Office of Research and Development

Homeland Security Research Program

Water Security Test Bed Webinar

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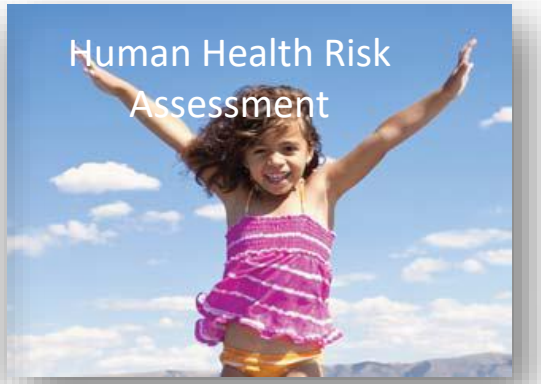
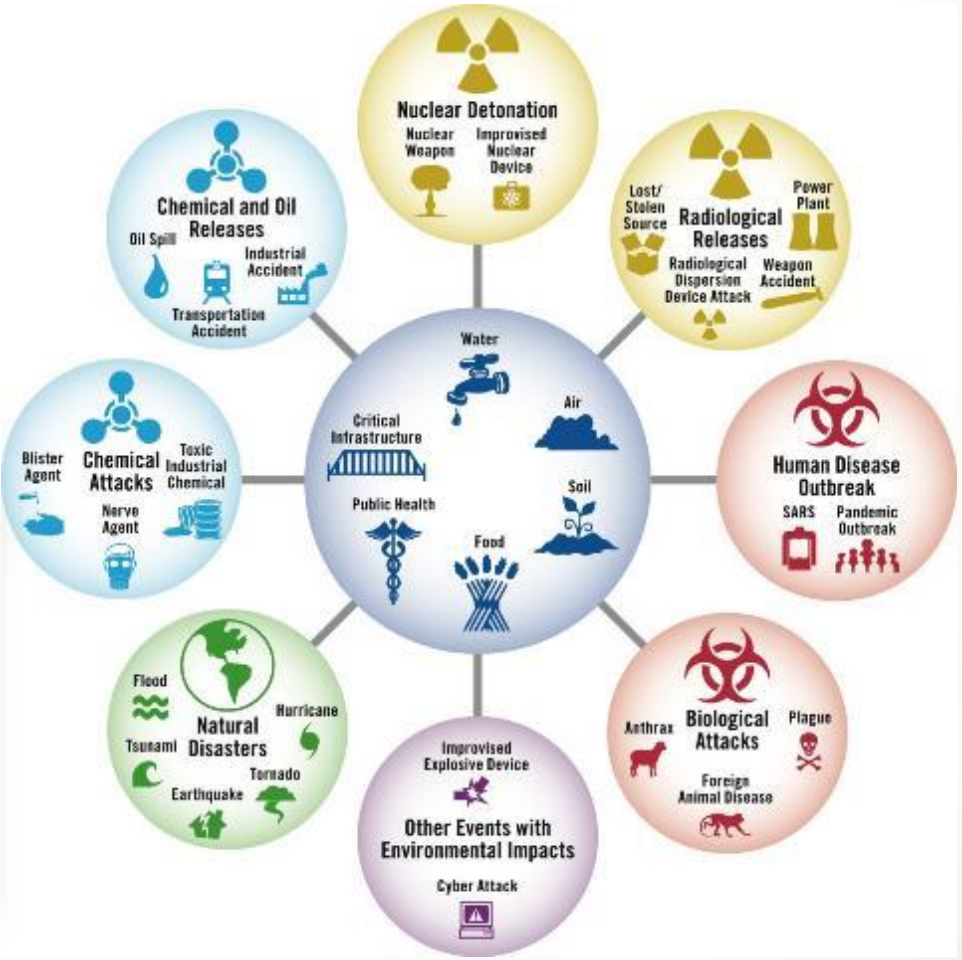
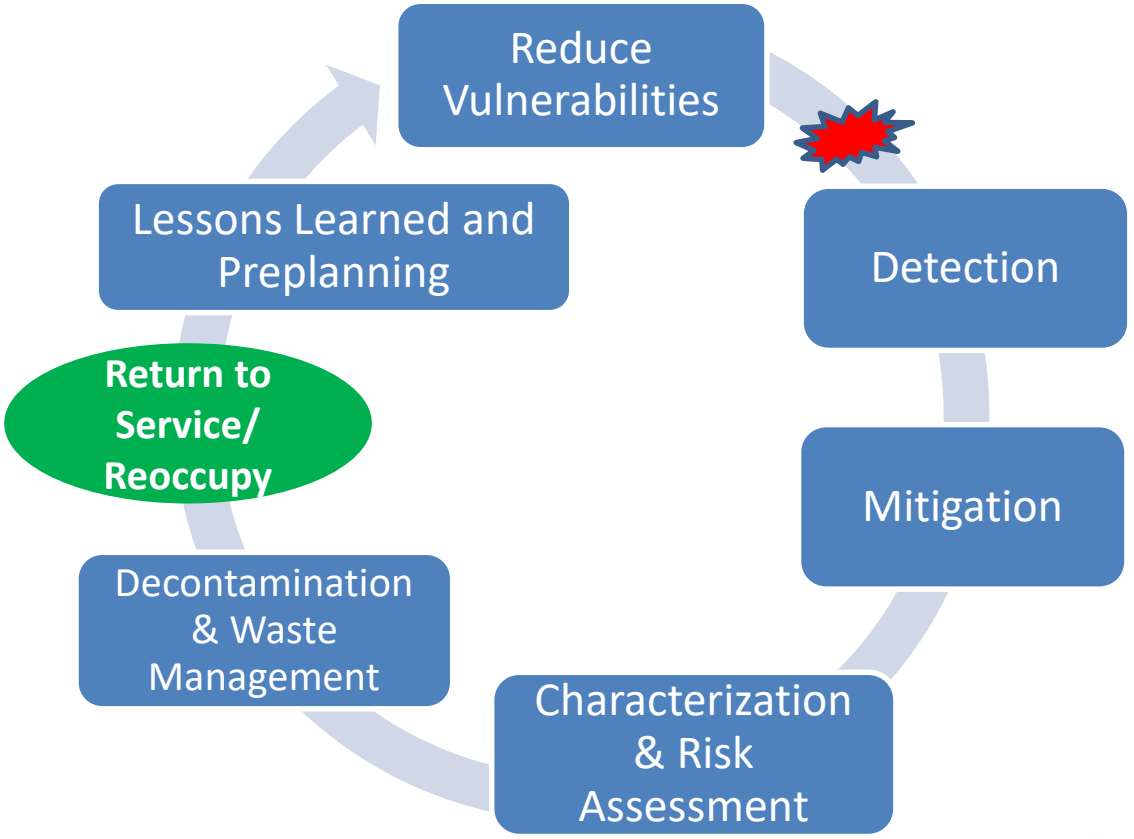
ORD Research Programs



