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Subject Matter Expert Panel Review of the Full-Scale Water Security Test Bed (WSTB)

A Summary Report

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A Summary Report

by

James A. Goodrich, Jeffrey G. Szabo, John S. Hall, Kelly A. Dipolt, and Hiba S. Ernst
U.S. Environmental Protection Agency
Cincinnati, OH 45268

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Office of Research and Development
Homeland Security Research Program
Cincinnati, OH 45268

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Questions concerning this document should be addressed to:

James A. Goodrich, Ph.D.
National Homeland Security Research Center
Office of Research and Development
U.S. Environmental Protection Agency
26 W. Martin Luther King Drive
Cincinnati, OH 45268
Goodrich.james@epa.gov

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Abbreviations

AWWA	American Water Works Association
BOD	Biochemical Oxygen Demand
CDC	Centers for Disease Control and Prevention
CIPAC	Critical Infrastructure Partnership Advisory Council
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
HSRP	Homeland Security Research Program
INL	Idaho National Laboratory
NHSRC	National Homeland Security Research Center
ORD	Office of Research and Development
RFPs	Request for Proposals
SCADA	Supervisory Control and Data Acquisition
SME	Subject Matter Expert
TOC	Total Organic Carbon
USEPA	The United States Environmental Protection Agency
VSAT	Vulnerability Self-Assessment Tool
WaterISAC	Water Information Sharing & Analysis Center
WE&RF	Water Environment and Reuse Foundation (Currently Water Research Foundation)
WRF	Water Research Foundation
WSTB	Water Security Test Bed

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Executive Summary

In its role as the lead federal agency for water infrastructure protection, the United States Environmental Protection Agency (USEPA) assists water utilities to prepare for and respond to disasters, including homeland security incidents. USEPA's Homeland Security Research Program (HSRP) is charged with conducting research aimed at filling gaps in scientific and technological knowledge so that USEPA, emergency response personnel, and water utilities can better prepare and respond to such incidents.

To test and evaluate water infrastructure decontamination technologies in a simulated full-scale distribution system, the USEPA's National Homeland Security Research Center (NHSRC) designed and constructed the Water Security Test Bed (WSTB), a facility located at the Idaho National Laboratory near Idaho Falls, Idaho. To better address the needs of water systems' response to distribution system incidents, NHSRC convened a subject matter expert (SME) panel on August 3, 2017 at the WSTB. The purpose of the SME panel was to elicit independent viewpoints of the overall concept, approach, implementation, and sustainability of the full-scale WSTB facility. The USEPA did not at any time, solicit consensus from the SMEs. The SMEs discussed many specific topics including distribution system, premise plumbing, and water treatment decontamination research to build upon the existing WSTB capabilities.

Overall, the SMEs found the WSTB to be a unique, productive, creative, and cost-effective facility and the research accomplished for the level of funding was deemed a good value contribution to the water industry. The SMEs recommended that given the decreased funding, the WSTB research should stay focused on the core expertise of distribution system research, premise plumbing, and mobile emergency water treatment systems, and that cyber-security research should be added, when possible. Some of the specific SME's recommendations included:

- Expanding the realism of the facility to **enhancing water network complexity** by building the test bed to at least a couple city blocks with multiple sizes and piping material types (especially PVC), network dead ends/loops, storage tanks, and real-world tank operation and hydraulic demands.

- Decontamination success is expected to vary by source water or the daily disinfection process utilized by a community. The WSTB could be utilized to **evaluate variable finished water quality impacts on decontamination efficacy.** Understanding efficacy under variable raw and finished water conditions would be critical to informing emergency response actions across the U.S.

- Past chemical decontamination research at the WSTB has utilized well-mixed river water solutions of Bakken Crude Oil or aqueous firefighting foam. Flushing with water only was shown to be effective and the addition of a surfactant turned out to be unnecessary. However, **decontamination of other chemicals and petroleum products** could prove to be more challenging and should be evaluated.

- Currently, the WSTB is available from May through October. It was recommended that the WSTB facility be enclosed to facilitate a **four-season testing** and to increase research frequency and availability to other researchers in the water field.

- WSTB research has indicated that both microbial and chemical decontamination of household plumbing and appliances were fairly successful following flushing with an amended bleach solution. However, the appliances did exhibit very low levels of contaminant release (leaching) in days following flushing. It was suggested that the appliances be flushed/operated with their recommended soaps and detergents to determine d**etergent's role in household appliance decontamination.**

- A further extension of the premise plumbing and household appliance research would be to evaluate the **impact that new low flow appliances** may have on decontamination effectiveness. Lower flow rates with more restricted flow paths could decrease the effectiveness of decontamination protocols.

- The **evaluation of mobile emergency water treatment unit processes** was an important capability of the WSTB, especially in response to all-hazard incidents, such as floods. The SMEs recommended additional testing and evaluation of new mobile innovative unit processes.

