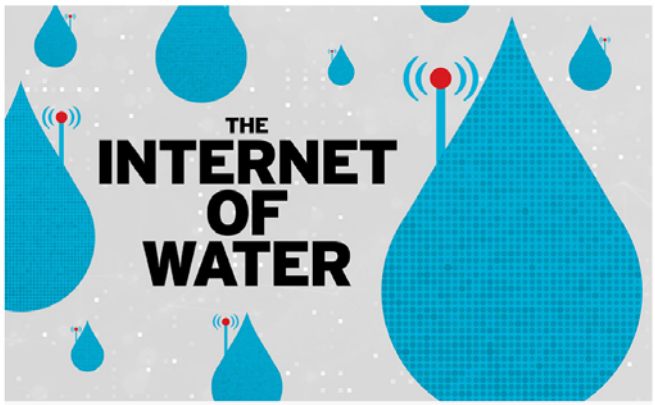
ENR, August 28, 2019

Data Drives Smarter Water Systems Decisions

Advances in technologies help water systems operate more efficiently, save money and build resilience



Tasha King-Davis, environmental compliance and permits head at the Memphis, Tenn., division of public works, has become a believer—an evangelical even—in the power of data.

As the administrator of the nation's 14th-largest industrial wastewater discharge monitoring system, she and her staff of 13 can only physically sample the discharges from each of Memphis' 104 industrial sites about twice a year.

But a year ago, Brown and Caldwell started installing sensors on the outfalls of some of those plants and now, King-Davis can check what those plants are putting into the wastewater stream 24 hours a day, seven days a week—from her phone. She can even set up alerts through Microsoft Power BI so she's notified if any of them exceed permissible limits.

"It's an amazing tool that I wish we knew about years ago," she says. "You can't hire enough people to go to 104 industries and pull that data continuously every day. The fact that we can use tech, use data and actually help improve our department and become best in the industry —that means a lot to me. It's my passion." The pilot test in Memphis is just one small example of the potential of "digital water" or the "internet of water" that is gaining acceptance in an industry that has historically been slow to embrace change.

https://www.enr.com/articles/47424-data-drives-smarter-water-systems-decisions

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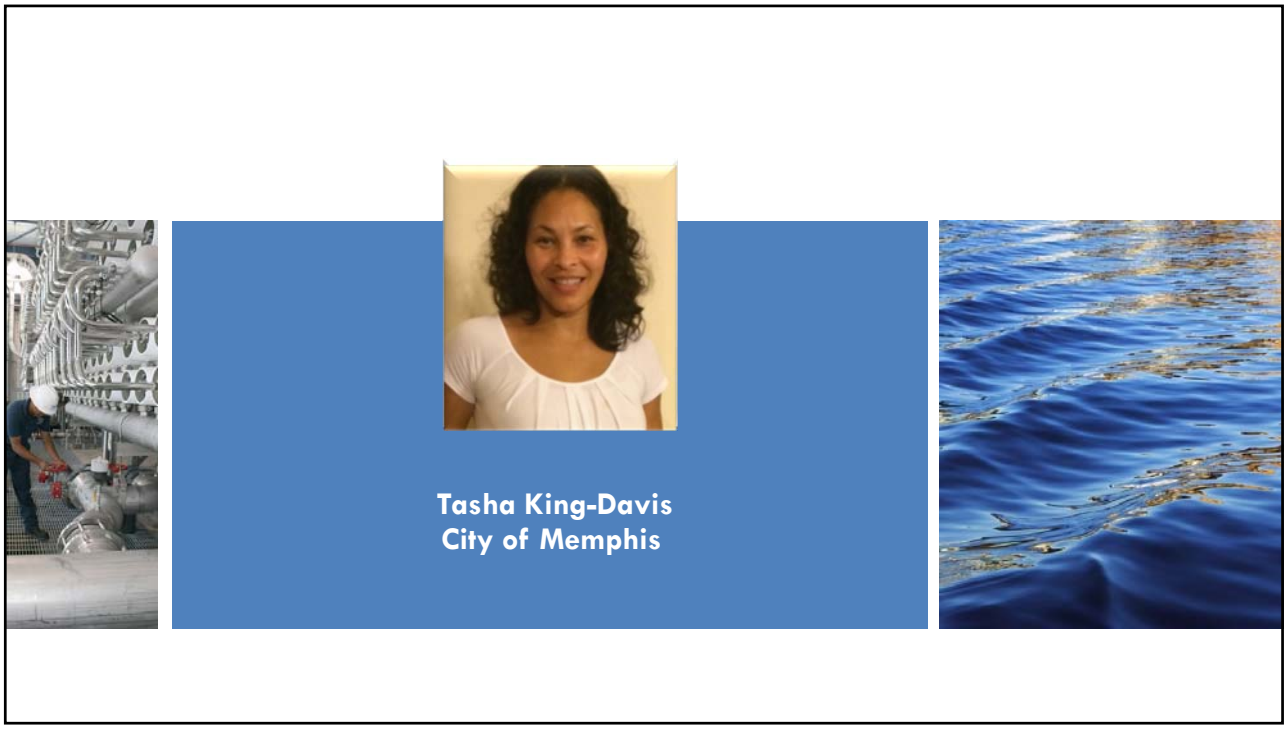
Tasha King-Davis
City of Memphis

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Why Memphis turned to digital solutions
Brown AND Caldwell

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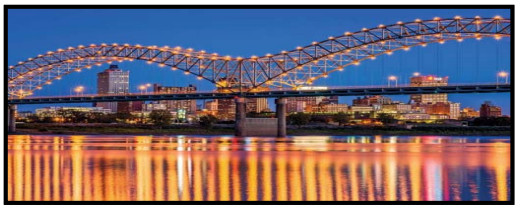

Population over 650,000

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City of MEMPHIS

Ideal for Industry and Commerce

Logistics Infrastructure

Memphis' 4 Rs

Runway

Road

Rail

River

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City of MEMPHIS

Ideal for Industry and Commerce

Water Quality

Utility Rates

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City of MEMPHIS

POTW

100 industries

Over 70,000 businesses

Over 500,000 households

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City of MEMPHIS

POTW

M.C. Stiles WWTP

Wastewater Treatment Plants

T.E. Maxson WWTP

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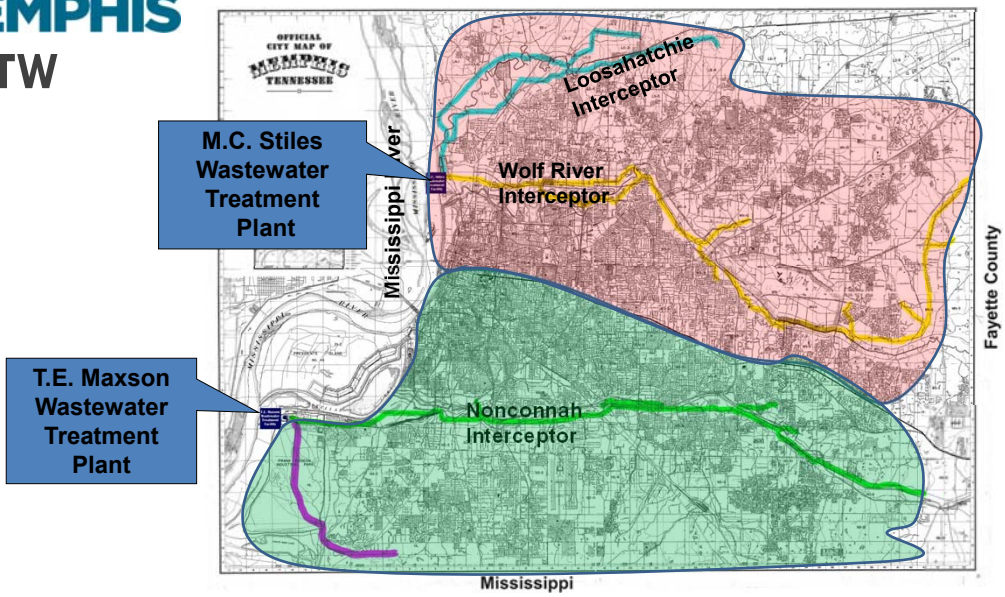
City of MEMPHIS