EPA's "All Hazards" Universe

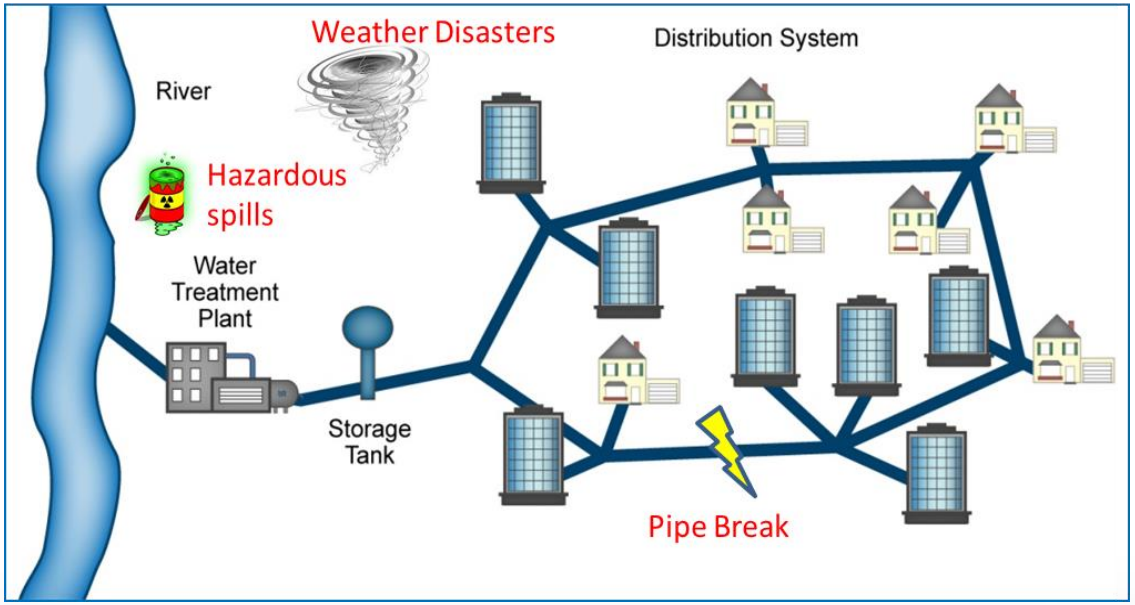


Water System Security and Resilience Systems Approach



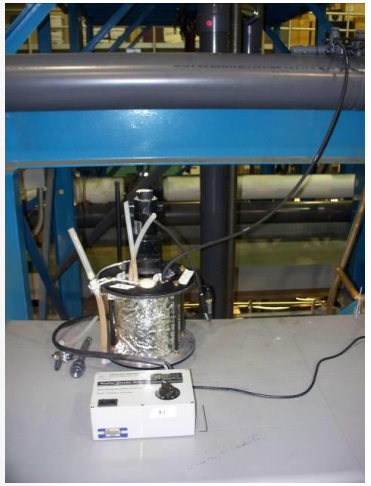
Water Security and Resilience Evolution of Program