- The WSTB would be enhanced by having a supervisory control and data acquisition (SCADA) system. By having a SCADA system, the WSTB could be utilized to research the impact of **cyber-attacks on the physical network and appurtenances** (e.g., water hammer [a sudden water pressure wave in a pipe], pump destruction) that could result in the loss of operator control and situational awareness. These studies would help water systems be better prepared for such incidents. Integral to this recommendation is the addition of real-time smart sensors to the WSTB and the addition of modeling of the distribution system to the WSTB research program.

- A great deal of discussion centered around **training, communication, outreach, and partnerships** as tools to identify research gaps, to increase collaboration, and to improve both financial and in-kind resources.

The information and recommendations provided by the SMEs will help the HSRP develop better applied solutions for water utilities and emergency response personnel. Long term research and development approaches and collaborations were also suggested to ensure the sustainability of the WSTB and its relevance for improving the overall readiness and resilience of water system infrastructure. USEPA HSRP is grateful and appreciate the time the SMEs took to provide their individual ideas and suggestions for expansion of this capability.

1.0 Introduction

Homeland Security Presidential Directive 9 (HSPD-9, 1/30/2004), and Presidential Policy Directive 21 (PPD-21, 2/12/2013) tasked USEPA with responsibilities for water infrastructure protection. In this role as lead federal agency, USEPA assists water utilities to prepare for and respond to man-made and natural disasters, including homeland security incidents. USEPA's Homeland Security Research program (HSRP) conducts research to help utilities rapidly detect and respond to such incidents, and provides the science to help in infrastructure decontamination and rapid return to service.

Advancing the science and engineering of decontaminating pipe systems and of safely disposing of high-volumes of contaminated water are high priorities for the USEPA. The Agency's National Homeland Security Research Center (NHSRC) developed the first-of-its-scale full-scale water security test bed (WSTB). The test bed was constructed in collaboration with the Department of Energy's Idaho National Laboratory (INL), in Idaho Falls, Idaho. The system replicates a section of a typical municipal drinking water piping system with roughly 450 feet of pipe and two fire hydrants laid out in an "L" shape. The eight-inch cement mortar lined ductile iron pipes used for the construction of the WSTB section were excavated after twenty years of use for water conveyance (Figure 1). These pipes allow for technology testing in an environment that simulates a typical, real-world operating water distribution system. The WSTB was built above ground for easy access during experiments, for leak detection, and for spill containment to protect the groundwater.

The purpose of the WSTB facility is to evaluate infrastructure decontamination technologies previously tested by the USEPA's HSRP at the bench- and pilot-scale. Using the WSTB simulated full-scale distribution system allows researchers to inject contaminants that cannot be tested in operating municipal water facilities due to the risk to public health and the costs of having water facilities out-of-service. With WSTB data in hand, HSRP researchers can then evaluate decontamination methodologies to determine those that are best suited for use by water utilities. Treatment of contaminated water is a critical factor for drinking water distribution systems attempting to return to operation following a contamination incident, but also for interdependent sectors, such as health (e.g., hospitals and drug production), fire fighting and industrial use facing contamination challenges. Utilizing the constructed 28,000-gallon (106,000 liters) lagoon, the WSTB facility also has the capability to test portable water treatment technologies for the effective management of the contaminated water that is discharged from the pipes. Lastly, decontamination of premise plumbing and household appliances can be evaluated in an adjacent building at the site, connected to the main pipe.

The Department of Homeland Security established the Critical Infrastructure Partnership Advisory Council (CIPAC) to facilitate interactions between the water sector owners and operators and the government entities working to address water sector issues. The CIPAC guides the identification of data gaps and informational needs for the water sector, and enhances collaborations and leveraging of resources among the partners. One of the key priorities in the 2017 CIPAC Roadmap to a Secure and Resilient Water Sector, is to **Improve Detection, Response and Recovery to Contamination Incidents**. The CIPAC Roadmap highlighted the need to: "Conduct research and develop pilot and field-scale testbeds to inform and facilitate decontamination procedures, emergency response, and cross-sector collaboration."

In order to better address the needs of water systems' response to contamination incidents and too ensure that research conducted at the WSTB meets the needs of the CIPAC and key stakeholders, NHSRC convened a panel of subject matter experts (SMEs) on August 3, 2017 at the WSTB. Five SMEs representing drinking water, wastewater, and storm water trade associations; a large community water and wastewater utility; state drinking water administrators, and Idaho National Laboratory were charged with responding to five questions regarding the WSTB's background, research accomplishments, and future WSTB plans.