POTW



M.C. Stiles Wastewater Treatment Plant

T.E. Maxson Wastewater Treatment Plant

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City of MEMPHIS POTW

Wastewater Collection and Transmission System

Memphis Model

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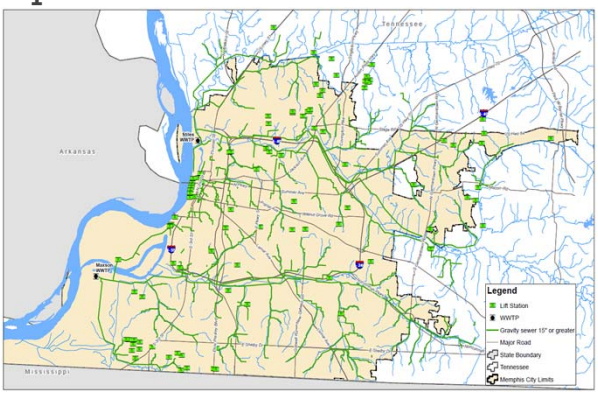
City of MEMPHIS POTW

Wastewater Collection and Transmission System

- Sanitary Sewer Service area 442 square miles
  - 314 sq. miles within the City limits
  - 128 sq. miles outside of City limits
  - Predominantly gravity flow
    - 2,800 miles of pipe
    - 100 lift stations
    - 80,000 manholes



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Industrial Monitoring and Pretreatment Program

Size:

- Largest Program in Tennessee
- Largest Program in Region IV
- Top 20 in the Nation
- Top 15 SIUs discharge .5 to 14 MGD

Staff:

- 4-6 employees responsible for inspections and sampling.
- 4 -6 employees responsible for evaluating compliance based off of data submitted by the IU.

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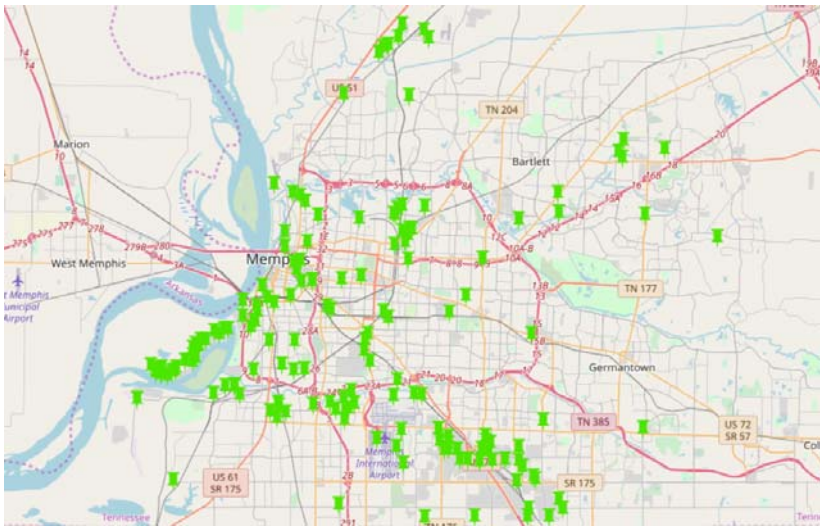
City of MEMPHIS

Operation Remote Monitoring



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Operation Remote Monitoring

Mission:

- More eyes in the field
- Obtain real-time data on industrial discharges
  - Evaluate compliance more effectively
  - Ability to be PROACTIVE and not reactive
  - Protect the POTW

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The (901) On Digital Solutions

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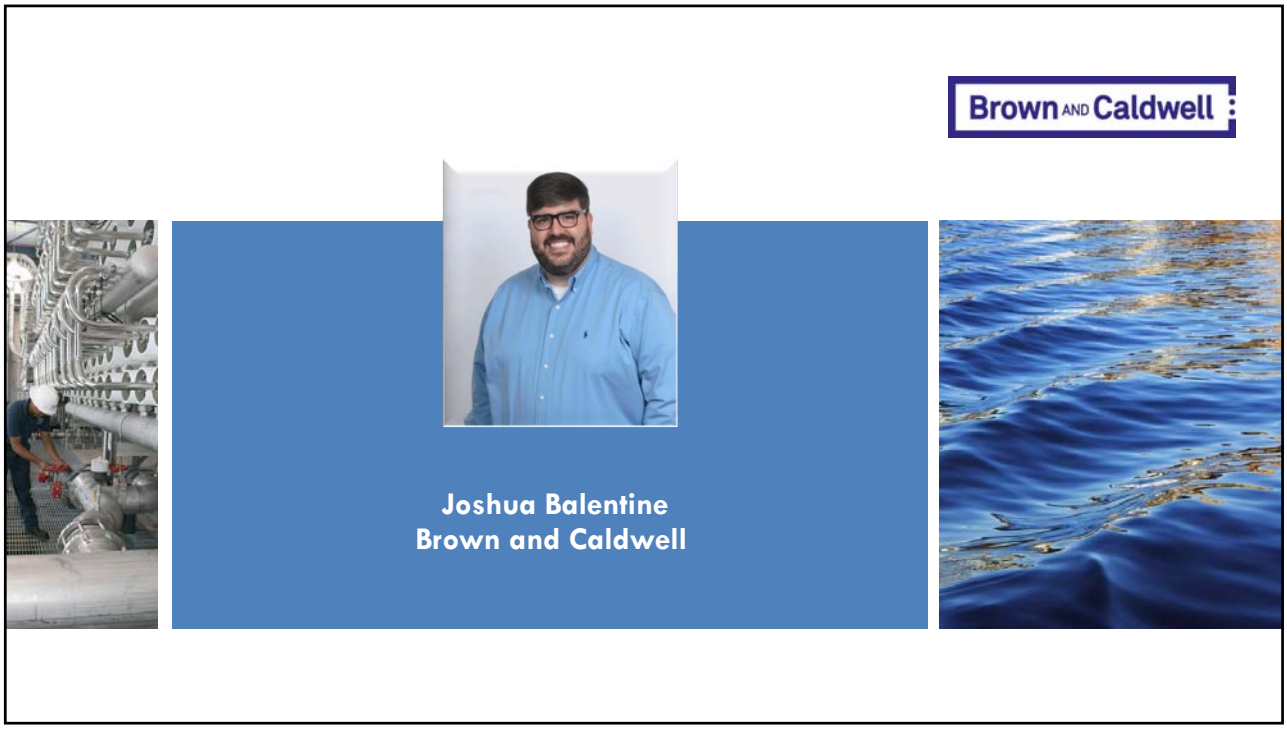
Brown AND Caldwell
Joshua Balentine
Brown and Caldwell

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Industrial Pretreatment Programs and how to supplement with digital solutions
Brown AND Caldwell

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Pretreatment Program Monitoring Requirements

- Pretreatment program objectives are ensured by the following minimum source control requirements:
  - Control authority sampling once per year
  - Control authority inspections once per year
  - Industrial User sampling twice per year
- In cases of more frequent sampling
  - City in most cases doesn't have access to real-time meters
  - City may not receive the data until the next month
  - Continuous and monthly data may be generalized not showing full impact of discharge

24-hour composite sampling event for source control program

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What is Enhanced Source Control?

- Monitoring Industries more frequently for more parameters
- Monitoring for pollutants and emerging contaminants
- Assessing the fate of pollutants in the treatment system
- Pollutant Inventory/Tracking
- Public Outreach Program
- Installing smart sensor network at industries
- Installing smart sensor network in the collection system and WWTP

Enhanced source control is used to not only reduce the pollutant concentrations to the POTW, but to ensure optimization of the WRRF and beneficial reuse of valuable byproducts

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Smart Sensors at Industrial Users

- Determination of water quality parameters of concern at the WWTP and Collection System
- Installation of Smart Sensors at Industrial Discharge Points
- Deployment of a dashboard and predictive analytics

Sewer Use Ordinance or Permit gives the authority to conduct monitoring at SIUs. This is no different than setting up a 24-hour composite sampler.