Detection	Mitigation	Cleanup	Resilience
Contamination warning system data and tools	Flushing strategies	Infrastructure decon, wash water treatment	System designs, vulnerability tools, treatment indicators



Schematic of drinking water distribution system.

Applied Research Solutions Approach



Bench-Scale → Pilot-Scale → Full-Scale

Andrew W. Breidenbach Environmental Research Center

- Internationally recognized for water research
- Second largest research and development facility owned and operated by EPA
- Located on a 22-acre complex
- 429,646 GSF with approximately 710 personnel
- Multiple Labs/Centers
- 100 Years of Water Research History

Features:

- 7,000-square-foot Research Containment Facility
- Large-scale (6.4 L/min) pilot plant
- Advanced Materials and Solids Analysis Research Core

Test & Evaluation Facility –
Cincinnati, Ohio

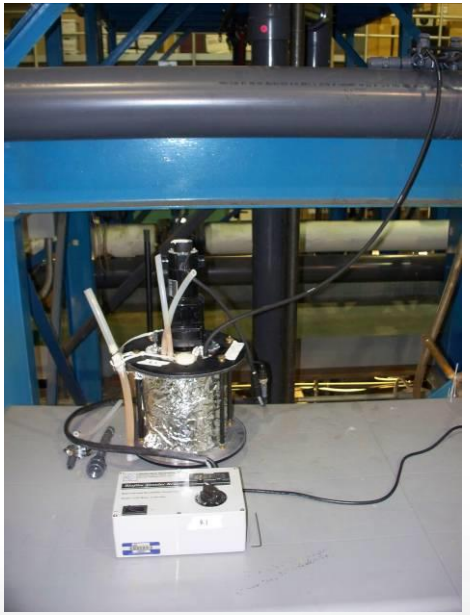
- Located on the grounds of Cincinnati's Mill Creek wastewater treatment plant
- Studies on new treatment technologies for contaminants in water and wastewater
- 36,101 GSF with approximately 35 personnel

Features:

- Machine shop for fabricating specialty items & building or repairing experimental apparatus
- 16 experimental locations in the 24,000 ft^2 high-bay area

Bench-Scale Experiments

- Bench scale systems simulate a drinking water environment and allow small-scale decontamination experiments
- Biofilm annular reactors



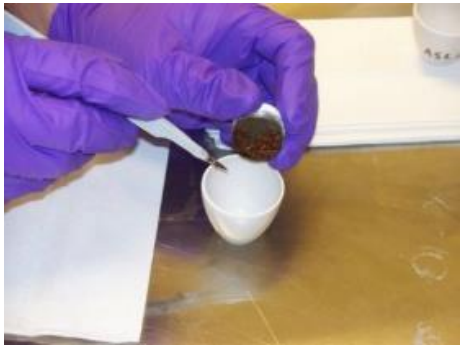
Pilot-Scale

The Distribution System Simulator (DSS)

Located at the USEPA's Test and Evaluation facility

Example: Contaminant Persistence and Decontamination of Drinking Water Infrastructure

- Persistence studied - determine the need for decontamination
- ^{137}Cs, ^{85}Sr, ^{60}Co and spore form of *Bacillus* spp - all persistent
- Flushing alone not successful for decontaminating infrastructure
- Coupons made from commonly used water pipe materials inserted into a pipe loop to test decontamination methods
- *Field scale testing is required*



Future Wastewater Research

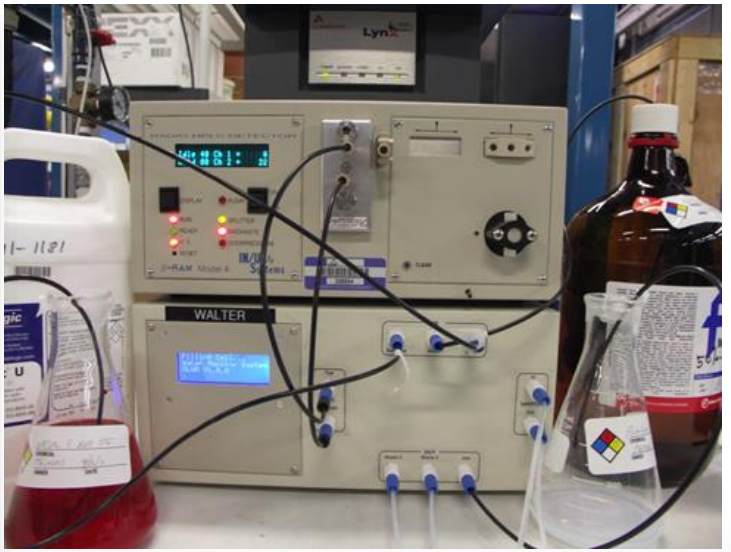
Activated sludge experimental set-up: assessing how contaminants travel through wastewater treatment systems

