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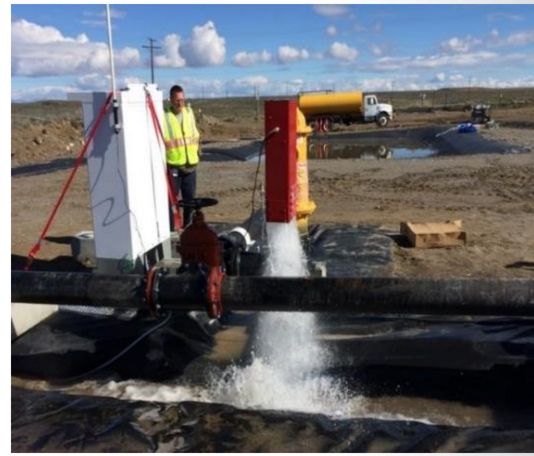
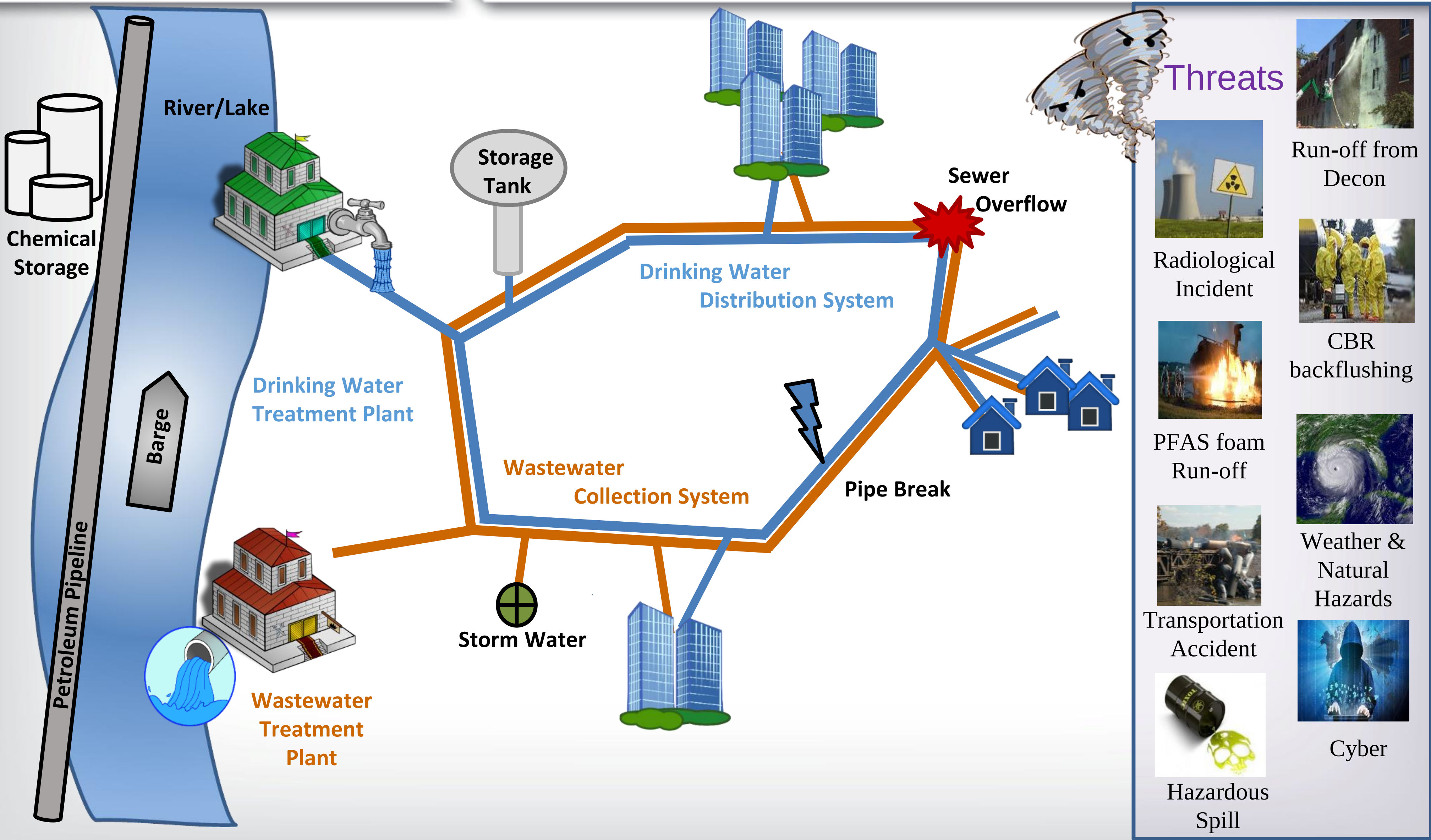


Research for the Kinks, Loops, and Twists in the Water Cycle During Recovery from Contamination Incidents

Matthew Magnuson & Hiba Ernst

EPA INTERNATIONAL DECONTAMINATION RESEARCH AND DEVELOPMENT CONFERENCE
May 8, 2018

Water Security and Resilience – A Systems Approach to Incidents



Contaminated Water: Generation & Concern

How is contaminated water generated?