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Memphis Phase 1 Project (Currently Implementing)

- Focused on pH and dashboard development
- 10 Smart pH Sensors at industrial dischargers
- Smart pH Sensors at Influent and Effluent of both WWTPs
- Dashboard to display real-time industrial data
- WWTP Operations Dashboard with data analytics

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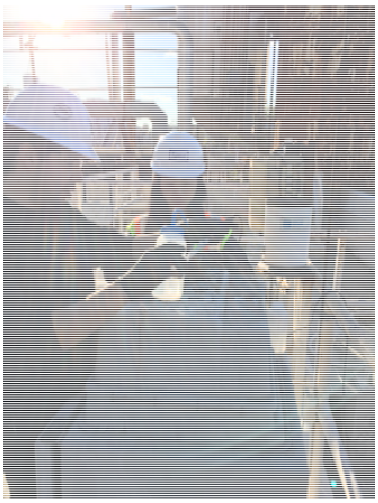
What do we mean by "smart" sensors

- Not all data collection requires "significant" human involvement
- A vast array of parameters can be collected at high frequency with new technology sensors
- Data can be collected, transmitted and analyzed in near real-time
- Literally hundreds of devices are available for dozens of WQ parameters



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Benefits of Smart Sensors at Industrial Users

- Compliance Verification – Data used to compare with compliance samples
- Asset Protection – pH sensors to determine corrosive wastewater discharges
- Potential Cost Savings and Avoidance
  - Understanding and minimizing corrosive pH noncompliance
  - Minimizing premature infrastructure degradation
  - Minimizing regulatory penalties due to collection system violations (i.e., overflows)

Smart Sensor Calibration

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Sensor signals can be "read" in real-time from mobile devices

Screen-shot from iPhone shows industry exceedances during holiday weekend

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Memphis Smart Sensor Project Findings

- s::can devices selected for testing are robust and work well in harsh environments, requiring very low maintenance (primarily weekly calibration checks)
- Linking s::can data to intelligent platform is simple and can be conducted on a broad range of commercial and proprietary software for data integration
- Challenges (specific to s::can)
  - Onsite power is required
  - Sensors require continuous submersion in fluid, and may have issues in intermittent flows

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Memphis Pilot Project Findings (cont.)

- Continuous pH showed significant excursions at some sites; outside of both low and high pH permit limits.
- This "continuous" data is needed to address corrosion issues in the collection system at IU discharge IU manholes
- Real-time pH data can aid collection system staff in proactively protect collection system assets

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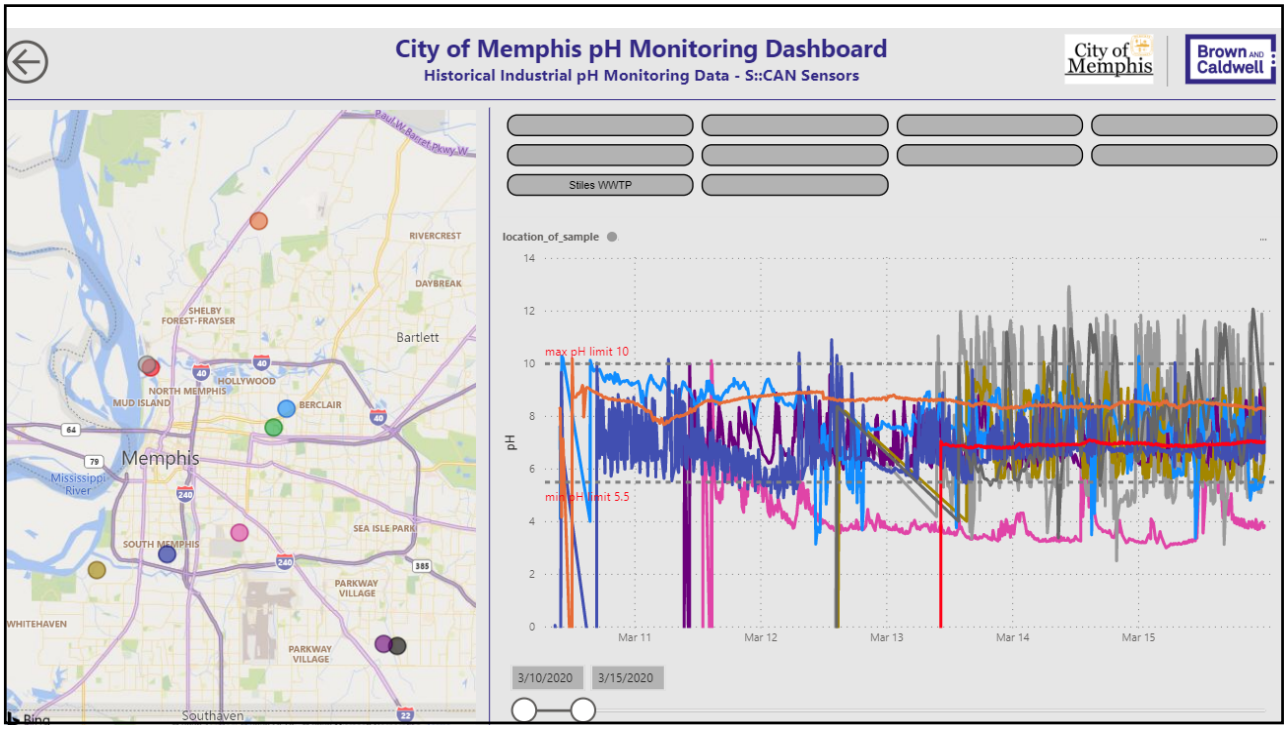

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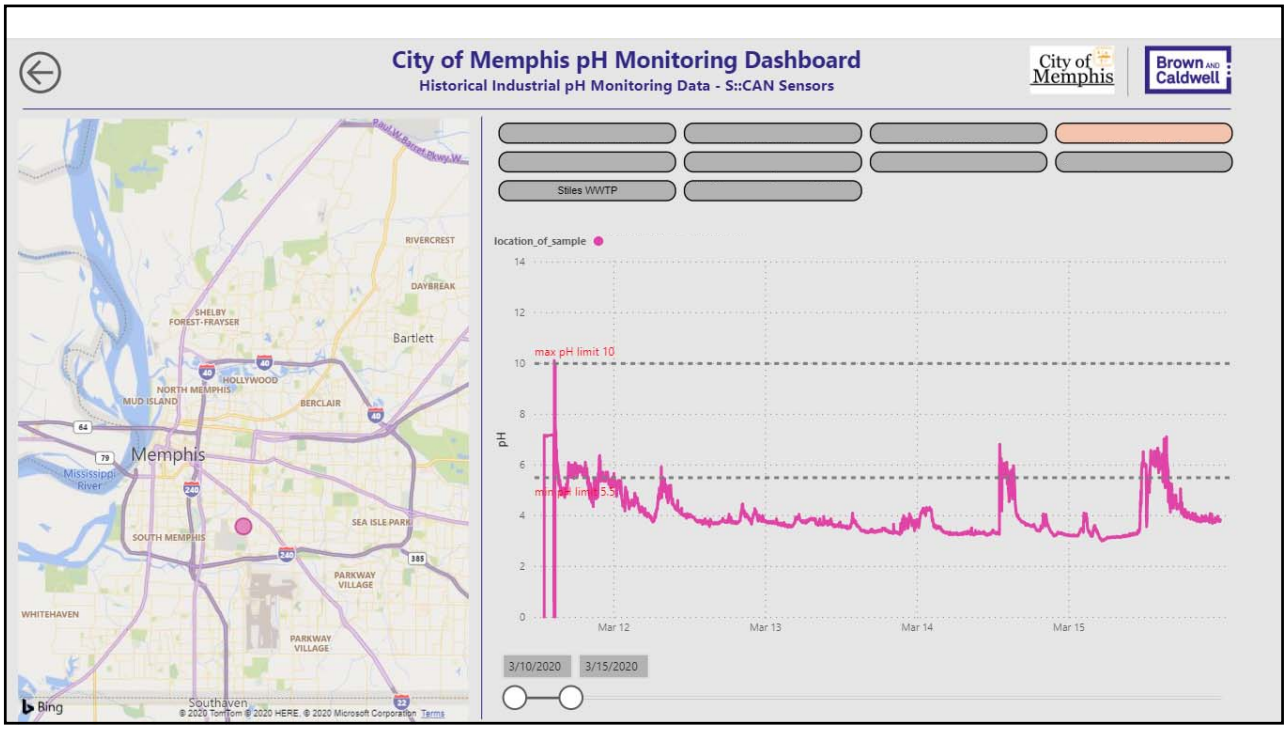
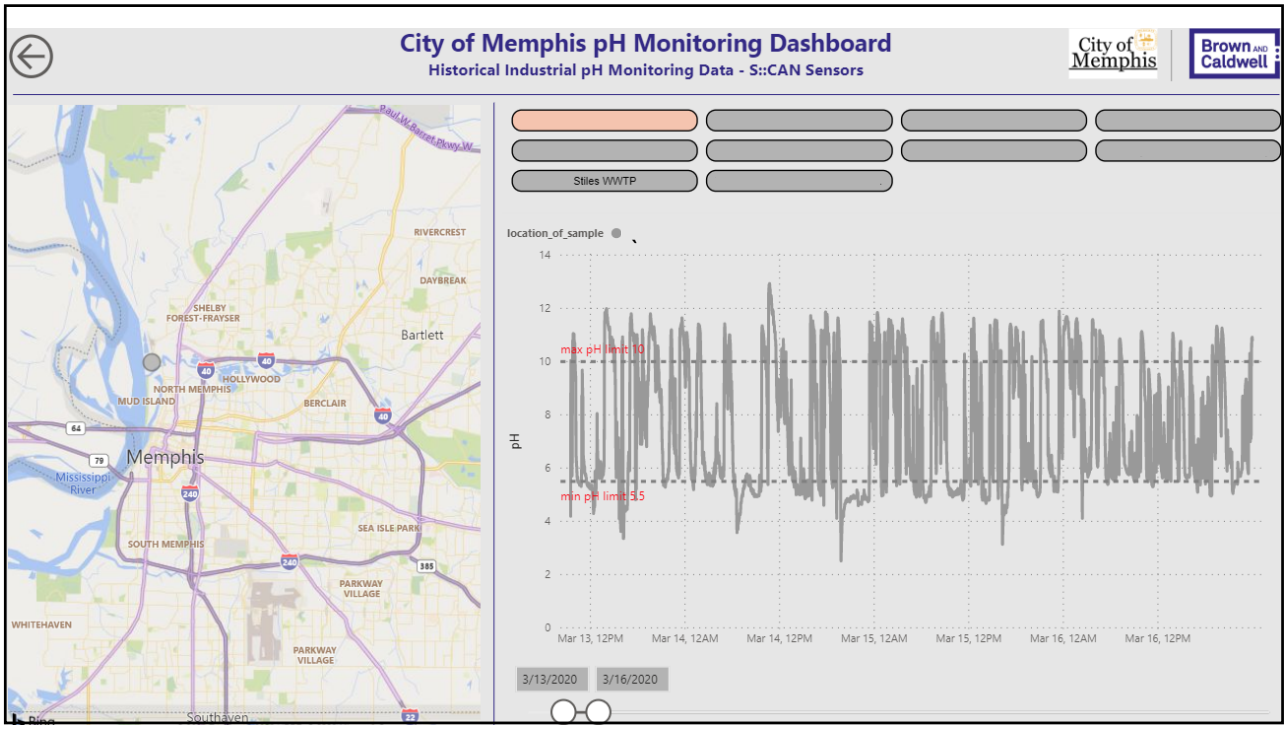