Wastewater test bed: assessing persistence of contaminants on sewer infrastructure

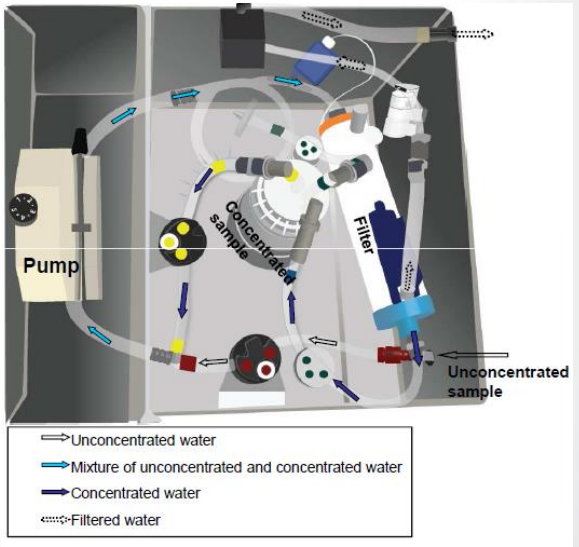
Real-Time Sensor Technologies

- Development, testing and evaluation of new sensing technologies
- Performance testing in operational settings

Sievers 900 Portable (UV Persulfate TOC)



LabLogic Beta Ram on line water Quality monitoring system

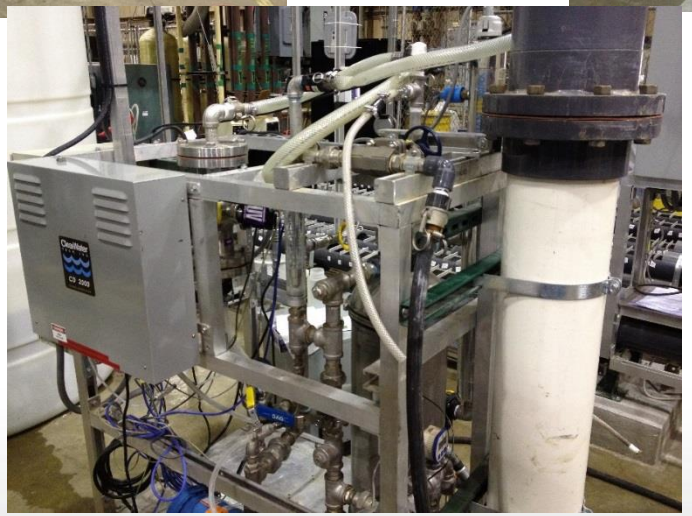


Water Sample Concentrator

Field Deployed Sensor Station

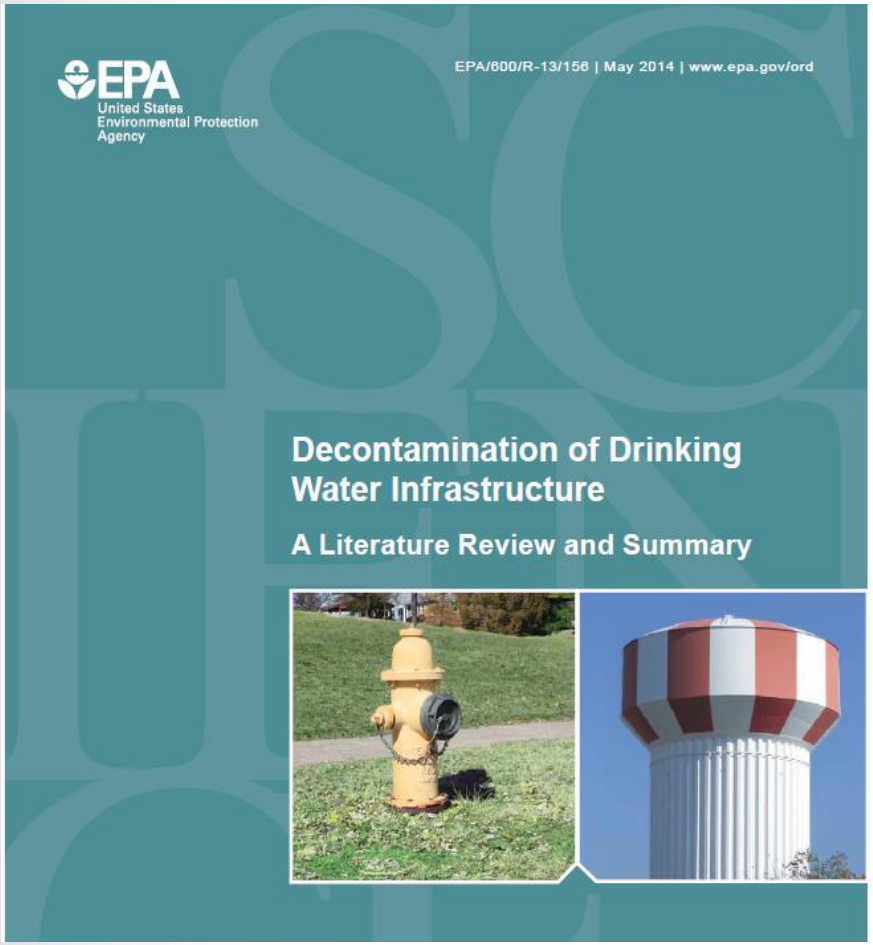
- Free and total chlorine
- pH, conductivity, turbidity, temperature, ORP
- Event monitor/alarm trigger