- Direct contamination of drinking water and wastewater by chemical, biological and radiological (CBR) agents
- Washdown activities involving CBR agents from indoor-outdoor areas
- Decontamination of residence, personal protective equipment, medical facilities
- Runoff during precipitation events prior to or during decontamination activities

Concerns

- Contaminated waters may pose a threat to the public through events like basement sewage backups, combined or sanitary sewer overflows
- Contaminated sludge, resulting in biosolids handling and disposal issues
- Direct contact with contaminated waters may pose a risk for workers in wastewater collection and treatment systems
- Lack of unified guidance and best practices for wastewater systems

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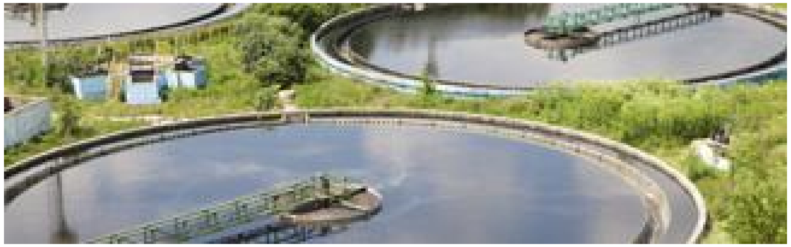
Water Systems Security and Resilience



- Water Infrastructure Protection
- Detecting Contamination
- Mitigating Impacts
- Water Infrastructure Decontamination
- Water Security Test Bed

Opportunities of Other Federal Agencies

Previous Research Grant Results

Guidance on Preparing Documents for the Homeland Security Research Program

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Applied Research for Resilience to Contamination:

Water, Wastewater, and Infrastructure

Inclusion of Water Industry Needs: e.g., WE&RF Workshops

High Consequence Pathogen Specific Needed Technical Information

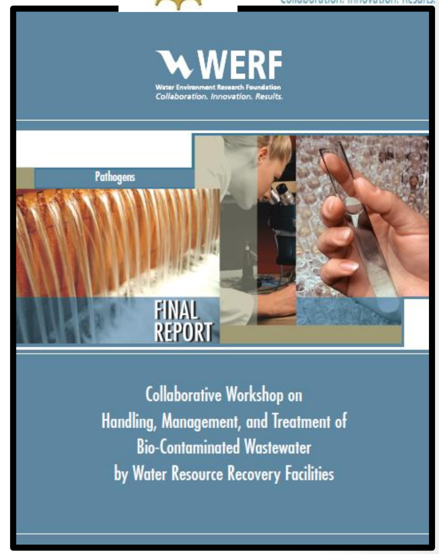
- Utility response planning
- State of the knowledge – *Bacillus anthracis*
- Beyond anthrax – high consequence pathogens

Research Gaps:

- Synthesis of existing data
- Survivability, persistence, fate, and viability in various media and processes
- Sampling/analysis, real time monitoring, analytical methods and technologies
- Worker exposure and risk assessments

Addressing the Gaps:

- Fate and transport of spores and viruses in wastewater treatment
- Persistence of microbial contaminants on the infrastructure
- Development of unified guidance (WE&RF and EPA)
- Research on worker exposure and PPE



Product: *Collaborative Workshop on Handling, Management, and Treatment of High-Consequence Biocontaminated Wastewater by Water Resource Recovery Facilities*

Similar Workshops for Chemical and Radiological Contamination

Inclusion of Water Industry Needs: e.g., Ensuring Water Availability for Cleanup

Integrated Wash-Aid, Treatment, and Emergency Reuse System

- On-site system for washing buildings, wash water containment, particle treatment, and water reuse
- Portable dirty bomb contaminant mitigation technology
- Deployable within 72 hrs
- Allow responders to continue operations
- On-site treatment to meet water demand and reduce overall contaminated wash water production

https://www.youtube.com/watch?v=IV7N2jWm6js&feature=youtu.be

IWATERS: Ad-Hoc Systems for On-Site Treatment of CBRN Contaminants from Wash Waters

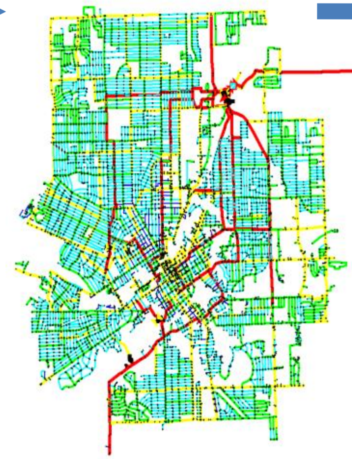
Michael Kaminski | *Argonne National Laboratory; May 9 - Session 2; C113*

Part of IWATERS, for vehicle washing, will be demonstrated immediately after this session.