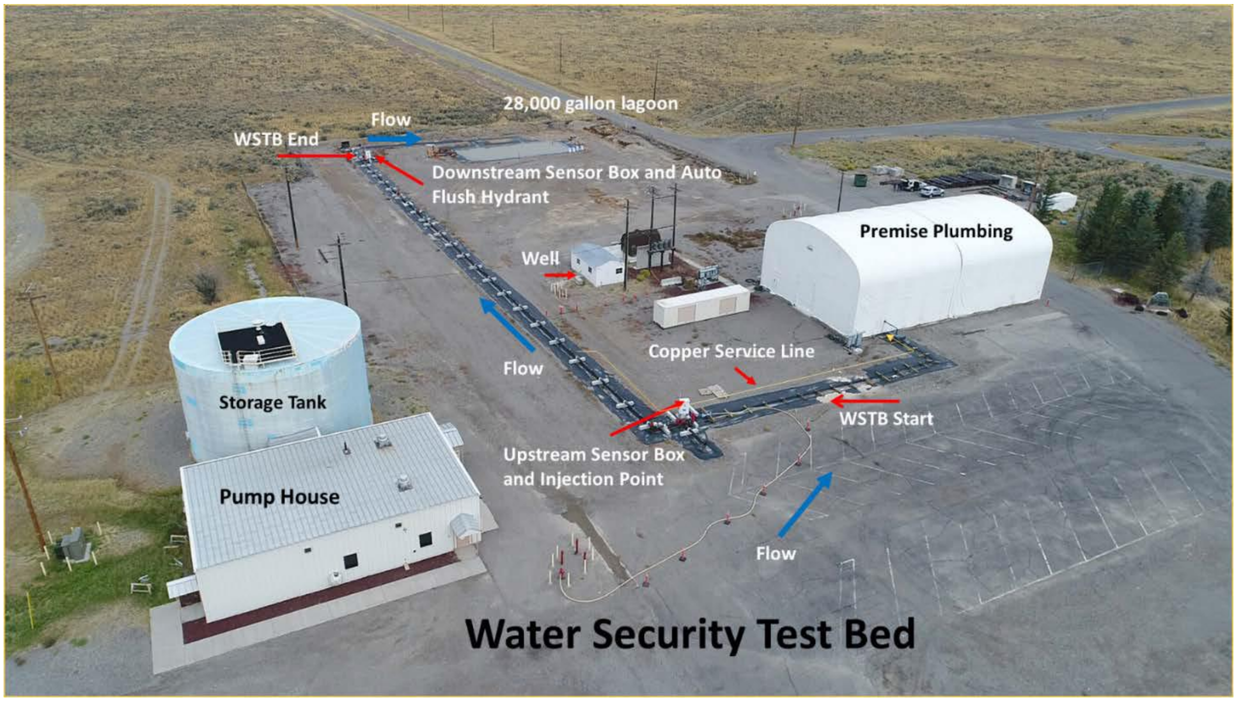

Figure 1. Water Security Test Bed (WSTB) and capability within the Idaho National Laboratory site.

2.0 SME Panel Charge

The NHSRC invited a group of SMEs to provide independent viewpoints of the overall concept, approach, implementation, and sustainability of the full-scale WSTB facility. The SMEs' input was sought to enhance and communicate the WSTB capabilities and resources to expand its use as a national capability that supports the nation's water sector. The advice of the SMEs was provided independently and no consensus was expected. At no point in the meeting were they asked for a consolidated, consensus recommendation. Appendix A identifies the SMEs and their affiliations. In addition to USEPA Office of Research and Development (ORD) staff, representatives were present from:

- the Department of Homeland Security
- the Department of Energy's Idaho National Laboratory.

The SMEs received Charge Questions (Appendix B), a WSTB technical brief (USEPA 2017) and a video of the WSTB describing the facility in preparation for the face to face meeting.

The objective was to elicit their individual opinions on:

- The relevance of past research
- Additional gaps in scientific knowledge that need to be addressed
- Research that could be conducted under the current, and future expanded configurations
- Collaborations and partnerships that would be useful in order to expand the availability of the WSTB
- Communication and technology transfer activities that should be undertaken

Appendix C is the outline of the agenda for the WSTB face-to-face meeting. The SME panel first toured the WSTB site, which included the 450 feet (137 meters) of pipe, the lagoon, the set-up in the building of the premise plumbing and the appliances. In addition, a demonstration of the automatic hydrant flushing was presented. An overview of the HSRP was followed by a more detailed discussion of the Water Security and Resilience Research. The history, design, and summary of research conducted at the WSTB to date was then presented prior to an open discussion of the day's activities and research results.

3.0 Discussions and Specific Recommendations

The SMEs provided individual comments throughout the presentations and in response to the Charge Questions. Their comments often generated discussions between not only the SMEs but from other attendees. This summary is HSRP's interpretation and compilation of all the comments provided throughout the meeting along with one set of written comments provided after the meeting. The SMEs were also given the opportunity to review this report and provide edits and comments.