Water and Washwater Treatment



Ozone/UV Mobile Trailer

Bench- to Pilot- to the Water Security Test Bed



EPA/600/R-13/156 May 2014 www.epa.gov/ord

EPA/600/R-08/016 January 2008 www.epa.gov/ord

Water Security Test Bed (WSTB)

U.S. Water Sector identified full-scale testing of water security tools, sensors, methods, with real contamination, a MAJOR gap

Our Response: build and operate a full-scale water system that:

- Simulates intentional and inadvertent distribution system contamination (chem, bio, rad) and disruptions (cyber-attacks)
- Supports diverse applied research
- Located at Idaho National Lab (near Idaho Falls, Idaho)

WSTB Capabilities

The WSTB is a Full Scale Distribution System Simulator capable of:

- Field deployment and evaluation of
  - Real-time sensors to detect contamination events,
  - decontaminate drinking water infrastructure,
  - innovative water treatment unit processes, and
  - cybersecurity
- Joint experiments with Water Utilities and other State and Federal Agencies

Phase I of the WSTB

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

Where Did the Pipe Come From?

- Drinking water pipe that was in service from the early 1970's until a few years ago
- The pipe was in good condition when it was excavated
- The pipe was partially filled with water, but no major leaks were found

- Cement-mortar lined ductile iron
- Some pipes are corroded where the lining was worn or broken
- Four and eight-inch diameter pipes were excavated.