Inclusion of Water Industry Needs: e.g, Support to City of Flint

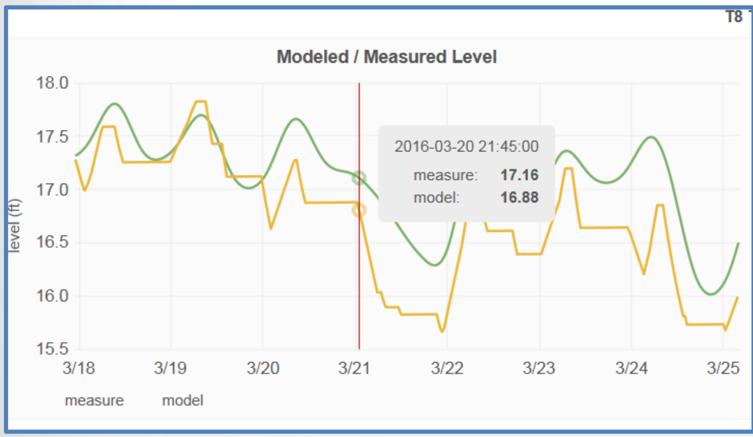
Calibrate model to SCADA data

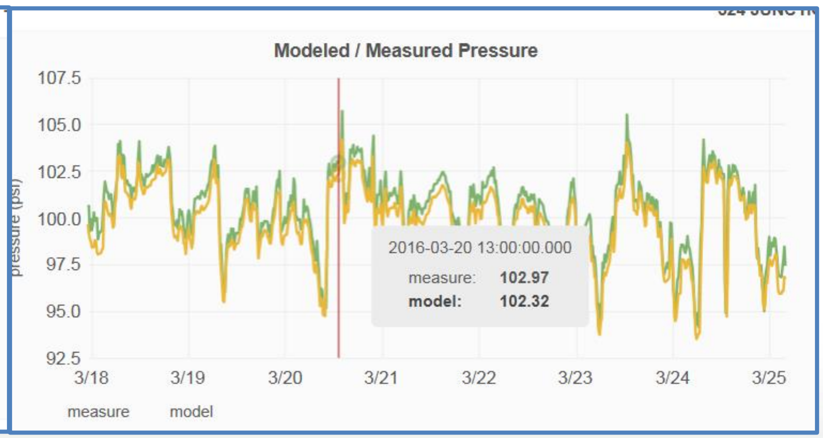
- Using EPANET-RTX, link model to SCADA data
- Assess errors in model
- Install RTX:LINK to provide direct connection to SCADA
- Data analytics including real-time trends, water age, tank turnover time, tank mixing, understanding water flow, energy usage, and system demand

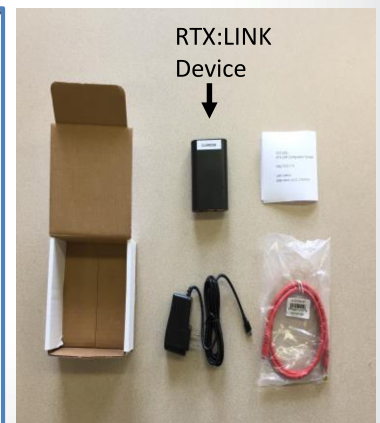


Improve Operations

- Flow patterns and residence times
- Changes in customer usage
- Effects on pressure and water quality
- What are the effects of oversized infrastructure on water quality?
- Can sampling locations be improved?



