

# Report on the 2016 U.S. Environmental Protection Agency (EPA) International Decontamination Research and Development Conference



2016 EPA International Decontamination  
Research and Development Conference



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REPORT ON THE  
2016 U.S. Environmental Protection Agency (EPA)  
International Decontamination Research and Development Conference

NATIONAL HOMELAND SECURITY RESEARCH CENTER  
OFFICE OF RESEARCH AND DEVELOPMENT  
U.S. ENVIRONMENTAL PROTECTION AGENCY  
RESEARCH TRIANGLE PARK, NC 27711

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## Disclaimer

The United States Environmental Protection Agency, through its Office of Research and Development's National Homeland Security Research Center, funded and managed this effort through EP-C-14-001 with ICF. This report has been subjected to the Agency's review and has been approved for publication. Note that approval does not signify that the contents necessarily reflect the views of the Agency. Mention of trade names, products, or services does not convey official EPA approval, endorsement, or recommendation. Q&A notes are derived from notes that were taken during the conference with a review by the presenters after the conference. Q&A notes may not accurately reflect the actual discussion. Readers should contact the presenter for clarification of the discussion.

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# 1. Acknowledgements

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The 2016 International Decontamination Research and Development Conference would not have been possible without the efforts from the conference organizing committee members Lukas Oudejans, Timothy Boe, Brendan Doyle, Matthew Magnuson, Tanya Medley, Sanjiv Shah, and Jeff Szabo. Their contributions to the planning of this conference are greatly appreciated.

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## Executive Summary

The 2016 U.S. EPA International Decontamination Research and Development Conference assembled scientists to facilitate presentation, discussion, and further collaboration on research and development focused on chemical, biological, and radiological (CBR) contamination incidents, including those stemming from terrorism or natural disasters. For three days at the U.S. Environmental Protection Agency's (EPA's) campus in Research Triangle Park, North Carolina, more than 240 national and international participants representing federal, state, and local government agencies, academia, industry, and public advocacy groups attended presentations and actively engaged in discussions and a poster session to explore current issues and future directions. This diverse audience included experts in emergency response; development of decision-support tools; risk communication; sampling, detection, treatment, and decontamination methods; and waste management related to CBR agents.

This Executive Summary outlines the events and presentations of the Conference and references more detailed information in the Conference Report. The information is organized by topic: two General Sessions, twelve Concurrent Sessions (by topic area), and the Poster Session.

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## General Session 1: Program Overviews, Responses, and Field Studies

The first section of General Session 1 consisted of five talks welcoming attendees and outlining the history of the EPA National Homeland Security Research Center (NHSRC) and the United Kingdom Government Decontamination Service's Science and Technology Program. Dr. Lukas Oudejans, Chair of EPA's NHSRC Conference Organizing Committee, welcomed participants and provided opening remarks. Dr. Shawn Ryan, Division Director of the NHSRC Decontamination and Consequence Management Division (DCMD), welcomed federal partners and international collaborators. He stated that the Conference goal was to assemble participants to foster collaboration and encourage networking. Dr. Ryan applauded the role of the Conference in supporting and sharing advances among scientists and responders to help with modern decontamination challenges. Mr. Johnathan Hermann, EPA (retired), provided a brief historical perspective of progress in the decontamination field in the past ten years. Dr. Gregory Sayles, Acting Director of NHSRC, provided further details on the goals of the Conference, highlighting the importance of bringing together the scientific, regulatory, and response communities to convey the state of the science and continue to foster advances through collaboration. Dr. Sayles emphasized the relevance of this effort in light of recent incidents that have challenged decontamination researchers and practitioners. The last speaker in this section, Dr. Dudley Hewlett, reviewed the research undertaken by the United Kingdom (UK) Government Decontamination Service (GDS) across all major threat areas. [Section 3 of this report provides additional details on these presentations.](#)

The second section of General Session 1 summarized responses and field studies in three presentations. The first presentation outlined the current status of Fukushima efforts by the Japanese Ministry of the Environment in off-site cleanup, progress on a centralized interim storage facility established for safely managing and storing soil containing radioactive materials generated from decontamination work in Fukushima Prefecture, and volume reduction and recycling of contaminated soil generated by decontamination. The second presentation highlighted some of EPA's research, support, and coordination efforts and how those efforts have been applied to recent incidents involving CBR contamination. The third presentation, on the Jack Rabbit II program, covered participating partners and stakeholders, experimental design, test execution, and results and analysis. High-definition, high-speed, and infrared video footage of the chlorine releases, captured from multiple vantage points during each experiment, was shown.



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### GDS Organization & Remit

- Provide advice, guidance and support to those responsible for dealing with the consequences of an accidental or deliberate release of CBRN and hazardous materials;
- Enable quick access to a **Framework of specialist suppliers able to offer expert decontamination and related services in response to a CBRN or major HazMat incident;**
- Advise the Government on the national capability for the decontamination of buildings, infrastructure, transport assets and the open environment.