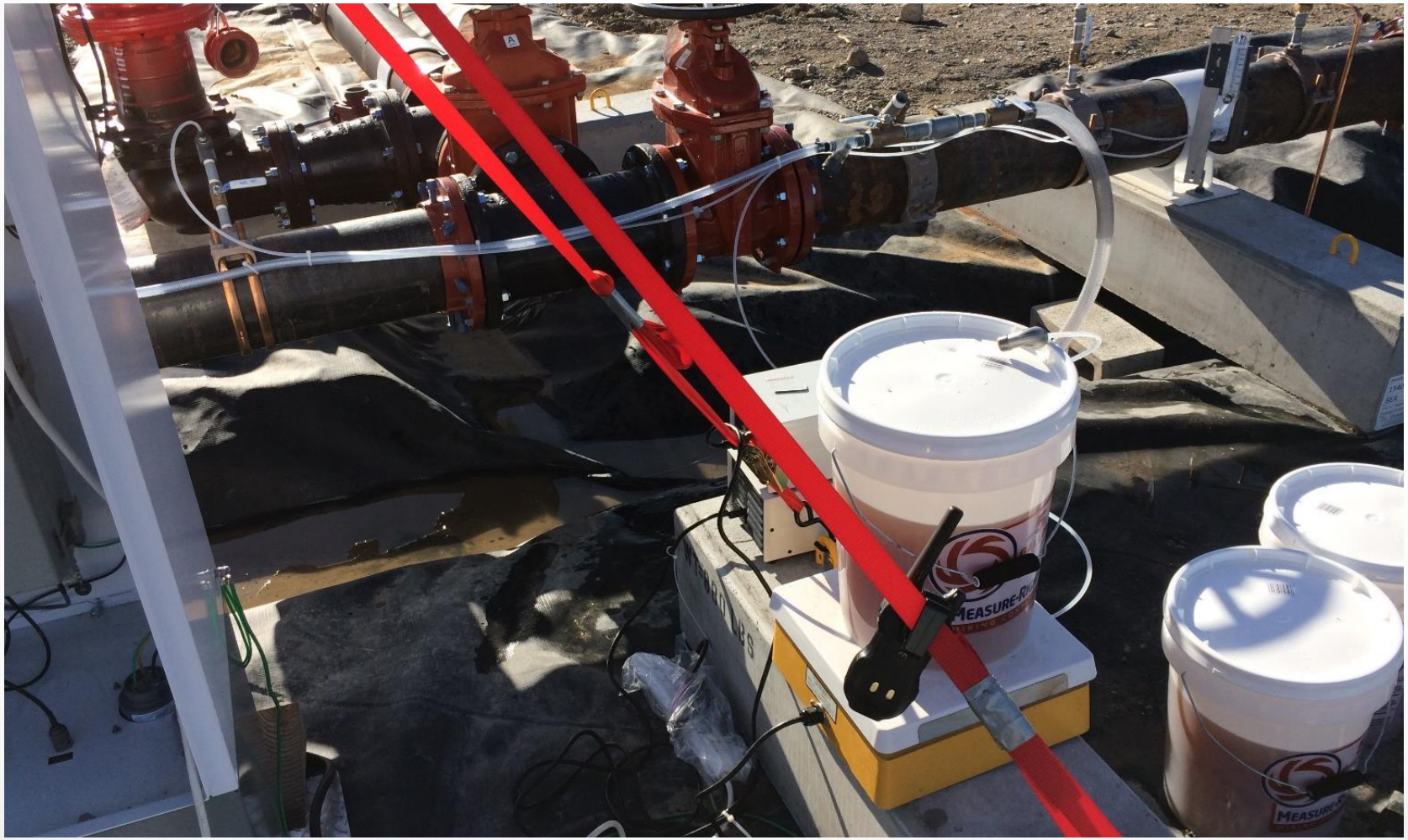
Aerial View – Phase I

Water Security Test Bed as of November 12, 2014

Injection Point and Sensor Boxes

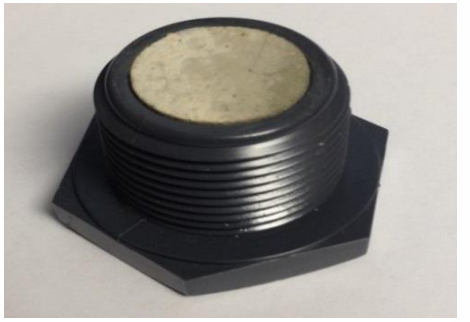
Chlorine and UV Sensors with Cellular Modem