Overall, the SMEs found the WSTB to be a unique, productive, creative, and cost-effective facility and made recommendations to help the HSRP develop better applied solutions for water utilities and emergency response personnel. Long term research and development approaches and collaborations were also suggested to ensure the sustainability of the WSTB and its relevance for improving the overall readiness and resilience of water system infrastructure.

Three core WSTB research competencies were identified for the WSTB:

- Distribution system pipe decontamination (see Section 3.1)
- Premise plumbing and appliances decontamination (see Section 3.2)
- Mobile Emergency Water Treatment Systems (see Section 3.3)

Future additional research competencies identified were:

- Operational technology cyber-security (see Section 3.4)
- Wastewater decontamination and reuse impacts (see Section 3.5)
- Training, communication, and outreach (see Section 3.6)

The following sections discuss the SME independent suggestions, organized by topic areas:

3.1 Distribution System Pipe Research

- **Enhance water network complexity (e.g., two city blocks)**

  A number of the SMEs stated multiple times the importance of increasing the complexity of the WSTB. Building the test bed to at least a couple city blocks would expand the realism with regards to multiple pipe types (especially PVC) and size, network dead ends/loops, storage tanks, and real-world tank operation and hydraulic demands. Also mentioned was the need for better management/knowledge of the integration of finished water storage tanks in terms of:

  - Operating the distribution system when the tank is being cleaned
  - Impacts on the distribution system when contaminated
  - Maintaining fire flow when contaminated
  - Pipe decontamination impacts on the tank water quality.

  A complex loop design was suggested. This would provide a more thorough evaluation of decontamination efficacy and practicality as well as provide an opportunity to coordinate real-time modeling, water quality sensor research, and emergency responder training (to be discussed later). A larger and more complex network would create more real-world representativeness for:

    - Highly variable spatial and temporal water demands
    - Linking the modeling of future water demands with distribution system operation/decontamination
    - Evaluating changes to infrastructure design/equipment.

- **Re-lining pipes following decontamination from microbial, chemical, and metals contamination**

  Past research at the WSTB (USEPA 2016a) has shown that flushing with water plus disinfection with high levels of chlorine dioxide were not sufficient to remove *Bacillus globigii* spores, surrogates for *Bacillus anthracis* spores (the causative agent for anthrax), from the pipe wall. Therefore, physical scouring with (1) an ice slurry or, (2) a chain cutter was investigated with some improvement in spore removal – the physical scouring was more effective than just flushing/disinfection. However, *B. globigii* spores were still found on the pipe wall and additional decontamination or pipe replacement may be necessary to return the system to service. The SMEs recommended evaluating pipe re-lining techniques in order to have a complete picture of options to use should a distribution system pipe be contaminated with anthrax spores. Evaluation of pipe relining technologies would include assessing the capital cost, deployment/acquisition of contractors, and performance of the technologies. Most utilities in the United States have many miles of unlined cast iron pipe and information on pipe lining would be useful for not only emergency response but also general rehabilitation of ageing infrastructure. This capability would:

    - Validate methods for *in-situ* surface characterization and remediation of pipes, valves, pumps
    - Determine the affinity between chemical substances and common water system infrastructure construction materials and even premise plumbing and fixtures (discussed later).

  Successful cleanup techniques would prevent pipe replacement, which would be an extremely costly and disruptive solution.

- **Variable finished water quality impacts on decontamination efficacy**

  WSTB decontamination experiments, to date, have all been conducted with the INL high quality groundwater with minimal chlorine demand and a low/stable total organic carbon (TOC). A number of the SMEs recommended using a higher loading TOC and turbidity finished water that would resemble finished drinking water resulting from surface waters. Surface waters subjected to high percentages of wastewater effluent and stormwater might have differing finished water characteristics resulting in varied distribution system decontamination success. Testing with surface waters would provide a better understanding of decontamination efficacy for water systems treating surface water with very different TOC, turbidity, organic matter characteristics, and chlorine demand. Decontamination success is expected to vary by source water or the daily disinfection process utilized by a community. Understanding efficacy under variable raw and finished water conditions would be critical to informing emergency response actions across the U.S. This would provide additional technical information to those utilities across the U.S. who use alternate disinfectants or are contemplating switching to an alternative disinfectant from free chlorine. According to one of the SMEs, chlorine dioxide decontamination, as performed at the WSTB to date, should be compared against alternating additional/different disinfectants. This would also be beneficial to those utilities that are experiencing changes in their existing surface water quality (e.g., increasing cyanotoxin events) and those that are adding or switching to new source water supplies, such as Flint, Michigan.