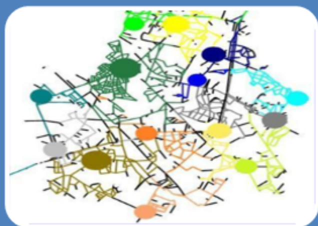




Applications of Software Tools

Water Distribution System Tools to Support Decontamination Efforts

Terra Haxton| *Environmental Protection Agency; May 8 - Session 1; C113 (this session)*

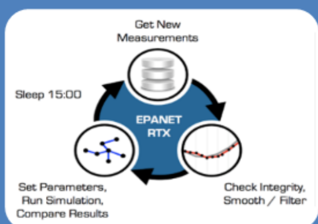


TEVA-SPOT Sensor Placement

- Greater Cincinnati Water Works (2015 MLB All-Star game)
- Montreal Water Utility, Montreal, Canada (*E. coli* notification)
- Water Security Initiative utilities

CANARY Event Detection

- Singapore Public Utility Board (2009-present)
- Greater Cincinnati Water Works (2007-present)
- Source water, green infrastructure and water reuse monitoring



EPANET-RTX Real-time Hydraulic Modeling

- Northern Kentucky Water District (2012-2014)
- City of Milford, Ohio (2014-present)
- City of Flint (2016 – present)

Detecting Contaminants

Detection: Then and Now

Then (2006)

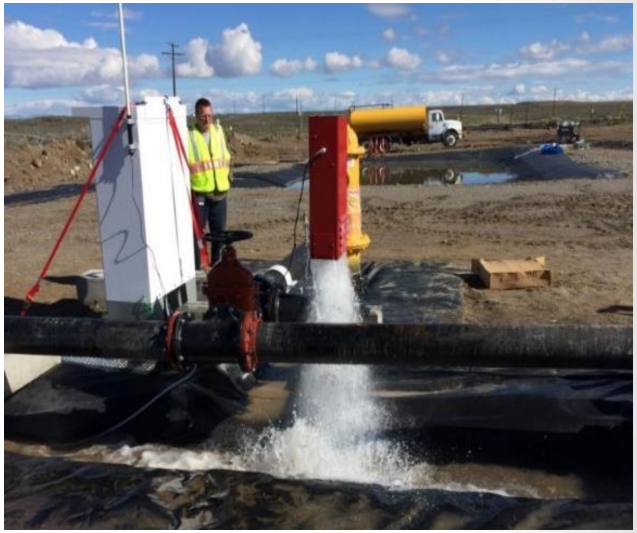
- Lots of sensors to test. Lots of inventors and new ideas
- Sensors were placed at strategic points within the distribution system (TEVA-SPOT)
- Control rooms collected lots of SCADA data
- When an alarm triggered, send out a truck and a collect a “real sample”
- The utility owned the data
- AMR was the exception.

Now (2018)

- Not many new sensor ideas to test. End of the toothpaste tube
- Sensors can be anywhere within the watershed using matrix, mesh principles
- Control rooms take in lots of SCADA data – how to use effectively
- Triggered alarms are tied to response actions such as open and flush fire hydrants, open and close valves, reroute to additional treatment
- Utility being pressured to share
- AMR is the rule.

Drinking Water: Where do we need to get?

- Detect and respond quickly to minimize impact
- Flushing can work, especially for restoring chlorine residuals
- Use software tools to optimize integrated detection and flushing systems
- Greater role of control room. Real time transmission of pressure loss, or maintenance data from fire hydrant room (AMR network?)
- Is there a role for AI and robotic sampling?



Source Water: Where do we need to get?

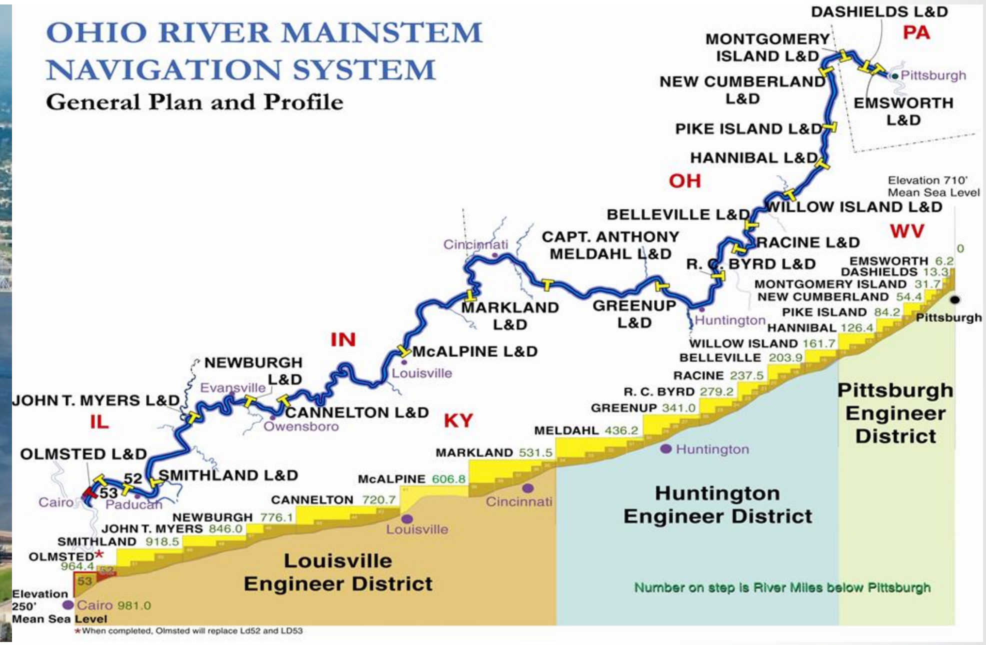
- What's coming down the river and what can we do about it?
- Real time river data and baseline data
- Spill model for utilities to use source water monitors and existing river monitors to determine when and how long to close intakes
- Get the processed data directly into the hands of the person with the authority to close and open the intake valve.