City of Memphis pH Monitoring Dashboard
Historical Industrial pH Monitoring Data - S::CAN Sensors
City of Memphis
Brown AND Caldwell
Stiles WWTP
location_of_sample
max pH limit 10
min pH limit 5.5
pH
Mar 12
Mar 13
Mar 14
Mar 15
3/10/2020
3/15/2020
Memphis
Bartlett
Southaven
Bing

73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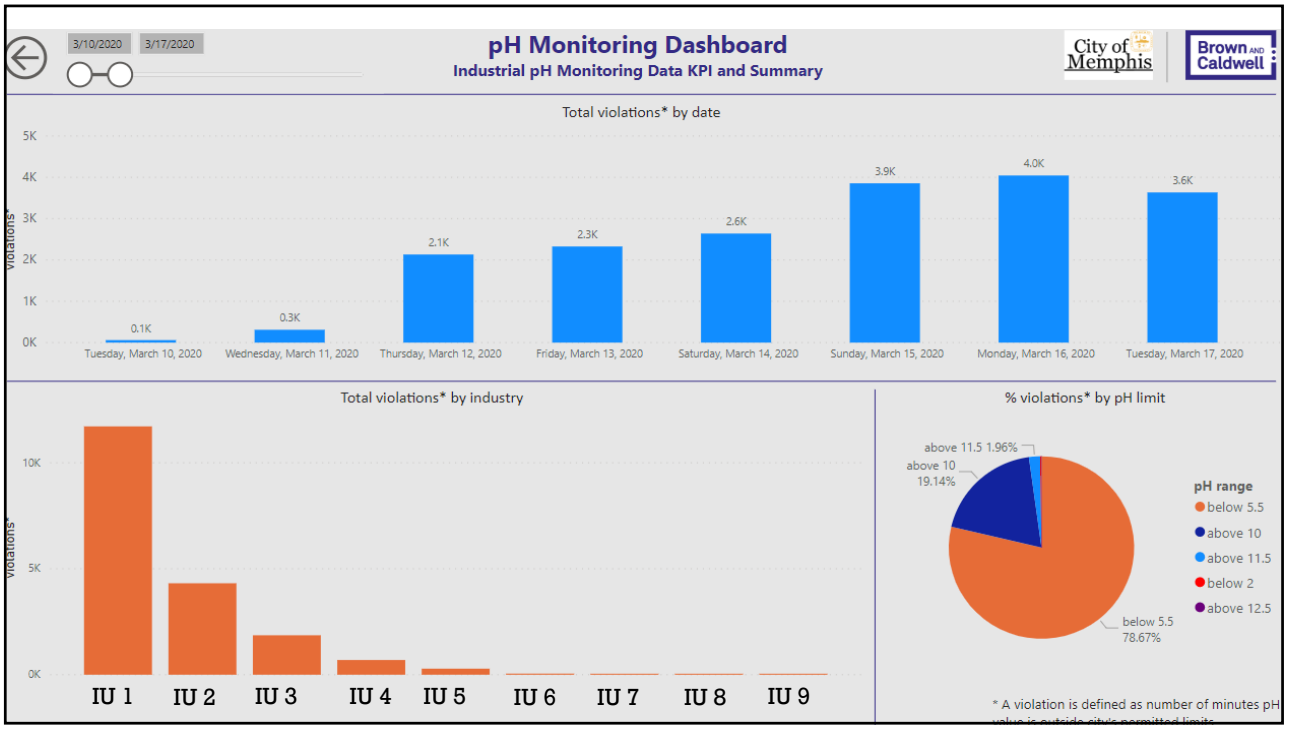
pH
Mar 13, 12PM
Mar 14, 12AM
Mar 14, 12PM
Mar 15, 12AM
Mar 15, 12PM
Mar 16, 12AM
Mar 16, 12PM
3/13/2020
3/16/2020
Memphis
Bartlett
Southaven

74



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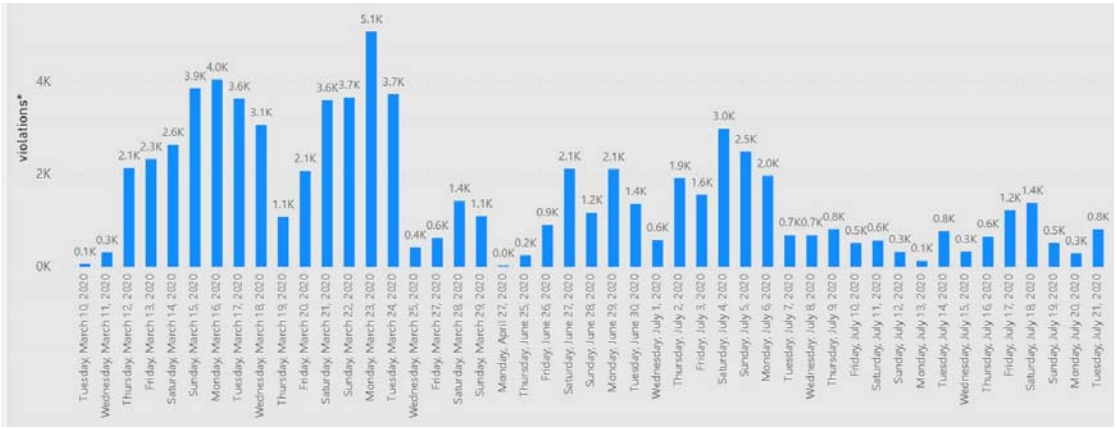
Promising Results (after 2 months of monitoring)