- **Decontamination of other chemicals and petroleum products**

  Past chemical decontamination research at the WSTB (USEPA 2016b) has utilized well-mixed river water solutions of Bakken Crude Oil (soluble fraction) or aqueous firefighting foam. Flushing with water only was shown to be effective. The addition of a surfactant turned out to be unnecessary and even complicated the quick return to service of the main pipe. Some SMEs thought it likely that many surface water and small system intakes are shallow enough that an oil slick or other chemical contaminants could be pulled into the water treatment plant in very high concentrations as compared to our injection of well mixed solutions. It was also suggested that other classes of chemicals that have differing characteristics from the Bakken Crude Oil should be tested. These chemicals could be selected from those most typically being transported across the United States via pipelines, rail, tanker trucks, and barges.

- **Radiological decontamination**

  The SMEs recommended that a wider array of water quality contaminants should be considered. Suggestions included radiological medical wastes (Cesium-137) from cancer treatment and other radiological contaminants of concern.

- **Four season utilization**

  A suggestion was made to enclose the WSTB to facilitate a longer testing season and increase research frequency and availability to other researchers in the water field. Currently, the WSTB is available from May through October. During the previous experiments, daily heating of the water in the pipeline from direct sunlight has been a cause of concern in terms of experimental design, water quality treatment effectiveness, equipment operation/effectiveness, data interpretation, and scheduling. Building out the site could include a roof over the site to reduce water temperature variations, which can impact the experimental results, by reducing the warming effect of direct sunlight. Full enclosure of the site, similar to a warehouse would extend the time available for experiments and provide more control over external environmental factors. Decontamination efficacy should also be conducted during cold air/water temperatures, which could impact chemical effectiveness, equipment reliability, and operator capabilities. An enclosure would also enable the WSTB be used in the event of an actual emergency any time of the year to test decontamination methods in real-time.

3.2 Premise Plumbing and Appliances

- **Detergent's role in household appliance decontamination and impact of brand/type**

  WSTB research has indicated that both microbial and chemical decontamination of household plumbing and appliances were fairly successful following flushing with an amended bleach solution (Szabo et al. 2017). However, the appliances did exhibit very low levels of contaminant release (leaching) in days following flushing. To improve decontamination, an SME encouraged operating the appliances with their recommended soaps and detergents.

There are multiple appliances and manufacturers for each of the household appliances tested at the WSTB. An SME recommended that appliances be tested for decontamination efficacy across brands, type (e.g., top loading vs. side loading, tankless flash water heaters), and purchase cost.

- **Work with manufacturers to make appliances easier to decontaminate**

One of the SMEs suggested that USEPA should work with the manufacturers to evaluate the feasibility of changing the design and fabrication of appliances to make decontamination easier and more successful in the future. The degree of difficulty, tools, skill required, and ease of decontamination for the average homeowner for new designs need to be evaluated to facilitate future do-it-yourself type of clean-up.

- **Low flow fixture decontamination impacts**

A further extension of the premise plumbing and household appliance research is to evaluate the impact that new low flow appliances may have on decontamination effectiveness. Lower flow rates with more restricted flow paths could decrease the effectiveness of decontamination protocols. There is also concern that the growing use and requirements of low flow appliances will contribute to increases in microbial build-up and biofilm contamination during routine use, which could harbor threat agents if contaminated. Not only could this require more extensive decontamination approaches, such as extended flushing and chemical usage, but could also be an increasing public health risk due to the growth of pathogens, such as *Legionella*. Thus, the increasing use of low flow appliances suggests the need for routine decontamination approaches for use by the homeowner as part of instruction manuals and for use on a regular basis, even in the absence of a known contamination incident.

- **Lead service line replacement impacts**

DC Water and Sewer Authority has provided approximately 60 feet of lead service line that had been removed from their system. Adding the lead service line in parallel with the copper service line would help to evaluate the impact of lead service line full and partial replacement on water quality in the premise plumbing was suggested.

- **Sampling and the fate and transport of contaminants**

Past experiments have shown that even after two days of flushing with an amended bleach solution and clean tap water, contamination can still be detected leaving the appliances, at differing rates (Szabo et al. 2017). The research also showed that sampling and analyses need to be conducted for not only the main contaminant in question, but also for components such as additional diesel, oil, gas, and perfluorinated alkyl substances to fully ensure public safety. In addition to the decontamination methodology recommendations previously mentioned, this persistent contamination suggests the need for additional and perhaps modified sampling procedures and protocols. Information is needed on what other parameters, analytical techniques, sampling and holding time procedures should be developed as part of the decontamination methodology.