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### An Overview of the UK Government Decontamination Service's Science and Technology Program; Slide 3

Dudley Hewlett | *Department for Environment, Food and Rural Affairs, United Kingdom*

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Following the second section of General Session 1, Dr. Stan Meiburg, EPA’s former Acting Deputy Administrator, spoke about the perspectives of EPA’s leadership on homeland security research and the importance of basing EPA’s response to disasters on the best science and lessons learned. He encouraged attendees to focus not just on scenario-based responses, but also capability-based responses and to communicate across boundaries and foster real relationships to respond appropriately. [Section 4 of this report provides additional details on these presentations.](#)



### Rolling Stock Decon Test

July 2015

Sun	Mon	Tues	Wed	Thu	Fri	Sat
			1	2	3	4
			Railcar Prep for Transit	Railcar Arrival to SNL	Railcar stored, secured	Interim Decon
8	9	10	11	12	13	14
Medic Team Travel	Mobilize at test site	Site Prep, Equip Setup	Fumigation prep	Fumigation	Fumigation	Fumigation
15	16	17	18	19	20	21
Fumigation	Aeration	Site Cleanup, Test Carbon	Railcar Transport Prep	Demobilize Return Railcar	Travel	Temporary scrubber storage and return (-4.6 weeks)

**Fumigation target criteria:**

- 36 hours at:
- 212 mg/L MeBr
- 75 °F
- 75% RH

**Timeline:**

- setup
- enclosure
- preconditioning
- samples placement
- fumigation
- sample retrievals
- capture/aeration
- takedown
- charcoal testing

**Fumigation of a Subway Railcar Using Methyl Bromide to Inactivate *Bacillus anthracis* Sterne; Slide 10**

Jasper (Joe) Hardesty | Sandia National Laboratories

Underground Transport Restoration (UTR) Project, and the fourth described the fumigation of a subway railcar using methyl bromide to inactivate *Bacillus anthracis* Sterne as part of the UTR Project. [Section 5 of this report provides additional details on these presentations.](#)

## General Session 2: Chemical, Biological, and Radiological Research Efforts

The first presentation in General Session 2 explained EPA’s compendium of methods for use in analyzing environmental samples for chemical, pathogen, radiochemical, and biotoxin contaminants. The presentation provided guidance for selecting sampling and analysis protocols for characterizing and clearing subway facilities following a biological attack involving anthrax. The second and third presentations provided perspectives on next-generation decontamination technologies as supported by the U.S. Army Research Office and the Hazard Mitigation Science and Technology Program in the Department of Defense (DoD) Chemical and Biological Defense Program. [Section 8 of this report provides additional details on these presentations.](#)

### Concurrent Sessions

Sessions were conducted concurrently throughout the duration of the Conference to allow broader coverage of topic areas. The concurrent sessions focused on various aspects of CBR contaminants and decontamination techniques. Two sessions covered restoration of underground transport (subways) and water infrastructure protection and decontamination. Biological agents were a recurring theme for many sessions, including detection, environmental resilience and sampling methods, and research and decontamination. Other sessions addressed topics related to chemical and radiological agent research, livestock remediation, and waste management.

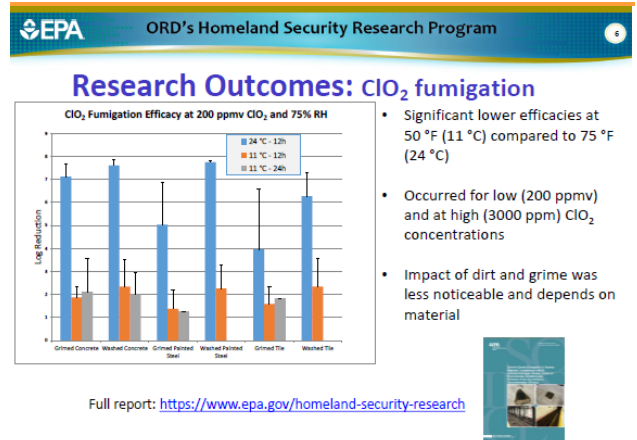
## Underground Transport Restoration

The first concurrent session included five presentations on sampling protocols, use of virtual reality devices, neutralization of airborne biological agents, decontamination options, and Rapid Return to Service (RRS) guidance related to underground transport restoration. The first of these presentations focused on the development of guidance for selecting sampling and analysis protocols to characterize and clear subway facilities following a biological agent release. Knowledge and technical gaps for sampling and analyzing subway environments were discussed. A second presentation expounded on new technology in the form of affordable augmented reality and virtual reality devices to revolutionize the approach for data gathering and situational awareness. Sandia National Laboratories is developing software for a wearable headset that can document sample collection activities and display infrastructure information to the user.

In the third presentation, Sandia National Laboratories demonstrated a potential method for containing and neutralizing biological pathogens, liquid aerosols of chemical materials, and vapors. Sandia demonstrated the method in a 512-cubic-foot test chamber at Sandia and then in a mock subway system during the Operational Technology Demonstration (OTD). The OTD is part of the U.S. Department of Homeland Security (DHS) Science and Technology Directorate's Underground Transport Restoration (UTR) Project. As part of the UTR Project, EPA evaluated multiple methodologies for decontaminating subway and railcar materials contaminated by a biological agent, which comprised the fourth presentation. The presentation addressed many decontamination efficacy studies and their relevance in selecting the decontamination systems for potential use during the full-scale UTR OTD. The development of a web-based software tool for comprehensive remediation and restoration for the RRS of underground transportation systems was demonstrated in the last presentation as part of the discussion on guidance and strategy development. [Section 6 of this report provides additional details on these presentations.](#)