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Closing thoughts

- Low AND high pH discharges can be harmful to sewer and pump station assets
- Consider smart sensors and real-time data in to inform staff of corrosive pH conditions attributed to industries
- Large reduction in pH noncompliance
- Link data to what's happening in WWTP's and anticipate potential diversion of off-spec water
- Use diagnostic tools that leverage machine learning to find those correlations
- Use machine learning to improve upon those relationships and predict when something will occur

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Introduction

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Vice President

Leader for Intelligent Water Systems

sdent@carollo.com

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Real Time Modeling, Smart Systems, and System Optimization

How four utilities are building smart systems using new tools and approaches to improve performance and reduce costs across the organization

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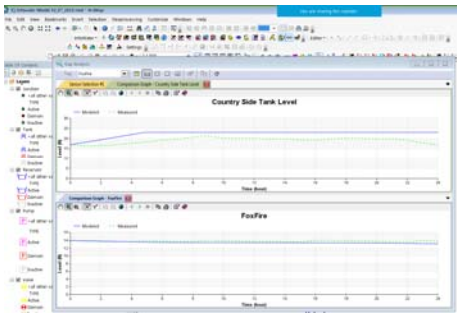
Potential Drivers for Real Time Modeling (RTM)



- Data sharing
- Efficiency improvements
- Technology improvements
- Cost savings
- Better systems management
- Long term vision of Utility
- Facilitating decisions
- Emergency Planning/Response
- Continuous Model Calibration
- Energy Management
- ….?

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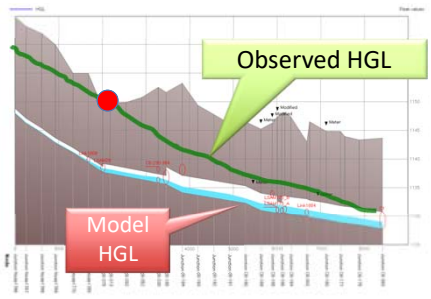
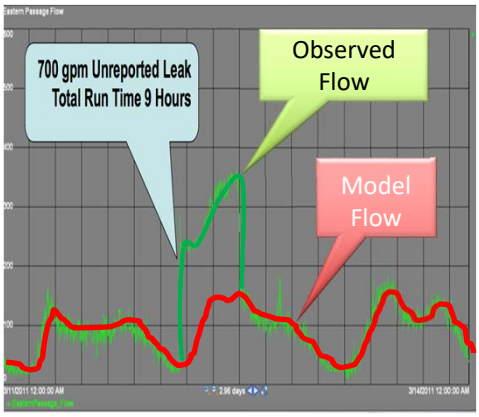
Examples driving RTM

WASTEWATER COLLECTION



✓ Identify Surcharge & Overflows

WATER DISTRIBUTION



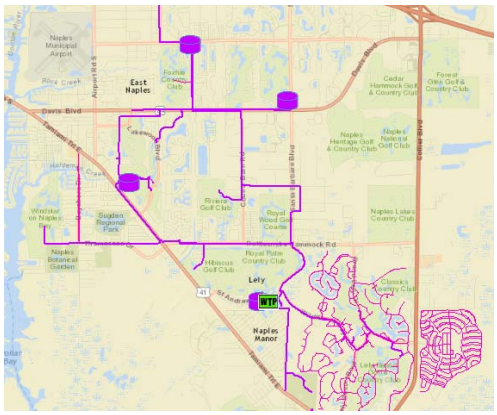
✓ Leak Detection

Smart Utilities…

- Collier County, Florida
- Dallas, Texas
- Houston, Texas
- Boynton Beach, Florida

Collier County Water Sewer District, FL

Irrigation Quality (IQ) System



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RTM Pilot Project Goals

- **Test Application – SCADAWatch (now Info360)**
  - Real Time Modeling (RTM) product (Innovyze)
  - Couples the County's IQ GIS, IQ modeling software, and IQ SCADA data
- **Data Access** - Allow Departments Outside of Operations…
  - Dashboard Web Access to near real time data
  - View data overlaid on web-based GIS
- **Reduce Response Time** - for Event Modeling
  - Efficient access to near real time data
  - Accelerate workflow response, and model calibration
- **Provide Insight into the RTM Process** - assess software for further application of RTM to the water and sewer models.

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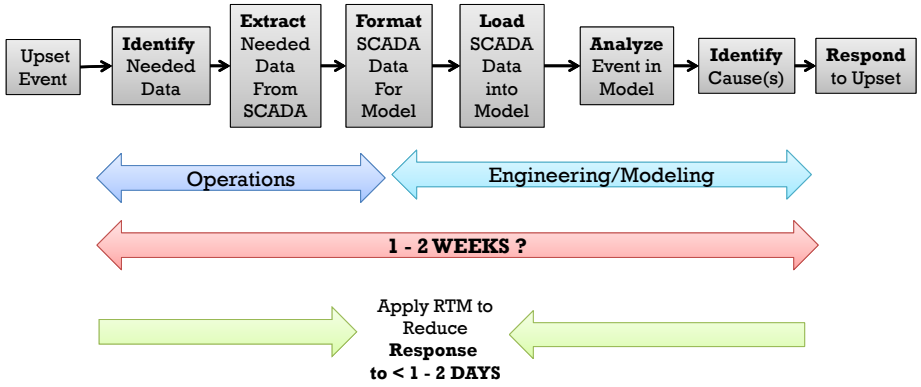
Integrate SCADA Data and Modeling - Reduce Response Time to Analyze Events



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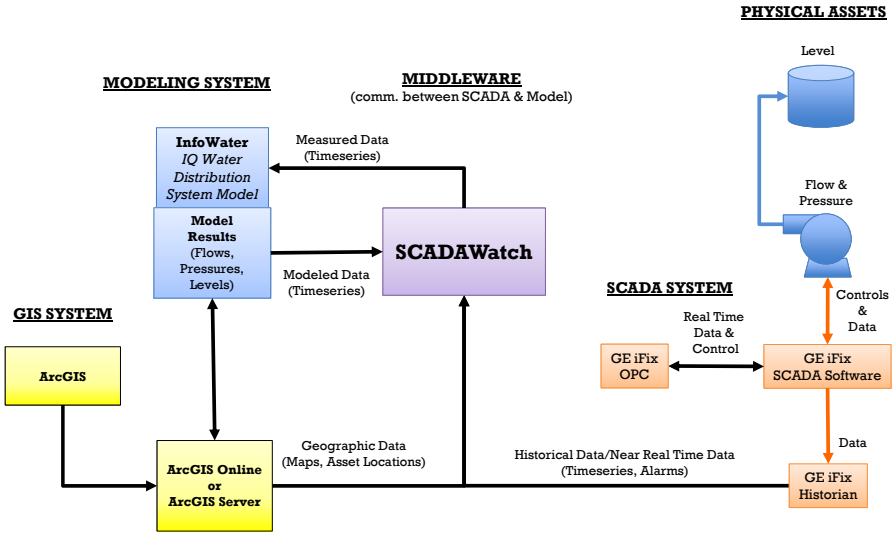
SCADAWatch – Configuration



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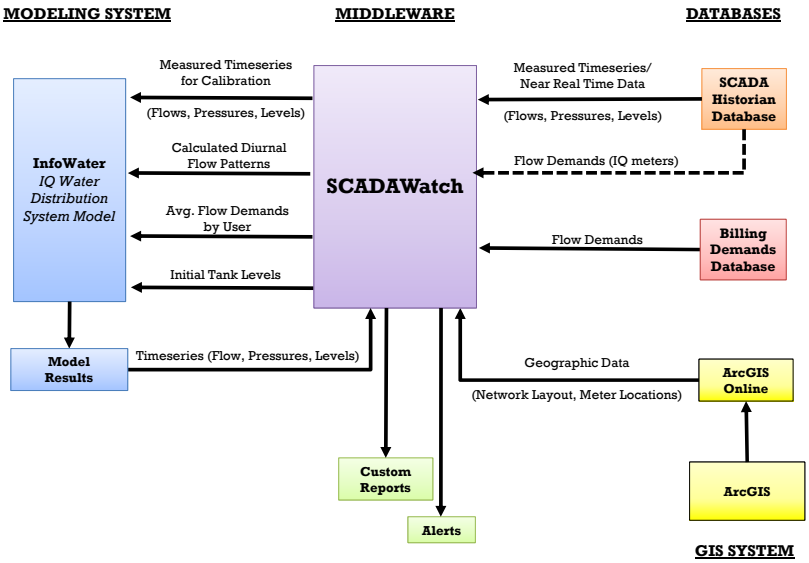
SCADAWatch – Data Flow