- **Aerosolizing and premise plumbing exposures**

  In addition to *Bacillus anthracis*, airborne exposures from home appliances to *Legionella* and to chromium VI were mentioned as concerns. The addition of a toilet, sink, and shower in the facility would add to the uniqueness of the premise plumbing set-up and facilitate airborne and dermal exposure studies. Additional studies of surface chemistry/affinity between chemical substances and piping/plumbing materials can be conducted to replicate and validate the bench scale research currently being conducted within the HSRP. This issue becomes more important as many local governments require such appliances in new buildings and retrofits resulting in lower future water demands in distribution systems. This raises the question as to whether the WSTB decontamination science would still be applicable to the next generation distribution system with new infrastructure construction materials. A related suggestion was to operate large industrial/commercial cooling towers and self-contained looped water systems (e.g., hospital operating rooms) to look at *Legionella* decontamination options.

3.3 Mobile Emergency Water Treatment Technology Systems

- **Continued evaluation of mobile emergency water treatment systems**

  The evaluation of mobile emergency water treatment unit processes was an important capability of the WSTB, especially in response to natural disasters such as floods and hurricanes. The SMEs recommended additional testing and evaluation of new mobile innovative unit processes, especially for newer ones that may be developed. In particular, additional treatment evaluations for perfluorinated compound contamination was suggested, such as fluidizing the commercial granular activated carbon /sand mixture beds. An interesting link to our modeling research was suggested by the SMEs regarding the placement and number of emergency water treatment systems needed within a distribution system (1) to possibly treat millions of gallons of waste/wash water, or (2) to provide safe drinking water, or (3) to isolate, mitigate, and decontaminate portions of the distribution system.

  Coupling the HSRP distribution system plume modeling to isolate contamination with the use of mobile emergency water treatment units, tactical strategies could be developed to inform decisions on where to place the treatment units, when to move and re-locate the units, and how many units would be necessary. An SME asked, “whether a water system would need 5 or 50 units, and if they would have to be located on multiple city blocks.” To determine the number and location of mobile units, distribution system plume modeling would need to be merged with mobile unit characteristics and capabilities.

3.4 Impact of Cyber-Security on Operational Technology

- **Water hammer and other cyber-related incidents**

  During the discussion, an SME stated that the WSTB needs a legitimate supervisory control and data acquisition (SCADA) system that operators can use. Most SCADA systems are designed for thousands of control/monitoring points and since there are only a few sensors, valves, pumps, and hydrants in the current WSTB configuration, commercial control system products are not feasible. Adding complexity to the WSTB would help, as discussed above, but to fully investigate real-time operator control and cyber impacts on distribution system operational failures, linkage to a full SCADA system is necessary. This could be possible if done in collaboration with a water utility. Any research that would include cyber-attacks on the physical network and appurtenances (e.g., water hammer [a sudden pressure wave in a water pipe], pump destruction, etc.) that results in the loss of operator control and situational awareness would help water systems be better prepared for such incidents. USEPA should partner with other federal entities with cybersecurity expertise to develop and carry out cyber-attack scenarios.

- **Real-time smart sensors and modeling**

  Related to the above discussion is the addition of real-time smart water quality and flow sensors to the WSTB and evaluation of the performance of those sensors. Carried to its full extent, multiple smart sensors could result in the development and evaluation of 'smart grid' sensor hardware and distribution system operation software (linked to the power grid), including links to 'smart appliances' and consumer devices. An SME stated that a water-electric 'smart grid' using digital information and controls technology would improve the reliability, security, and efficiency of the water supply and distribution network. A 'smart grid' would be another link to the HSRP real-time modeling research on resilience and emergency response tools as well as integration of the water network with the electric grid fostering research on the interdependencies of these two important lifeline sectors. The coupling of smart appliances to optimize energy usage with feedback from water quality sensors would improve water use efficiency to help systems adjust to variable water demands within their distribution system. Development and incorporation of knowledge on real-time consumer water demands, water supply availability, and alternate energy supplies and cost would address energy/water efficiencies, improve water quality, and enable peak-shaving technologies.

  The SMEs were somewhat divided on the potential of widespread use of sensors since sensors have been available in the past decade, but have not proliferated, especially with the O&M challenges. The characterization of sensing technologies for both chemical and biological contaminants, at the full-scale, was recommended by several SMEs. Perhaps the WSTB could serve as a catalyst in this area working with manufacturers providing rigorous tests against a wide range of performance characteristics, requirements, or specifications. The internet of things has opened the door for inexpensive, easy to operate sensors that may gain traction in the coming years. Some SMEs stated that currently, only turbidity is used in compliance monitoring. The WSTB could be utilized to help provide confidence for consumers, water system managers, and regulators that additional real-time sensors may one day inform daily monitoring and may support regulatory compliance. It was stated that virtual sensors need to be linked with real-time models with the corresponding research to prove their reliability.