## Water Infrastructure Protection and Decontamination

This session examined, through five presentations, the obstacles and solutions associated with protecting and decontaminating water infrastructure. The first highlighted two tools that EPA's Water Security Division (WSD) is developing: Decontamination Preparedness and Assessment Strategy for Water Utilities (DPAS) and the Water Utility Decontamination Preparedness and Assessment Tabletop Exercise Toolkit (Decontamination TTX Toolkit). The second presentation focused on a full-scale reproduction of an aircraft drinking water system constructed at the EPA Test and Evaluation (T&E) facility in Cincinnati, Ohio. The third presentation delved into results from water treatment experiments with data demonstrating that disinfecting contaminated water in the field is more challenging than disinfecting clean drinking water because of the disinfectant demand present in real-world wash water, the potential for low temperature, and disinfectant dissipation due to sunlight. The fourth presentation described the development of routine and heightened biosecurity protocols, illustrated by the installation of undercarriage and wheel washing equipment at a beef cattle feed yard in the Texas Panhandle. The purpose would be to provide incentive for feed yard operators to install equipment that could be used immediately in a heightened biosecurity incident. The last presentation investigated the effect of *Bacillus globigii* spores on activated sludge activity and, conversely, the effect of activated sludge exposure on the properties of *Bacillus globigii*. [Section 7 of this report provides additional details on these presentations.](#)



### Decontamination Options in a Subway Environment Following a Biological Release; Slide 6

Lukas Oudejans, Joe Wood, and Shannon Serre | U.S. Environmental Protection Agency



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## Biological Agent Detection

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The first of five biological sessions focused on detection, identification, and clearance monitoring of bioterror agents. The first three of the four presentations in this session highlighted the need for rapid and cost-effective methodologies for detecting *Bacillus anthracis* and other unknown bioterror agents or mixtures of threats. The first presentation described the ability of a system based on a “bioluminescent” reporter phage to detect viable *Bacillus anthracis* spores in environmental samples (water, surfaces, soil). The challenges faced when working with complex samples and mitigation strategies used to overcome them were discussed. The second presentation highlighted the importance of a system that is less labor intensive and yields results more rapidly. This rapid and quantitative biological indicator system can lessen the burden associated with decontamination. The third presentation discussed the advantages of using a high-throughput, mass spectrometry-based proteomics approach to detect and identify environmental pathogens in mixtures in near real-time. The approach determines amino acid sequences of peptides derived from the proteolysis of proteins as a basis for reliable bacterial identification.

The final presentation in this session explored third-party performance testing information and overviewed the draft ATSM (American Society for Testing and Materials, now ASTM International) standard for evaluating bio-detection instruments and assays, including different testing modules, use of two performance tiers, and different levels of rigor. Structuring the standard in that way would allow for the assessment of instrument performance over a range of metrics, rather than on the basis of a simple pass/fail. [Section 9 of this report provides additional details on these presentations.](#)

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## Environmental Resilience/Biological Agent Sampling & Methods

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The second biological session was dedicated to environmental resilience and biological sampling methods through four presentations. The first of these stressed the importance of measuring environmental resilience to address environmental systems and services comprehensively. The next two presentations discussed sampling methods that could be required for a wide-area incident and for wastewater and landfill leachate (high concentrations of native flora and diverse chemistry). The second presentation described a study to assess the current state of knowledge regarding sampling methods that could be used for characterization sampling following a wide-area biological incident, specifically focusing on *Bacillus anthracis* contamination. The third presentation provided information on surrogate selection, sample processing, and analytical methods useful for spore studies using nonsterile sample matrices. The fourth presentation summarized the comparative sensitivity (or resistance) of the spores of *Bacillus anthracis*, *Clostridium difficile*, and *Bacillus atrophaeus*. The main objective of that study was to evaluate the validity of using Dugway-prepared *Bacillus atrophaeus* spores as a surrogate for spores of the Ames strain of *B. anthracis* in decontamination testing. [Section 11 of this report provides additional details on these presentations.](#)

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## Biological Agent Research

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The four presentations given in the third biological session focused on research and decontamination strategies for biological agents. The first presentation discussed the removal and transport of *Bacillus* spores from concrete surfaces following rain events. This presentation explained that, despite many interrelated variables, a better understanding of movement of pollutants is critical for the protection of human and environmental welfare. The second presentation

**Triton's BIs and Detector**

- Self-contained BIs and an incubator/detector system
- Quantitative
- *Bacillus thuringiensis* (Bt) AI Hakam
  - A close relative of *B. anthracis*, with the same growth and spore production properties
  - Without pathogenicity: do not have pXO1 or pXO2 plasmids found in *B. anthracis* that encodes for virulence genes and the anti-phagocytic capsule

**Rapid, Quantitative, Biological Indicator System with *Bacillus thuringiensis* AI Hakam Spores; Slide 4**

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### Rapid, Quantitative, Biological Indicator System with *Bacillus thuringiensis* AI Hakam Spores; Slide 4

Yoojeong Kim | Triton Systems, Inc.