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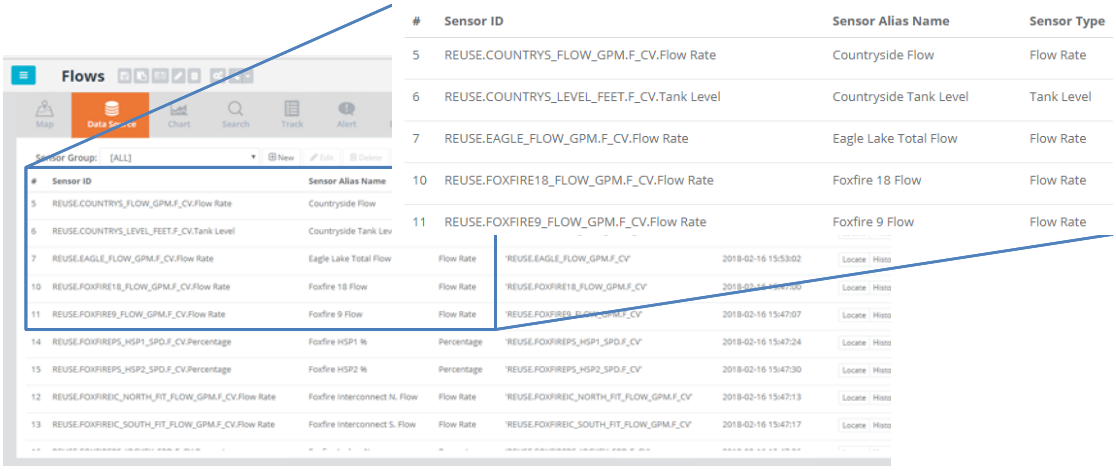
Setup and Configuration



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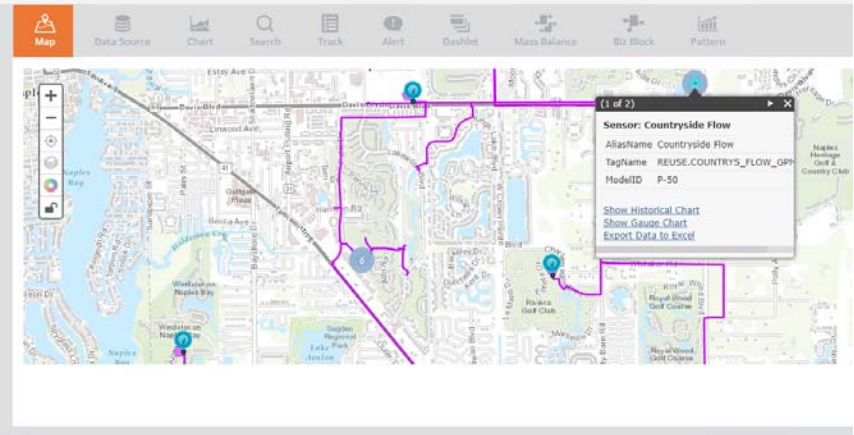
GIS Connection

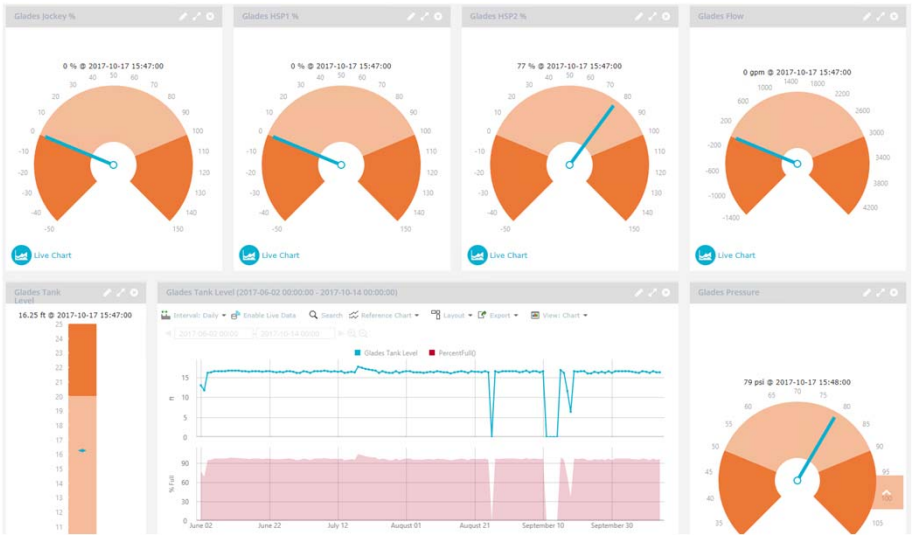


- ArcGIS Online Used (can use ArcGIS Server)
- Dynamic tag locations on GIS background layers

Data Extraction / Manipulation

- Data read from iHistorian at 1 Minute Intervals
- Automatically condensed to larger time intervals
- Graphs allow dynamic selection of time intervals and time range

Dashboard by Location – Glades Pump Station



- Gages for near real time data (pump usage, pressure, tank level)
- Timeseries for historical data (tank level, % full)

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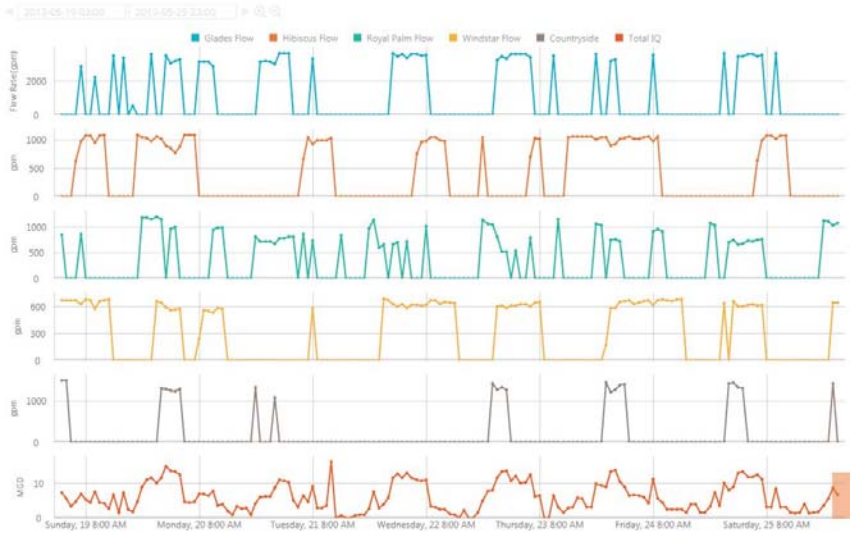
Dashboard by Parameter - Flow



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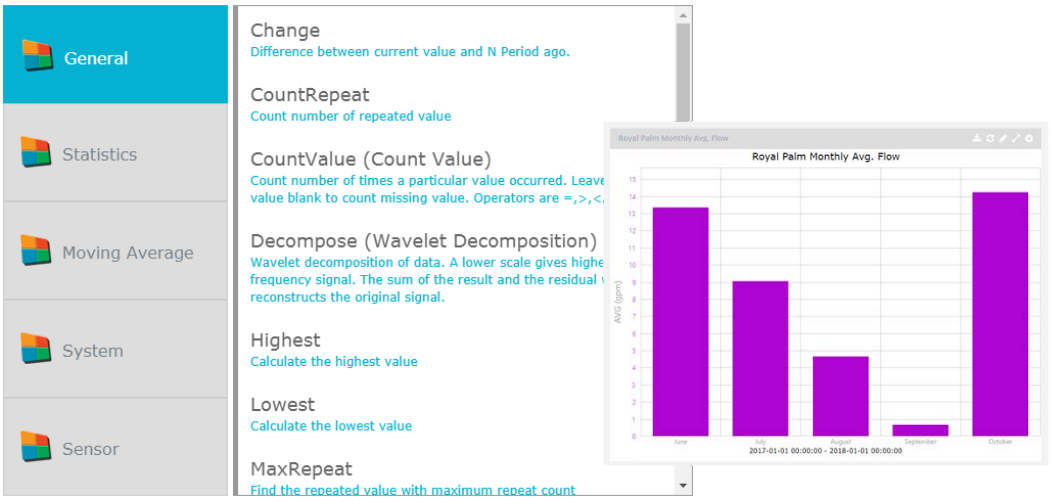
Analytics