Contaminant Injection



Looking Downstream

Removable Coupons for Decontamination Experiments



Coupon Sampling

Triggered Flushing

Lagoon, Tanker Truck, & Mobile Chlorine Water Treatment System

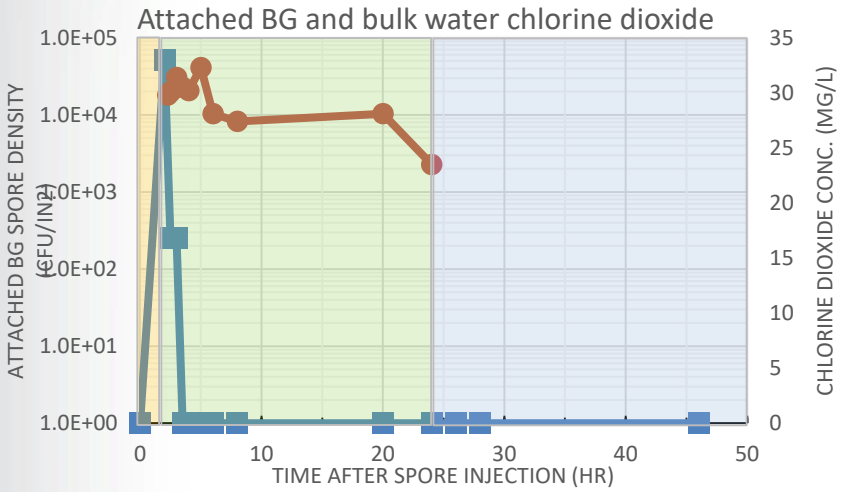
2014 Experiments

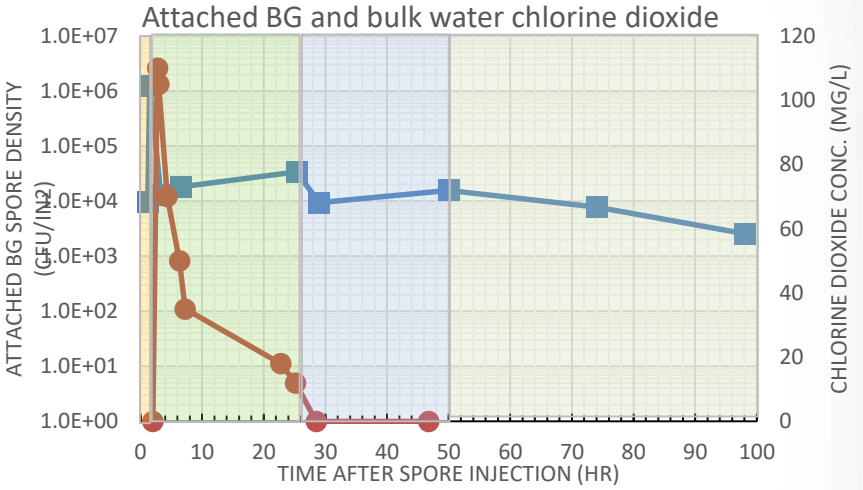
- A dye test (tracer) to evaluate travel times and system flows
- Sodium thiosulfate ($Na_2S_2O_3$) injection to remove free chlorine from the pipe – successfully triggered an automated fire hydrant flushing device
- Biological agent contamination

Anthrax Surrogate Experiment

- Biological agent decontamination
  - Chlorine dioxide was used as the decontaminating agent (performed well in pilot studies)
  - One hour after the contaminant injection, chlorine dioxide was injected and allowed to travel down the length of the pipe until the pipe was full of chlorine dioxide
  - The chlorine dioxide was allowed to contact the pipe under stagnant conditions for 24 hrs
  - After one day of contact, the pipe was flushed and returned to baseline flow
- Contamination and decontamination sampling
  - Bulk water and pipe coupons sample were removed before, during, and after contamination

Pipe Decontamination Data



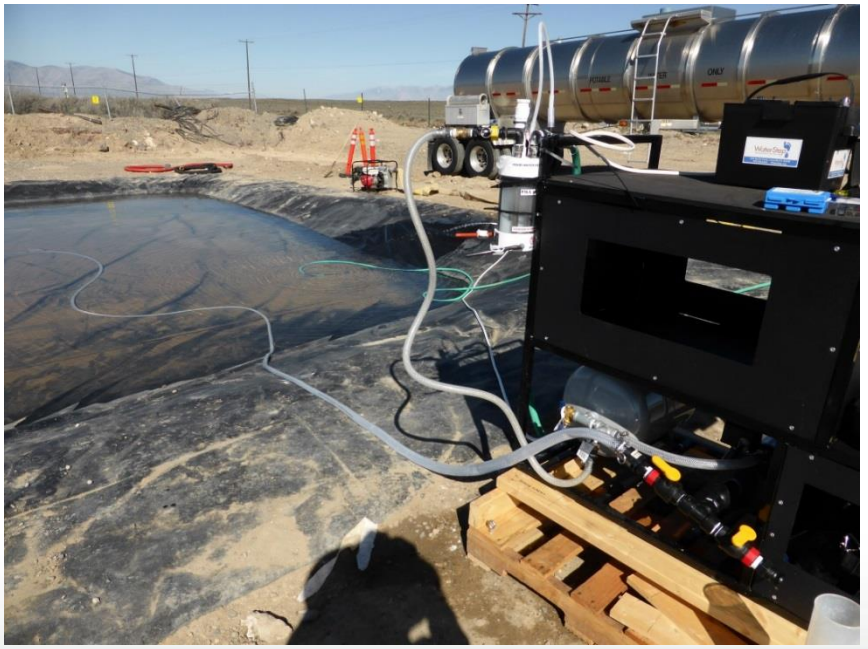


- Data from the pilot scale decontamination loop at EPA's T&E facility
- No spores detected on cement-mortar after treatment with 25-30 mg/L $CL0_2$

- Data from the WSTB at INL
- Spores persisted on cement-mortar in the presence of up to 100 mg/L $Cl0_2$
- Pipe demand, temperature fluctuation and dead end spaces impacted decontamination
- Decontamination will be repeated this year