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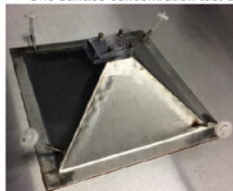
examined the application and efficiency of composite sampling. This study concluded that post-sample compositing is the most efficient composite sampling method, especially when contaminant concentrations are low. The third presentation discussed a developing online tool that would step users through a standardized approach to develop a sampling and analysis plan, including microbial data quality objectives, for field and analytical data collection during a biological contamination event. The tool would expedite sampling plan development and transparently document methods. The final presentation in this session addressed synthetic biology products such as engineered organisms, which offer unprecedented solutions to complex environmental problems but also raise serious concerns because of their unknown fate in the environment. Several methods in development could be implemented to track these technologies, but they might not be sufficient to ensure our security. Current frameworks and metrics used to track synthetic biology technologies and the manner in which synthetic biology challenges our security infrastructure were discussed. [Section 13 of this report provides additional details on these presentations.](#)

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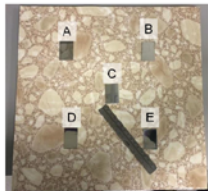
## Biological Agent Decontamination

### Spore Deposition

- **Aerosolized Btk**
  - Spores dispersed in ethanol and Dymel 134a propellant
  - Meter-dose inhaler (MDI) canister to generate aerosol (Calfee et al., 2014)
    - Puff mass measured each time
    - CFU/Puff measured each experimental day
- **Aerosol deposition pyramid on 35.5 cm (14") square test surface**
  - Puff of Btk spores introduced into pyramid and 18 hrs settling time
  - Sterile SS test coupons to estimate typical deposition in CFU/cm<sup>2</sup>
    - One surface concentration test done daily



Aerosol deposition pyramid



Coupons on test surface

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### Domestic Self-Help Clean-up of Biological Material in the Indoor Environment; Slide 8

Howard Walls | RTI International

The four presentations given in the fourth biological session examined the application of multiple decontamination methods of biological agents. The first presentation described results of studying decontamination test methods by evaluating survival of *Bacillus thuringiensis kurstaki cry-HD-1* and *Bacillus thuringiensis* Al Hakam spores after exposure to air inside a C-130 aircraft. The field test demonstrated that the hot, humid air inside the C-130 could be used to decontaminate aircraft successfully. The second presentation highlighted a study to assess the potential hazards caused by wet and dry wiping of common indoor surfaces. The third presentation discussed the use of blue light for decontamination of *Bacillus* spores. Defence Science & Technology Laboratory, United Kingdom, described the antimicrobial effects of blue light on a wide panel of *Bacillus* spores, including *Bacillus anthracis*, *Bacillus cereus*, *Bacillus thuringiensis*, *Bacillus subtilis*, and *Bacillus atrophaeus*. The final presentation demonstrated the successful use of a standardized quantitative procedure as a tool to study and verify the relative

susceptibility of microorganisms of antimicrobial chemicals that might be useful in validating the principles of disinfection hierarchy. [Section 15 of this report provides additional details on these presentations.](#)

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## Biological [Ricin] Agent Research

The final biological session focused on detection, decontamination, and processing efforts for ricin toxin. The first presentation described a concentrated cleaning product designed to remove chemical contamination from highly sensitive vehicles, aircraft, monuments, and other critical infrastructure. Its key feature is the stable emulsion formed when the water-detergent solution is sprayed over a surface; the emulsion keeps the agents in solution so that they do not redeposit on large surfaces. The second presentation discussed development of a sample processing approach for surface samples. Using this approach, no time-resolved fluorescent assay interference was observed with high concentrations of bleach residue, wetting buffer, and materials from sampling devices (sponge-sticks and macrofoam swabs). The third presentation introduced a performance evaluation and validation of the Omni Array Biotechnology, LLC, biosensor test for the rapid detection of ricin. The detailed validation indicated that the ricin biosensor test is a rapid, sensitive and specific, user-friendly laboratory detection method that has great potential application in many national and international public health and environmental test laboratories. The final presentation examined a study focused on the attenuation of ricin toxin on six types of materials representative of a mail sorting facility or indoor building materials. Increasing

temperature generally (but not always) improved the degradation of ricin, while relative humidity (RH) had little effect on attenuation. [Section 17](#) of this report provides additional details on these presentations.

## Chemical Agent Research

The four presentations given during this session focused on various methods for chemical agent research. The first presentation was an overview of the chemical terrorism risk assessment (CTRA) methodology, highlighting potential uses of the results to inform detection and decontamination research and development efforts. CTRA is probabilistic and allows the threat, vulnerability, consequences, mitigation techniques, and their associated uncertainties to be processed together to yield a comprehensive evaluation of risk to the nation for the compounds of concern. The second presentation in this session explained the Chemical Agent Reductions Database (CARD), an electronic database containing synthesis and degradation reaction pathways for over 650 different chemical threat materials. Although originally established for easy access to chemical reaction information, CARD is now being used extensively for assessing attribution such as identifying reactions that have specific byproducts, use certain hardware/reaction vessels, etc.