River - Spill Model

- Response to a Urea Ammonia Nitrate spill in the Ohio River, December 19, 2017
- 78 miles upstream of the Louisville, KY water utility intake
- ORSANCO used our model to predict the time the spill would reach the intake
- Water utility closed the intake preventing contamination of treatment plant

Riverine Spill Modeling System (RSMS)

- Tool supports emergency response decisions regarding drinking water plants intakes on the Ohio River
  - To know when and how long to close river intakes in response to spills
  - Utilities can use tool to prepare and train for potential worst case scenarios via adding readily available GIS data.



Ohio River Cincinnati Skyline - J. Miles Wolf

Ohio River Navigation - John D. Cheek, USACE

What could be the magnitude of a spill?

CARGO CAPACITY

BARGE	15 BARGE TOW	JUMBO HOPPER CAR	100 UNIT TRAIN	LARGE SEMI TRUCK
1750 TON	26,250 TON	110 TON	10,000 TON	25 TON
61,250 BUSHELS	918,750 BUSHELS	3,850 BUSHELS	350,000 BUSHELS	779 BUSHELS
1,375,000 GALLONS	20,625,000 GALLONS	30,240 GALLONS	3,024,000 GALLONS	7,885 GALLONS

EQUIVALENT UNITS

1 BARGE
1750 tons of dry cargo
= 16 JUMBO HOPPER CARS = 70 TRUCKS

1 TOW = 2.25 100 UNIT TRAINS = 1050 TRUCKS

EQUIVALENT LENGTHS

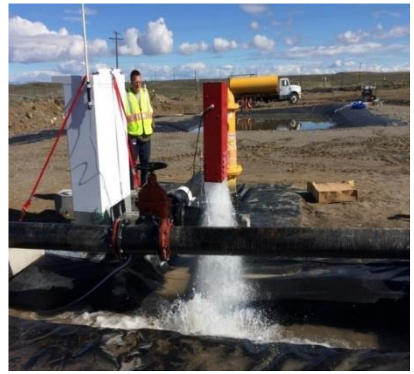
15 BARGE TOW
.25 MILE

2.25 UNIT TRAINS
2.75 MILES

1050 TRUCKS (Bumper to Bumper)
13.9 Miles

Science Data Development at a Scale Appropriate to its Application

Applied Research Solutions Approach



Application to Real Response Incidents

Bench-Scale

Pilot-Scale

Full-Scale

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Bench Scale: Advanced Oxidation Processes and Microbial Toxicity

UV LED experiments

- Performed with methylene blue, brilliant blue FCF and tartrazine under different conditions from those utilized in other AOP experiments

Other AOP experiments

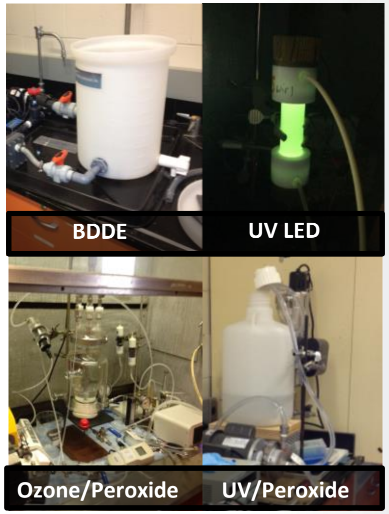
–Toxicity Tests:

- Nitrification Inhibition Test:
  - Indicates: Toxicity to wastewater biological treatment processes
- Microtox Toxicity Test:
  - Indicates: Eco-toxicity for discharge to receiving waters

–Target Contaminants (~10mg/L):