3.5 Wastewater Decontamination and Reuse Impacts

- **Wastewater/stormwater/reuse scenarios**

  Perhaps the most expansive recommendation from one of the SMEs was the inclusion of wastewater, stormwater, and green infrastructure. It was suggested to integrate storm water/wastewater into the urban water cycle that could include an intermittent pipe/collection system. Along with the previous recommendation to consider radiological medical wastes, research studies on additional contaminants such as nanoparticles, harmful algal blooms, pharmaceutical, and personal care products were suggested. Although these may be considered more as wastewater or source water pollutants rather than weaponized contaminants or contaminants resulting from a distribution system incident, they could represent other classes of contaminants and could serve as surrogates for warfare agents in decontamination research. Pathogenic hospital wastes could rise to the level of requiring an emergency response during outbreaks impacting wastewater treatment works and collection system workers, such as in the Ebola crisis. Decontamination of a broader selection of contaminants would not only serve to inform emergency response actions but also provide all-hazards support to water system managers dealing with infrastructure water quality issues stemming from long-term chronic seeding of the distribution system via poorer quality source water leading to biofilm, disinfection by-products, and other public health exposures. Co-generation of energy was also suggested as an important aspect to include.

- **Impacts of wastewater reuse integration into drinking water distribution systems**

  It would be useful to understand how the quality and quantity of reuse/recycled water and stormwater that is being integrated into many water systems nationwide could impact decontamination protocols and strategies. Drinking water provided via direct, or nearly direct, wastewater reuse and aquifer storage-and-recovery is likely to exhibit different water chemistry characteristics from the finished drinking water in the distribution system. As stated previously, the differing TOC, biochemical oxygen demand (BOD) levels, and other chemical characteristics could either improve or degrade decontamination efforts of the municipality or homeowner. As homeowners and communities turn towards greater collection of stormwater and gray water reuse, this source of water may become a contamination liability requiring additional infrastructure decontamination or in the case of stormwater, a source of additional water for decontamination approaches if not contaminated by plume deposition. Water system and homeowner gray water and reuse water could also allow contaminant breakthrough and recirculation during normal operations, absent a widespread contamination incident. Additional decontamination protocols could be necessary for localities with significant water recycling. Conversely, wastewater reuse treatment facilities that if coupled with the real-time emergency response distribution system models, could also provide additional decontamination capacity.

3.6 *Training, Communication, and Outreach*

A great deal of discussion centered around training, communication, outreach, and partnerships as tools to identify research gaps, increase collaboration, and improve both financial and in-kind resources.

- **Communication**

  There was the general conclusion to publicize the WSTB research at more and different conferences. This would increase awareness of the WSTB and potentially generate collaborative opportunities. State and national meetings such as those listed below were mentioned:

  - Cal-Nevada and Texas American Water Works Association (AWWA) sections
  - Water Information Sharing & Analysis Center (WaterISAC)
  - The National Rural Water Association
  - American Water Resources Association
  - The Water & Wastewater Equipment Manufacturers Association
  - National Association of Clean Water Agencies
  - Association of State Drinking Water Administrators.

  These were suggested in addition to the traditional AWWA Annual Conference and Exposition, Water Quality Technology Conference, and Water Environment Federation Technology Exhibition and Conference. Also suggested was the development of 1-pagers describing “If this, then….” contamination/decontamination scenarios. Outlets for these could be the NHSRC website or the websites of some of those organizations listed above. The AWWA Opflow periodical, which focuses on water industry operations issues, was also suggested as an appropriate outlet to communicate the WSTB findings.

- **Tailored collaborations and partnerships**

  The Water Research Foundation (WRF) and Water Environment and Reuse Foundation (WE&RF), currently conjoined as one organization in 2018 (the Water Research Foundation) develop Request for Proposals (RFPs) to answer specific questions as well as provide an opportunity for tailored collaborations. The WSTB was suggested as an appropriate facility to develop tailored collaboration RFPs and test innovative approaches/challenges. Other organizations that might have a common interest in the WSTB include:

  - Oil and gas associations
  - National Governors’ Association
  - State drinking water and/or emergency response agencies

- Department of Homeland Security
- Centers for Disease Control and Prevention (CDC)
- Federal Emergency Management Agency (FEMA)
- Department of Defense
- Department of Energy
- Water Utilities
- Manufacturers

- **Training for Utility Operators, On-Scene Coordinators and first responders**

The SMEs suggested that the WSTB could be used for training not only emergency responders but also utility operators. Exercises and the evaluation of existing protocols developed by the USEPA such as the USEPA J-100 standard compliant risk assessment software tool (for water, wastewater, and combined utilities), and the USEPA Vulnerability Self-Assessment Tool (VSAT) software tool (for drinking water or wastewater utilities), and simulations of other emergency response plans were suggested. The SMEs stressed the need for "staying ready" and for first responders to be able to "operationalize their training." Another idea suggested the development of decontamination software with methods, tools, videos, data, and modeling. A utility's Emergency Operation Center (EOC) was offered to integrate USEPA software and decontamination training and to also conduct a demonstration. Training should also include disruption of both power and water supplies as well as the use of the mobile emergency water treatment systems.