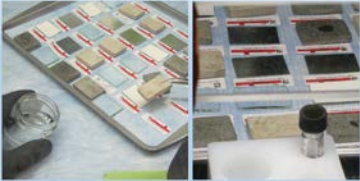
The development of the Chemical Hot Air Decontamination (CHAD) process was introduced in the third presentation. Such a technology would be suitable for sensitive electronic equipment such as aircraft instrumentation, without adversely affecting the surrounding environment. Decontamination of a material can be performed by detoxification (neutralization) of the chemical warfare agent (CWA) or removal of the CWA from the material. The final presentation in this session investigated the natural attenuation of VX following application onto five nonporous and five porous/permeable materials. Natural attenuation increased with increasing temperature, and attenuation was slower with porous materials. Data generated from this testing suggest that, given sufficient time, natural attenuation can significantly reduce VX surface contamination levels. [Section 10](#) of this report provides additional details on these presentations.

## Radiological Agent Research - I

This session examined radiological research and decontamination strategies. The first of the four presentations examined existing modeling of the effects of nuclear detonations, layering in prompt injuries, evacuation, and the exposures that accumulate during evacuation. The study observed the effect of different types of decontamination on the eventual cutaneous radiation injury (CRI) hazard on individuals and the overall effect on the numbers and types of CRIs. The second presentation summarized accomplishments, current projects, and future directions of EPA's NHRSC and included stakeholder input on fate and transport, detection, decontamination, and waste management, which, collectively, can help optimize EPA's response and recovery activities. The third presentation explained the collaboration between Defence Research and Development Canada and its North Atlantic Treaty Organization to study techniques for decontaminating sensitive equipment, which are specific to radiological and nuclear agents. The final presentation described efforts taken to evaluate cost-effective decontamination options for remediating the Advanced Medical Systems (AMS) site, development of a spreadsheet for evaluating mechanical decontamination technologies and the associated resource demand, and the outcomes of the effort. [Section 12](#) of this report provides additional details on these presentations.

**Attenuation Experimental Approach**

- Bench scale studies to evaluate efficacy of natural attenuation as a decontamination option
- Contaminate coupons of materials with VX
- House coupons in an environmentally-controlled test chamber during set attenuation intervals
- VX applied at test conditions, following  $\geq 60$  min. coupon preconditioning
- Single 2  $\mu$ L droplet per coupon



- Attenuation intervals ranged from 30 minutes, up to 35 days (depending on the environmental conditions)
- Following the attenuation intervals, groups of coupons (including control coupons) were removed from the chamber and solvent extracted
- Extracts analyzed via GC/MS to quantify residual VX

**Natural Attenuation of VX following Application onto Nonporous and Porous Materials; Slide 5**  
David See | Battelle

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## Radiological Agent Research - II

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This session examined research pertaining to response and remediation following radiological incidents. The first of four presentations summarized the development of a rapidly deployable, water-based formulation for use in early-phase mitigation after a major radiological or nuclear incident in an urban area. The formulation is designed to enhance the removal of radionuclides from contaminated surfaces and to prevent their redeposition. The second presentation discussed another water-based decontamination system called the Irreversible Wash-Aid, Treatment, and Emergency Reuse System (IWATERS). Argonne National Laboratory's representative discussed early simulation results and the practical implications of studies on the design and operation of IWATERS for strontium removal. The last two presentations centered on current, emerging, and low-tech remediation methods for wide-area radiological and nuclear incidents. The third presentation discussed addressing technology gaps and observations on remediation in Japan, and the fourth highlighted experiments determining the efficacy of indoor cleaning methods in removing radiologically tagged, simulated fallout material. [Section 14](#) of this report provides additional details on these presentations.

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## Livestock Remediation Options

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### Study Scope

Current disposal practices for building materials, animal carcasses, non-patient waste, diapers, etc. can result in infectious viral agents placed into US Landfills. Residual agents in materials from natural outbreaks, terrorist or unintentional events, etc. may persist long enough to potentially expose workers. Viral persistence in landfills can lead to a risk to the environment and the public.

Do viruses pose a threat to environmental and human health once introduced into a landfill?

Can viruses in landfills persist in leachate long enough that they are a risk to the environment and the public?

How does the persistence of viruses in leachate vary between landfills?

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### Viral Biothreat Agent Persistence in U.S. Landfill Leachate; Slide 4

Megan W. Howard | Battelle

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mobile autoclave manufactured by EnviroSafe Treatment Solutions. The specific study objectives were to: (1) measure autoclave temperatures and pressure during the full steam cycle for two soil types and wood chips using five wireless sensor/data loggers while operating at full capacity, (2) determine Scotch broom (*Cytisus scoparius*) seed efficacy for all test material runs, and (3) determine percent moisture content before and after steam treatments for both soils and wood chips. [Section 16](#) of this report provides additional details on these presentations.