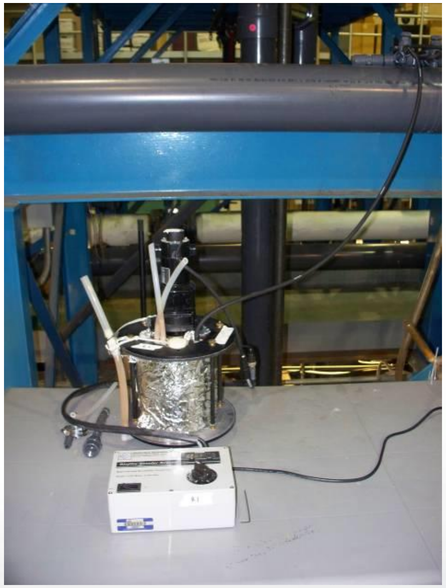
Propanil
Aldicarb
Carbamazepine
Bisphenol A (BPA)
Perfluorooctanoic Acid (PFOA)
Tris(2-chloroethyl) phosphate (TCEP)

Carbofuran
Atrazine
Cyanazine
Phenylephrine
Diethyl methyl phosphonate (DEMP)



Bench Scale: Annular Reactors for Contaminant Adherence

- Investigate persistence of chemical, biological, and radiological contaminants on water infrastructure materials on a small scale
- Utilize pipe coupons inside a rotational drum to simulate shear flows
  - Iron and cement-mortar for distribution system infrastructure
  - Copper and PVC for home plumbing
- Simulate decontamination approaches
  - Flushing
  - High levels of chlorine
  - Alternative disinfectants such as chlorine dioxide

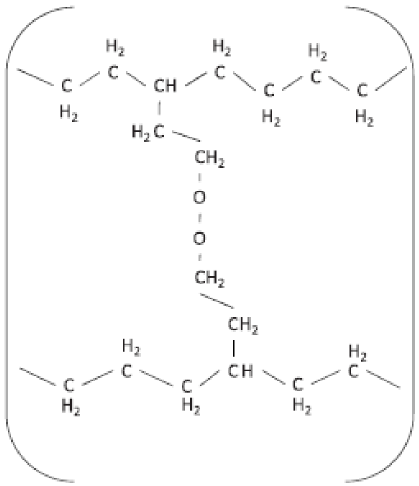


Bench Scale: Flushing of Polyethylene Tubing

Predicting Effectiveness of Removal of Organic Contaminants from Polyethylene Pipes by Flushing

Levi Haupert | *ORISE @ Environmental Protection Agency ; May 10 - Session 6; C113*

- Advantages of plastic pipes
  - Light
  - Flexible
  - Inexpensive
- Uptake and release of organic contaminants are expected to become increasingly important for decontamination of plumbing systems.



Bench Scale: Sequencing Batch Reactors for Persistence in Sludge

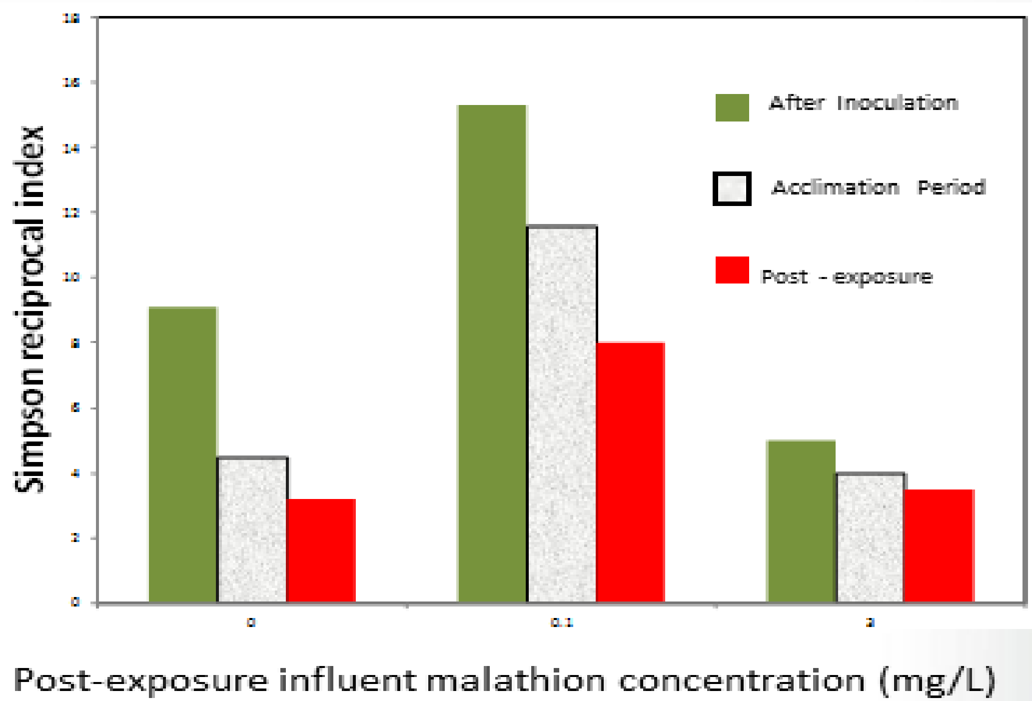
- Effect of *Bacillus globigii* (anthrax surrogate), MS2 virus, and malathion (organophosphate) contaminants on the activity of “activated sludge”
- Ability of activated sludge to remove/inactivate contaminants
- Examine both supernatant and settled sludge