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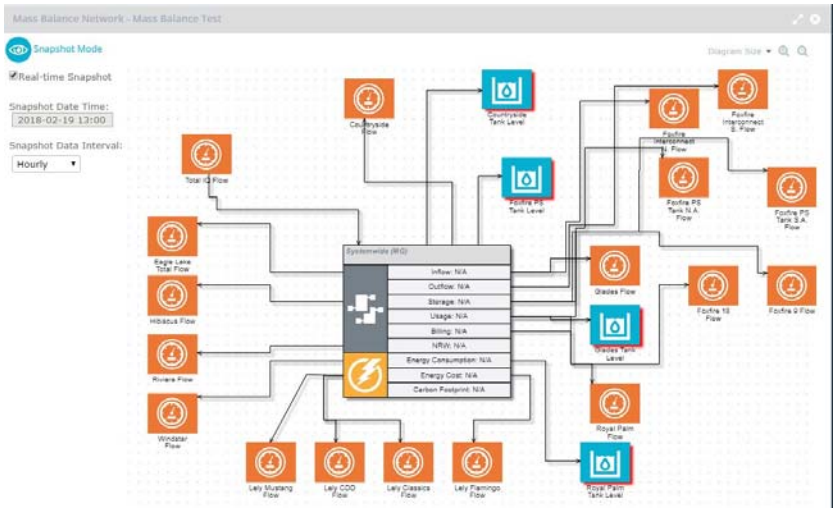
Mass Balance (System Summary – e.g. Non-Revenue Water)



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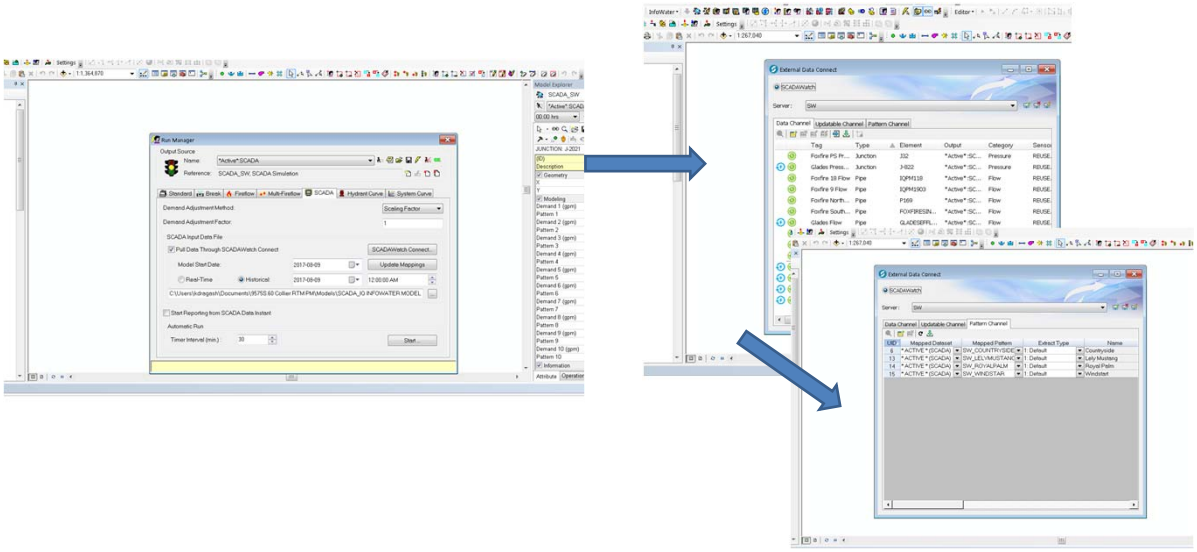
InfoWater – SCADAWatch Interface



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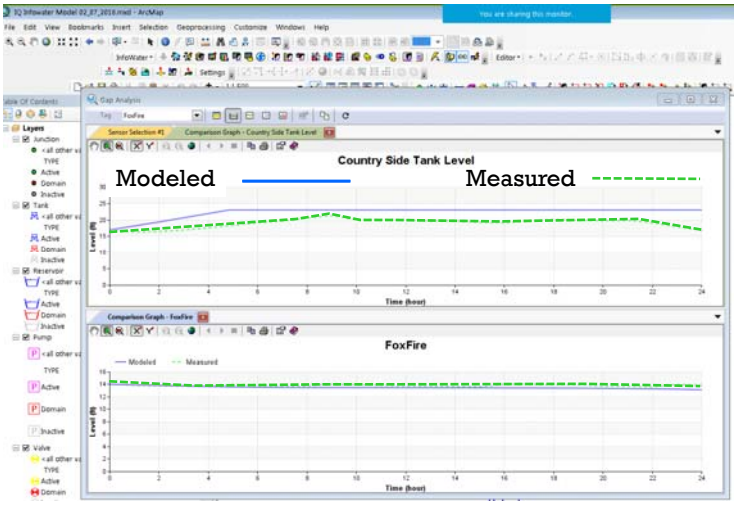
SCADAWatch Integration within InfoWater Model Results - 8/9/2017



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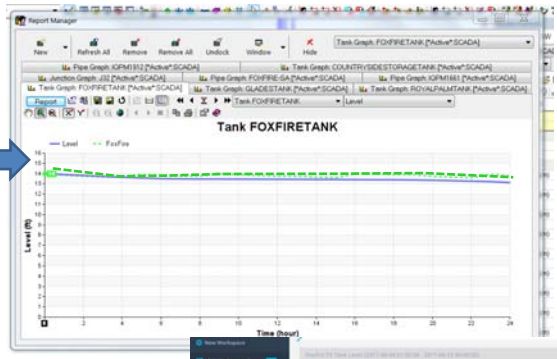
Results

InfoWater
(with SCADAWatch Results)



Modeled
Measured

SCADAWatch
(with InfoWater Results)

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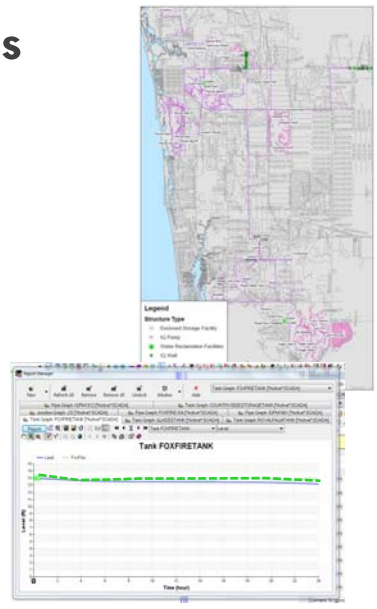
Benefits of these Smart Applications

SCADAWatch/InfoWater Benefits

- **Data Access Benefits**
  - Access of SCADA data from Dashboard interface
  - User-Definable Graphs
  - Two-way connection between SW and InfoWater
- **Modeling and Analysis Benefits**
  - Extensive Statistics and Mass Balance
  - Significantly Reduces Time & Effort for Calibration and Event Analysis
- **Software Vendor Product (Innovyze)**
  - Non-Proprietary
  - Continually Updated and Supported
  - Consultant Independent



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Smart Utilities…

- Collier County, Florida
- Dallas, Texas
- Houston, Texas
- Boynton Beach, Florida