The subject for this session was managing carcasses following a disease outbreak. The first of four presentations described the optimization and evaluation of using aboveground burial as an alternative to existing large animal carcass disposal methods. That site design would be critical to the success of this method was emphasized. The second presentation identified how leachate uniquely affects different viral types and that leachate composition is instrumental in viral persistence. Should waste from an incident involving viral agents containing residual agent be disposed of in a landfill, knowledge of the persistence of the virus in the leachate would enable landfill operations to be adapted to minimize potential exposures to waste management workers and the public. Current operational and economic considerations comparing chlorine dioxide fumigation to heat treatment for poultry barns were introduced in the third presentation. The final presentation discussed the validation of a

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## Waste Management Practices

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This session examined tools and methods surrounding waste management practices through three presentations. The first described the next version of EPA's Waste Estimation Support Tool (WEST), a decision support tool based on GIS (geographic information system) for estimating the characteristics, amount, and residual radioactivity of waste generated from remediation and cleanup activities after a radiological incident, and how upcoming enhancements would contribute to improving the planning and response capabilities of the tool. The second presentation discussed the use of antimicrobial products to treat agricultural/animal facility surfaces contaminated with high-consequence animal pathogens, evaluated using the Organization for Economic Cooperation and Development Quantitative Method. The third and final presentation consisted of two parts. The first briefly covered an approach to estimate constituents that likely would be found in a

decontamination effluent, and the second part focused on the development of a treatment system for decontaminating effluent, including unit processes for treating the various constituents expected in the effluent. [Section 18 of this report provides additional details on these presentations.](#)

## Poster Session

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An afternoon poster session on the second day of the conference provided a break between oral sessions with 35 posters representing a range of remediation-related issues. Topics included techniques for decontamination of various surfaces and environments, emerging technologies that enable faster and more accurate evaluation of onsite contamination, and fate and transport studies of various contaminants in environmental and municipal systems. [Section 19 of this report provides additional details on these poster presentations.](#)

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## Acronyms and Abbreviations

Abbreviation/Acronym	Definition
ADWR	Aircraft Drinking Water Rule
Am	americium
AMS	Advanced Medical System
AOP	advanced oxidation process
AR	augmented reality
ARS	acute radiation syndrome
ASFM	aqueous simulated fallout material
ASTM	American Society for Testing and Materials (now ASTM International)
Ba	<i>Bacillus anthracis</i>
Ba	barium
BAS	<i>Bacillus anthracis</i> Sterne
BG	<i>B. atrophaeus</i> subsp. <i>globigii</i>
BI	biological indicator
BOTE	Bio-Response Operational Testing and Evaluation
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTK	<i>B. thuringiensis</i> var. <i>kurstaki</i>
BVA	Blast Vulnerability Assessment
CANARY	Cellular Analysis of Antigen Risks and Yields
CARD	Chemical Agent Reductions Database
CBR	chemical, biological, and radiological
CBRN	chemical, biological, radiological, and nuclear
CBRNE	chemical, biological, radiological, nuclear, and explosives
CD	chlorine dioxide (gas)
CDC	(U.S.) Centers for Disease Control and Prevention
CERI	community environmental resiliency index
CHAD	Chemical Hot Air Decontamination
ClO <sub>2</sub>	chlorine dioxide (gas)
Co	cobalt
Co-60	cobalt-60
COBR	Cabinet Office Briefing Room
CONOPS	Concept of Operations
COTS	commercial off-the-shelf
CRADA	cooperative research and development agreement
CRI	cutaneous radiation injury
Cs	cesium
CSAC	(U.S. DHS) Chemical Security Analysis Center
CTRA	chemical terrorism risk assessment
CVMBS	College of Veterinary Medicine and Biological Services
CWA	chemical warfare agent
DCMD	Decontamination and Consequence Management Division
DECON	decontamination capabilities
DFU	dry filter unit
DHHS	(U.S.) Department of Health and Human Services
DHS	(U.S.) Department of Homeland Security
DHS S&T	(U.S.) Department of Homeland Security Science and Technology Directorate
DNA	deoxyribonucleic acid
DoD	(U.S.) Department of Defense
DPAS	Decontamination Preparedness and Assessment Strategy for Water Utilities

Abbreviation/Acronym	Definition
DPM	disintegrations per minute
DQO	data quality objective
DRDC	Defence Research and Development Canada
DSB	(ECBC) Decontamination Sciences Branch
DTRA	(U.S. DoD) Defense Threat Reduction Agency
DURC	dual use research of concern
ECBC	Edgewood Chemical Biological Center
ECOSA	Emergency Coordinated Scientific Advice
EPA	(U.S.) Environmental Protection Agency
ESS	electrostatic spray
ETV	(U.S. EPA) Environmental Technology Verification Program
Eu	europium
FCV	feline calicivirus
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FMD	foot-and-mouth disease
FNR	false negative rate
GC	gas chromatography
GDS	(U.K.) Government Decontamination Service
GIS	geographic information system
HAZMAT	hazardous materials
HD	sulfur mustard
HPAI	high-pathogenicity avian influenza
HPC	heterotrophic plate count
HSIN	Homeland Security Information Network
HSRP	(U.S. EPA) Homeland Security Research Program
HVAC	heating, ventilation, and air conditioning
IIAD	Institute for Infectious Animal Diseases
IND	improvised nuclear device
ISF	Interim Storage Facility
IWATERS	Irreversible Wash-Aid, Treatment, and Emergency Reuse System
JAEA	Japan Atomic Energy Agency
JBADS	Joint Biological Agent Decontamination System
JPMP	Joint Program Manager for Protection
JSTO	Joint Science and Technology Office
JSTO-CBD	Joint Science and Technology Office for Chemical and Biological Defense
kDa	kiloDalton
LED	light emitting diode
LLNL	Lawrence Livermore National Laboratory
LOD	limit of detection
LR	log reduction
MB	methyl bromide
MCL	Maximum Contaminant Level
MeBr	methyl bromide
MERS	Middle East respiratory syndrome
MIP	Microbiology, Immunology, and Pathology
MOE	Ministry of the Environment
MOEJ	Ministry of the Environment, Japan
MOU	memorandum of understanding
MS	mass spectrometry