Bench Scale:
Sequencing Batch Reactors

- About 80% of *Bacillus globigii* spores were removed with the settled sludge, while 20% remained in the effluent

- Between 1-3% of *Bacillus globigii* spores were observed to germinate in wastewater conditions

- Malathion and spores both had little short term impact on activated sludge performance



Microbial diversity profile: Microbial diversity decreased for each reactor both during the acclimation period and after exposure to malathion.

Pilot Scale: Drinking Water Pipe Loop

- 75- foot PVC pipe recirculation loop
- Allows the injection of contaminants and decontaminants into the loop
  - *Bacillus globigii*, strontium, cesium, cobalt
- Outfitted with 30 removable coupons made of pipe material
  - Ductile iron, concrete (others possible)
  - Water quality measurements
  - pH, conductivity, temperature, free chlorine, and ORP

Pilot Scale: Wastewater Treatment Plant

- Examine the fate of *Bacillus globigii* and MS2 virus in an activated sludge treatment system

- Determine extent of spore germination within pilot plant

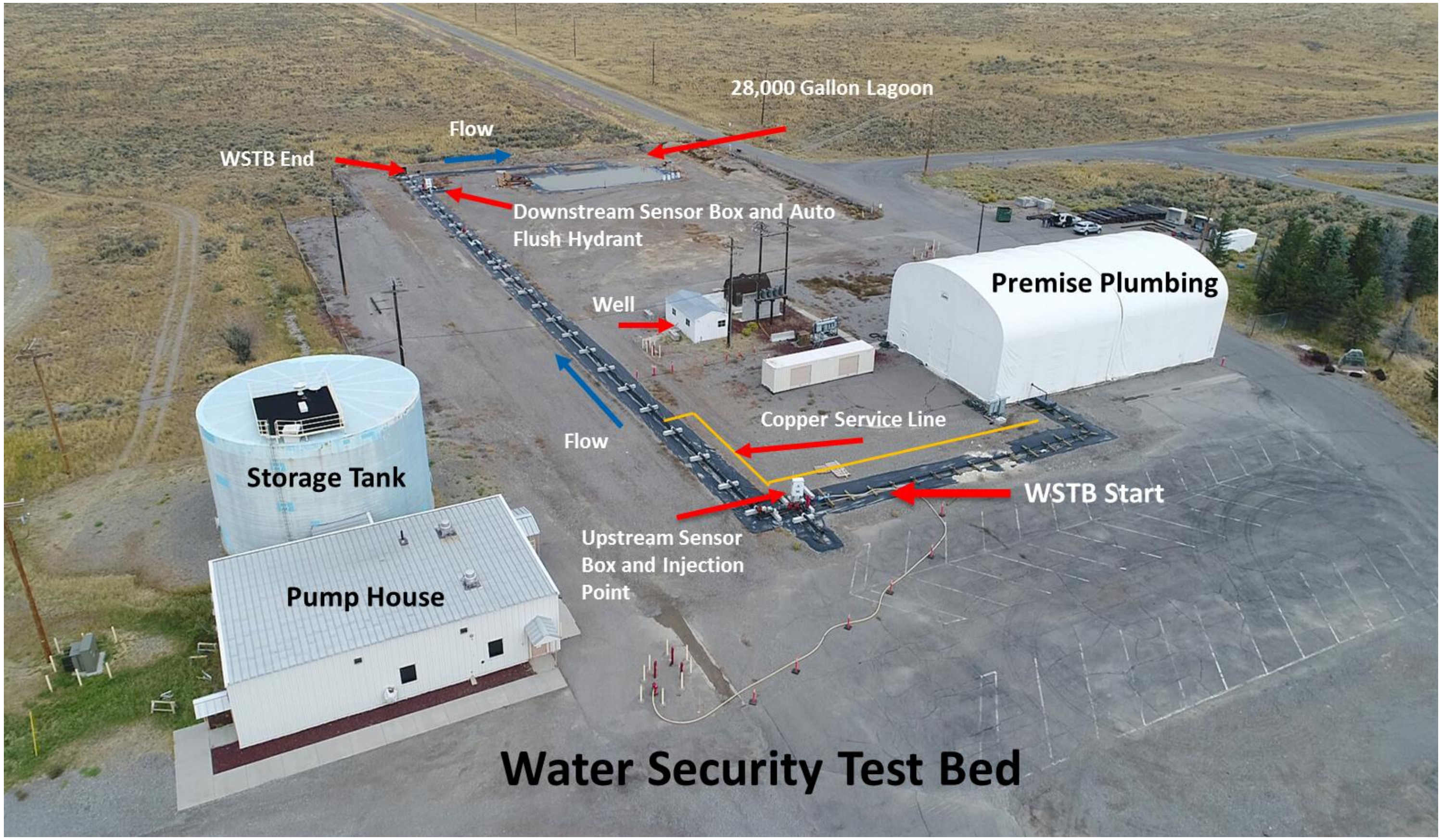
- Implications include handling of contaminated effluent and contaminated biosolids, as well as system decontamination