4.0 Overarching Comments

Although consensus was not solicited, some agreement emerged among the SMEs. Upon review of the individual recommendations, some commonalities were noted. They agreed the WSTB has been a good value for the research dollars and that there had been substantial, significant research accomplished given the level of funding. It was considered unique and should have a larger role supporting water system infrastructure research, drinking water safety, and homeland security. Comments such as those below were received:

- "terrific work"
- "a lot of current value"
- "a good place to encourage teaming and collaboration"
- "independent, honest broker assessment"

They also agreed that the WSTB should be publicized more, receive more feedback from end users, and that partnerships with utilities investigating their problems specific to their locale should be emphasized. Their advice centered on staying focused on the strengths of the WSTB, which are the distribution system, premise plumbing, and mobile emergency water treatment deployment. A long-term goal should be the development of the facility to incorporate and plan for the water system of the future that will be increasingly dependent on wastewater reuse, stormwater recycling, low flow appliances, and real-time water management.

USEPA HSRP is grateful and appreciate the time the SMEs took to provide their individual ideas and suggestions for expansion of this capability. This report will serve as a guide to inform the ORD HSRP Strategic Research Action Plan that is currently under development for the 2019 to the 2022-time frame. Research at the WSTB continues to address the decontamination efficacy studies needed to support emergency preparedness and response and this report will serve as a blue print for future research and collaborations.

References

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USEPA. 2016a. Water Security Test Bed Experiments at the Idaho National Laboratory. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-15/146. Accessed February 27, 2018 at https://goo.gl/JmU17Q

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Appendix A.

SME Panelists:

Biju George, Chief Operating Officer, Office of the General Manager, District of Columbia Water and Sewer Authority, Washington, DC

Michael Hagood, Director of Regional Initiatives, Idaho National Laboratory, Idaho Falls, ID

Lisa McFadden, Director, Integrated Technical Programs, Water Environment Federation, Alexandria, VA

Robert Renner, Chief Executive Officer, Water Research Foundation, Denver, CO

Alan Roberson, Executive Director, Association of State Drinking Water Administrators, Arlington, VA

Appendix B.

SME Charge Questions:

1. How is USEPA's research at the WSTB, completed and planned, supporting the needs of the water industry?

2. In support of HSRP's mission and priorities, what additional scientific gaps could be best addressed at the WSTB?

3. What other research can be undertaken at the WSTB (in its current configuration) to better serve the water industry and sector? Please include additional research that could be accomplished with enlarging the footprint of the existing WSTB.

4. The WSTB offers capabilities that other organizations might find useful in carrying out their missions. Can you recommend and/or foster partnerships and collaborations with water utility and trade organizations, utilities, private, state, and federal organizations to expand the availability of the site to other users?

5. What additional communication and technology transfer activities (such as focused workshops, conference sessions, technology commercialization/adaptation, and on-site training and demonstrations) should we undertake? Who should we partner with in conducting these activities?

Appendix C.

<u>SME Panel Visit Agenda:</u>

<u>Wednesday, August 02, 2017</u>

Willow Creek Building (WCB), 1955 Fremont Avenue, Security (optional)

15:00 SME's to get visitor badges (REAL-ID compliant photo ID required)
Michael Carpenter

Tour INL Town Facilities (optional)

15:30 Early arriving visitors who wish to see other INL capabilities
Michael Carpenter

<u>Thursday, August 03, 2017</u>

Marriott Residence Inn & Hilton Garden Inn

08:00 Hotel departure to tour WSTB, INL desert facility
Michael Carpenter, Hiba Ernst

Central Facilities Area, Gate 1

09:00 Pick up visitor badges (REAL-ID compliant photo ID required)
Michael Carpenter

Water Security Test Bed

09:15 Tour Water Security Test Bed — Jim Goodrich, Steve Reese

10:30 Depart WSTB, proceed to Energy Innovation Laboratory (EIL)
Michael Carpenter

Energy Innovation Laboratory (EIL), 775 University Blvd. Room A102

11:45 Arrive at EIL Conference room A102 — Michael Carpenter

11:45 Break

12:00 Working Lunch. — All

12:30 Homeland Security Research Program Overview — Greg Sayles

12:45	Water Security and Resilience Research.	Hiba Ernst
13:00	Break	
13:15	Water Security Test Bed Research.	John Hall, Jeff Szabo, Jim Goodrich
14:15	SME Comments/Discussion	SME Panel
16:00	Wrap-up and Next Steps	Kelly Smith
16:15	Adjourn	

<u>Friday, August 04, 2017</u>

06:00 Transport Visitors to Airport Michael Carpenter

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