Abbreviation/Acronym	Definition
MTA	Metropolitan Transportation Authority
NaOCl	sodium hypochlorite
NATO-CBRN	The North Atlantic Treaty Organization Joint Chemical, Biological, Radiological, and Nuclear
NHSRC	(U.S. EPA) National Homeland Security Research Center
NIES	National Institute for Environmental Studies, Japan
NIMS	National Incident Management System
NRCS	Natural Resources Conservation Service
OCSP	(U.S. EPA) Office of Chemical Safety and Pollution Prevention
OECD	Organization for Economic Cooperation and Development
OEM	(U.S. EPA) Office of Emergency Management
ORD	(U.S. EPA) Office of Research and Development
OSP	Office of Science and Policy
OSTP	(U.S. White House) Office of Science and Technology Policy
OTD	Operational Technology Demonstration
OW	(U.S. EPA) Office of Water
PAA	peracetic acid
PAL	Provisional Advisory Level
PAPR	Powered Air Purifying Respirator
PCR	polymerase chain reaction
PNNL	Pacific Northwest National Laboratory
PPE	personal protective equipment
PVC	polyvinyl chloride
R&D	research and development
RE	recovery efficiencies
RH	relative humidity
RN	radiological and nuclear
RRS	Rapid Return to Service
RTSFM	radiologically tagged simulated fallout material
RV	Rapid Viability
S&T	Science and Technology
SAGE	Scientific Advisory Group for Emergencies
SAIC	Science Applications International Corporation
SAM	Selected Analytical Methods
SAP	Sampling and Analysis Plan
SARS	severe acute respiratory syndrome
SCID	Sample Collection Information Document
SESSA	Site Exploitation System for Situational Awareness
SHC	Sustainable and Healthy Communities
SNL	Sandia National Laboratories
SPORE	Scientific Program on Reaerosolization and Exposure
Sr	strontium
SWMM	(U.S. EPA) Storm Water Management Model
T&E	Test and Evaluation
TEPCO	Tokyo Electric Power Company
TGEV	transmissible gastroenteritis virus
TIH	toxic inhalation hazard
TRF	time-resolved fluorescence
TSCA	Toxic Substances Control Act
UK	United Kingdom

Abbreviation/Acronym	Definition
USDA	U.S. Department of Agriculture
USDA-APHIS	USDA-Animal and Plant Health Inspection Service
USDA-NRCS	USDA-Natural Resources Conservation Service
UTR	underground transportation restoration
UV	ultraviolet
VHP	vaporous hydrogen peroxide
VR	virtual reality
VSP	Visual Sample Plan
VX	O-ethyl-s-(2-diisopropylaminoethyl) methylphosphonothiolate
WARRP	Wide-Area Recovery and Resiliency Program
WEST	(U.S. EPA) Waste Estimation Support Tool
WIS	Wehrwissenschaftliche Institut für Schutztechnologien (WIS): Research Institute for Protective Technologies and CBRN Protection (Germany)
WRF	Water Research Foundation
WSD	(U.S. EPA) Water Security Division
WSTB	Water Security Test Bed
WTAMU	West Texas A&M University
XTK	X-ray Tool Kit

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# 1. Introduction

This report summarizes presentations and discussions from the *2016 U.S. EPA International Decontamination Research and Development Conference*, held November 1–3, 2016, at the EPA Conference Center in Research Triangle Park, North Carolina. The technical content of this report is based solely on information and discussions from the Conference.

The Conference consisted of 58 speaker presentations organized into three general sessions and six concurrent sessions. A poster session showcasing 35 posters was held on the second day of the Conference. Dr. Lukas Oudejans and Dr. Shawn Ryan, both with EPA’s National Homeland Security Research Center (NHSRC), opened the Conference. Approximately 240 Conference participants represented federal, state, and local government agencies and laboratories; international organizations (seven countries including the United States); academia; and the private sector.

This report highlights the opening session of the Conference and summarizes each presentation given during the Conference. Each presentation summary includes the abstract provided by the speaker and an overview of the question-and-answer session that followed the presentation. The speakers’ presentation slides, which include additional detailed information, are found in Appendix C of this report. This report is organized according to the Conference agenda by general session and by concurrent sessions related to chemical, biological, and radiological (CBR) decontamination, water and wastewater management, livestock remediation options, and underground transport restoration as shown below. Poster session abstracts are located at the end of the report (page 65).

- Section 2 summarizes the opening session.
- Sections 3–18 contain the abstracts and question-and-answer summaries for 60 presentations given over the course of the three-day Conference and abstracts for the posters presented on Day 2. The presentations are organized according to the agenda.
- Appendix A provides the meeting agenda.
- Appendix B lists the Conference participants.
- Appendix C includes presentation slides for speakers who approved their distribution.

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## 2. Opening Session

Dr. Lukas Oudejans, Chair of the EPA/NHSRC Conference Organizing Committee, introduced Dr. Shawn Ryan, welcomed participants to the Conference, and provided opening remarks.