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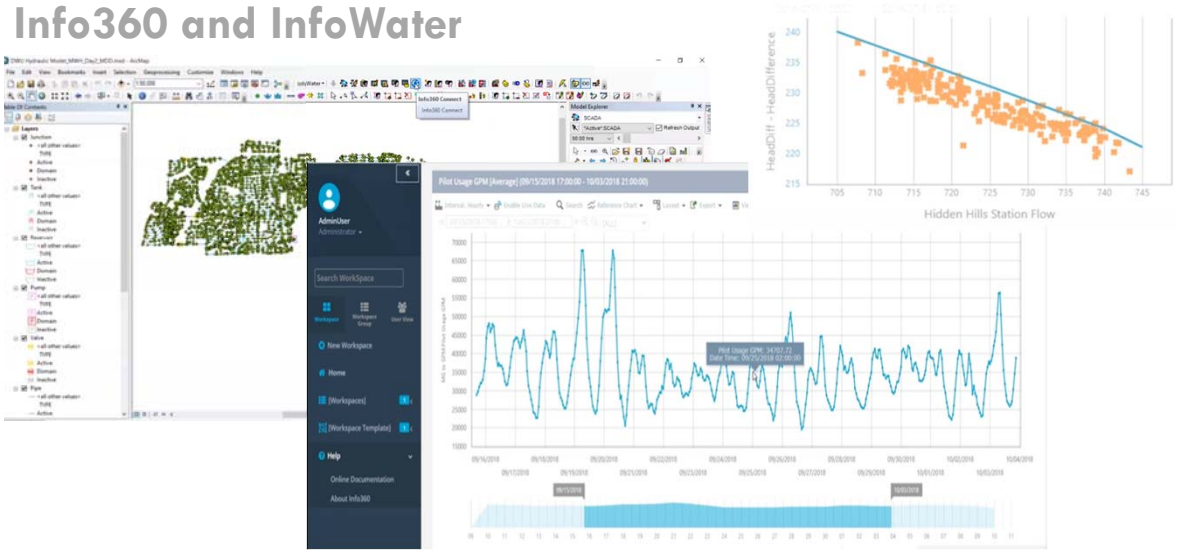
Dallas Water, Texas

Info360 and InfoWater



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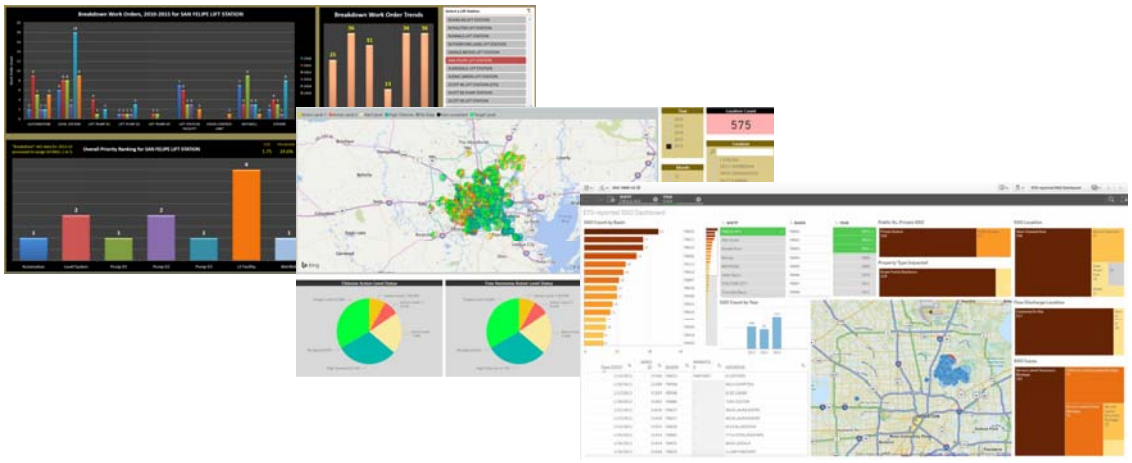
Houston DPW, Texas

Advanced Infrastructure Analytics Platform (AIAP)



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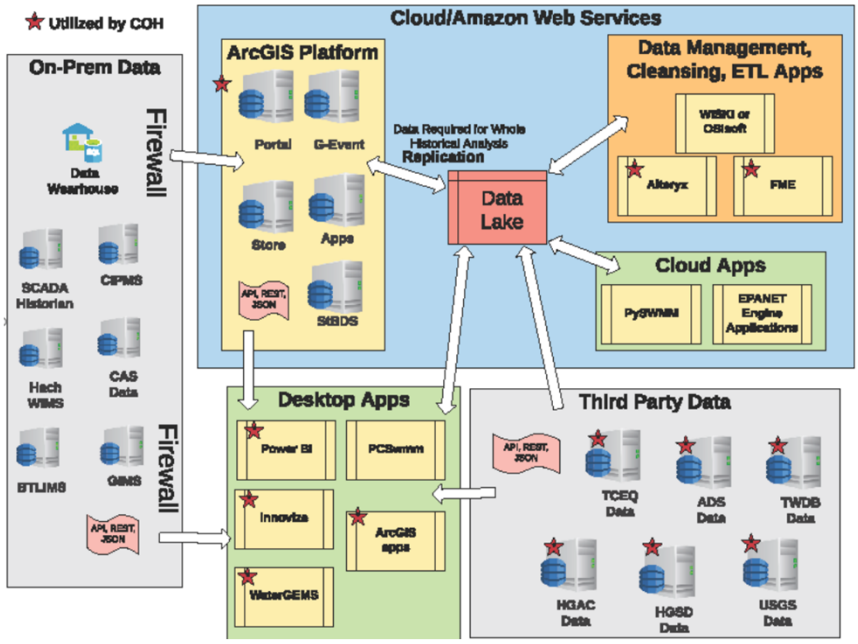
Houston AIAP Structure



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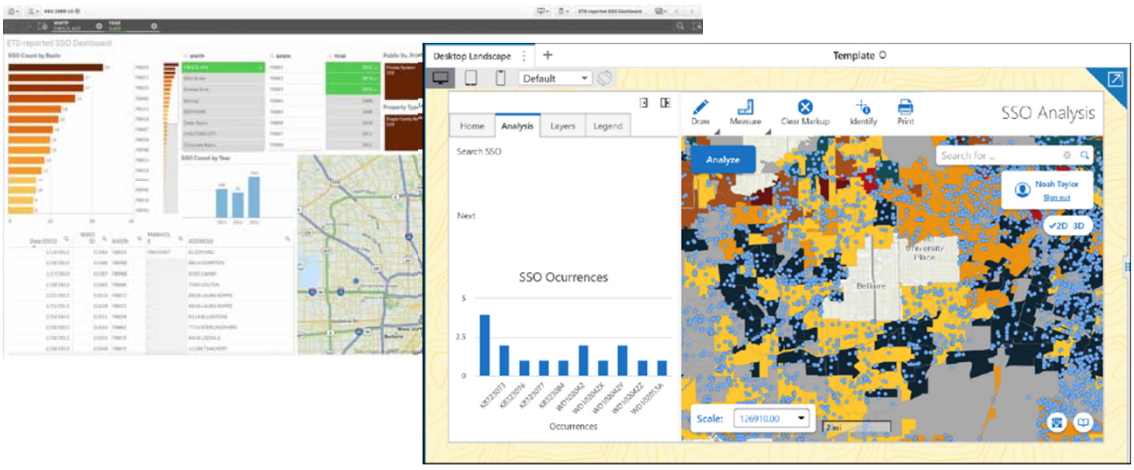
AIAP Example - SSO Analytics Dashboard

(PowerBI to Geocortex)



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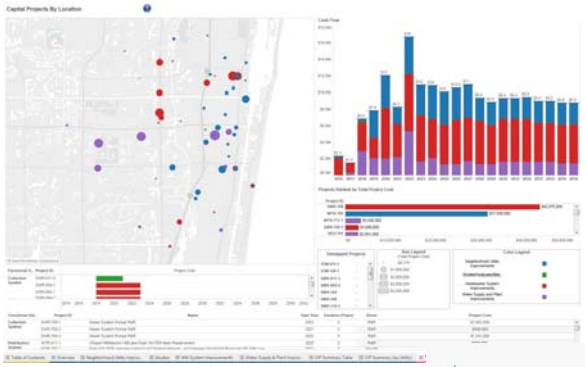
City of Boynton Beach, FL

Utility Management Optimization Program (UMOP)

PURPOSE: Develop easy to use dashboards not requiring custom software (no code/low code) that will:

- **Assist in analyzing CIP projects** to be able to move projects and change costs
- **Track yearly cashflow** based on available funds, and schedules of projects,
- **Utilize financial model** to see how CIP changes affect rates
- **Handoff to client** and not be tied to consultant/programmers.



Simply…

AN AUTOMATED MASTER PLAN AND FINANCIAL MODEL

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Getting the Right Information…
to the Right People…
at the Right Time…
is the Goal of Intelligent Water Systems
for Smart Utilities

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Thank You

Shawn Dent, P.E.
Vice President
Leader for Intelligent Water Systems
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Questions?

Thank you for joining us!

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