Wash Water Evaluation

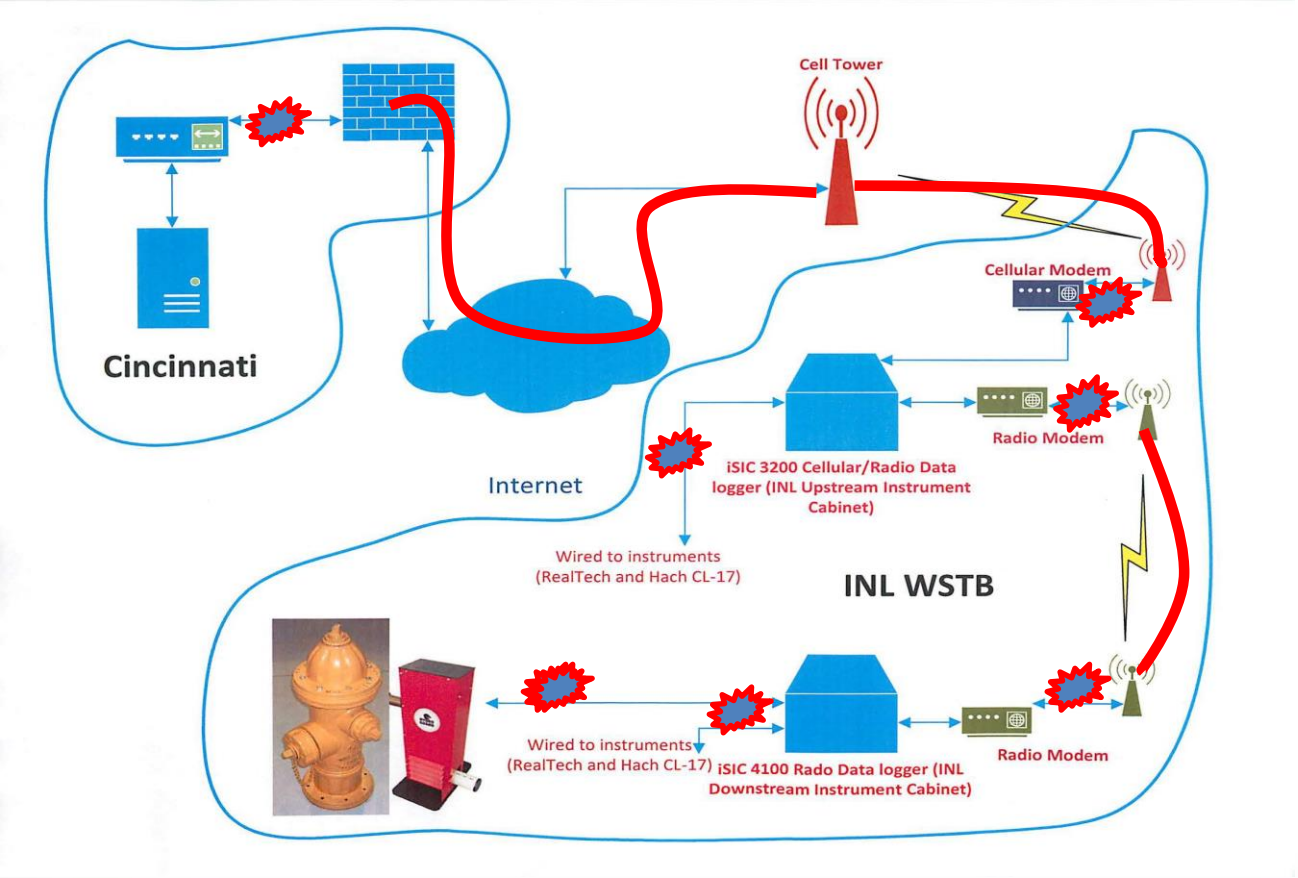
- WaterStep Portable Water Treatment System treated effluent lagoon water to disinfect spores that were flushed from the WSTB pipe.
  - System is designed to disinfect water (by on-site chlorine generation) for human consumption or discharge.
  - Chlorine generation and disinfection efficacy was evaluated
  - Insufficient chlorine generated to decontaminate washwater



2015 Experiments

- Additional ClO_2 decontamination and flushing of system
- Biofilm growth in the water main
- Effluent lagoon treatment using Cl_2, UV, and/or UV+O_3
- Crude oil contamination and decontamination - simulating a refinery/rail transport accident
- Cyber attack on system instrumentation and communications

Vulnerability/Consequence Cyber Security Assessment for Water Security Test Bed



Consequence

Potential veiled vulnerability exploitation

Experimental Concepts For 2015 and Beyond

Future studies may focus on:

- Connect to adjacent building and simulate home plumbing and appliances inside building or within construction trailers. Simulate homeowner decontamination.
  - Aerosolization of biological agents via a shower head
  - Testing and validation of water system components and household appliance decontamination
- SCADA vulnerabilities in water infrastructure
- Chem/rad/bio contamination due to natural, accidental, or intentional acts
- First responder training exercises

Challenges & Opportunities

Challenge

- Current scale and capability of WSTB not adequate to sustain a diverse research portfolio. Need to construct and test more complex pipe networks within the graded footprint of the WSTB
- Additional infrastructure build-out of the WSTB contingent on research partners' needs and capabilities

Opportunities

- National research asset for water security and Water Energy Nexus if fully built and funded
- Address gaps in threat identification and response (chem/rad/bio/cyber) in water infrastructure protection with applied research and demonstration at a remotely located, dedicated facility
- Collaboration with Water Utilities, State, and Federal Agencies
- *Research findings applicable to Daily Compliance with SDWA*

WSTB Team

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The Future of the Water Security Test Bed

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