- Previous experiments: fate of terpenes, aldicarb, and silver nanoparticles

Pilot Scale: Wastewater Testbed

- Investigate persistence of contaminants on a variety of sewer/collection system materials
  - Iron, PVC, HDPE, rubber (gaskets), cement-mortar, brick, vitrified clay
- Common sewer materials will be conditioned in flow
- *Bacillus* spores will be released into the flow and persistence assessed

Full Scale Research: Water Security Test Bed



Decontamination Research at EPA's Water Security Test Bed

Jeff Szabo | *Environmental Protection Agency; May 8 - Session 1; C113 (this session)*

Water Security Test Bed: As-Built

Phase I of the test bed is a once through system:

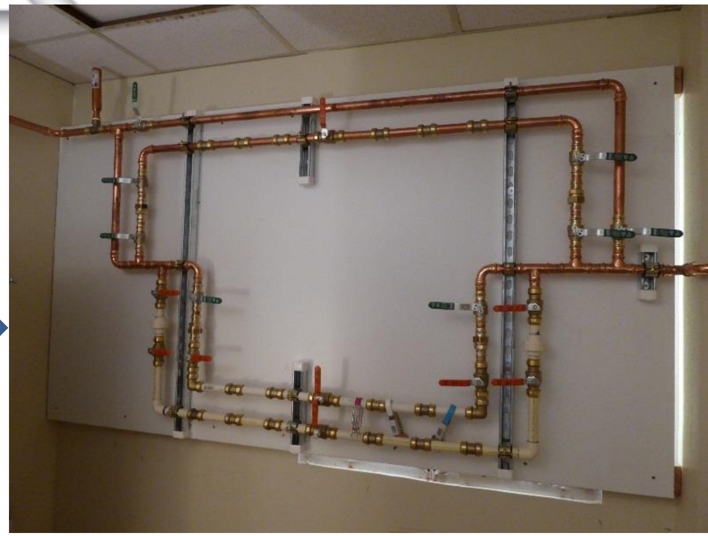
- 445’ of 8” cement mortar lined, ductile iron pipe (water main)
- 6 × 1” service connections/sample ports, 2 hydrants
- 15’ pipe material coupon section for sampling the interior of the pipe surface
- Above ground system, underlined by secondary containment
- 28,000 gallon lagoon/high rate groundwater pump/storage tank

Water Security Test Bed Video
https://vimeo.com/238875837/c539320b42

Phase 2 of the test bed linked premise plumbing to the main line:

- 200 ‘ of 1” Cu service line to building
- Installed household appliances
  - Hot Water Tank
  - Refrigerator
  - Washing Machine
  - Dishwasher
  - Utility Sink Taps
- Copper, PVC, PEX pipe sections

Premise Plumbing Decon



Inclusion of Water Industry Needs: e.g, Support for Cleanup Decisions

Full-Scale Testing

- Field-testing successful infrastructure decontamination methodologies in real world scenarios (Bakken oil spills, Fire fighting foam)

Response and Recovery

Application to Real Response Incidents

Potomac River

- **Support to: Region 9 following wild fires and contamination of drinking water with Benzene (February 2018)**
- **Region 6 OSC – Corpus Christi (Indulin AA-86) contamination in the water system (December 2016)**
- **Region 3 DW and OSC Region 3 -- Oil spill in Washington DC (Potomac River)**

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Thank you

"Priority Activity: Improve detection, response, and recovery to contamination incidents" – 2017 Roadmap to a Secure and Resilient Water and Wastewater Sector, Critical Infrastructure Partnership Advisory Council

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