Dr. Shawn Ryan, Division Director, EPA/NHSRC/DCMD, welcomed all attendees to the Ninth Annual Decontamination Conference; the first was held in 2004 with a small group. At the first conference, they discussed the knowledge gaps and what was learned from the 2001 biological (anthrax) incidents—where to go from there and how they could improve the capability to handle similar incidents in the future. They have added “international” to the workshop title since then, because partners across the world have similar concerns on which we can work together. Dr. Ryan welcomed the federal partners and international collaborators, whose contributions help grow and continue the Conference. The Conference remains dynamic: As new topics have arisen, they are included in the agenda for discussion. The goals of the Conference are to bring the community together, foster collaboration, and encourage networking. Improvements and advancements happen because participants work together. Many of the 2016 Conference presentations were focused on new or emerging topics. Dr. Ryan urged attendees to take advantage of the concurrent sessions.

Dr. Ryan then introduced Jonathan Herrmann, the former director of NHSRC and one of the pioneers. Although retired since 2013, Mr. Herrmann has continued to participate in the decontamination conferences.

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## 3. General Session 1: Program Overviews, Responses, and Field Studies

Auditorium C-111

Presentations and Q&A moderated by Lukas Oudejans and Timothy Boe | *U.S. EPA*

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### EPA’s Homeland Security Research: From CBRNE to “All-Hazards”

8:15 am

Jonathan Herrmann | (Retired) U.S. Environmental Protection Agency

Gregory Sayles | U.S. Environmental Protection Agency

Mr. Herrmann welcomed attendees to the Conference and provided opening remarks. He presented a brief history of the development of the NHSRC, focusing on the first 10 years. He emphasized a key factor in the ultimate success of the center: The original team was small (four to five people) with the right characteristics and capabilities, and everybody had the opportunity to contribute. The team developed the mission, vision, and operating procedures, which allowed the division to become what it is today. The center is dedicated to protecting environmental resources, responding to events, performing decontamination, and taking care of water systems, emphasizing chemical, biological, radiological, nuclear, and explosives (CBRNE) issues.

Mr. Herrmann stated that, when EPA was tasked with cleanup after 9/11, including characterizing site contamination and cleaning biological agents from buildings and facilities, the center assembled a team to help the EPA program offices in this undertaking. The work was done through the Office of Research and Development’s (ORD’s) research council. The center assembled a team to address CBRNE issues over the long term. The team worked with the EPA Office of Water (OW) on an action plan, concentrating on what local responders needed to characterize site contamination and cleanup and seeking the best approach to manage huge volumes of waste often generated after incidents.

In the early years (2003–2005), Mr. Herrmann stated that NHSRC used EPA’s Environmental Technology Verification (ETV) Program to review established drinking water systems and other topics. Originally, he said the intent was to staff the team at three, assuming that most of the needed information would come from the Department of Defense (DoD). Those data, however, were old and primarily related to the weaponized version of the material and not contamination. Finding that they could not use DoD data at that time, they argued to become a permanent part of

ORD, which they did in 2004. The team published the first version of the Selected Analytical Methods (SAM) manual to help responders. In 2006, Hurricane Katrina revealed new methods in conjunction with natural disasters.

Mr. Herrmann continued presenting the history of the Center for the middle years (2006–2009). During this time, the center concentrated on building customer relationships with the EPA program offices and regions and partnerships with other federal organizations. The center fully implemented its five-year research plan, developed the Environmental Risk Assessment Database, and launched the Blast Vulnerability Assessment (BVA) tool with the U.S. Army Corps of Engineers. In 2008, they assessed a civilian biological incident in Danbury, Connecticut, their first in-the-field experience and, to protect decontamination personnel and responders, established Provisional Advisory Levels (PALs). In 2009, Bedford, Massachusetts, experienced the New England mustard gas canister incident. From 2010 to 2013, the center began applying technology to real-world situations and started looking for ways to integrate these efforts as part of ORD's responsibilities.

Continuing with the history of the Center's development, Mr. Herrmann described that, in 2010, the Center developed rapid viability protocols for *Bacillus anthracis* to speed the sampling processing time. Experts in combustion engineering and air quality collected samples from burning the oil and dispersants at the Deepwater Horizon site. Also during this time, CANARY (software to facilitate protection against water system contamination) was piloted in Singapore and five U.S. cities. In 2011, the Center participated in an interagency Bio-Response Testing and Evaluation (BOTE) Project: a field-scale, indoor biological agent release with response by health/law enforcement personnel through environmental remediation and waste disposal. Also in 2011, a Center staff member served as a senior scientific advisor on the Fukushima incident. In 2012, the Center collaborated with the Department of Homeland Security (DHS) on the Wide Area Recovery and Resiliency Program (WARRP) and multiple threat and response exercises in Denver, Colorado. The Center worked on the Scientific Program on Reaerosolization and Exposure (SPORE) to understand short- and long-term environmental public health impacts following an outdoor biological attack.

As the next speaker, Dr. Sayles, Director, EPA/NHSRC thanked Mr. Herrmann for his leadership and mentorship and complimented the variety of backgrounds and technical abilities of Conference attendees. He stated the challenge is to broaden our thinking from CBR hazards to all hazards, highlighting that "all hazards" is daunting—how can we deal with *all* hazards? Questioning how to deal with both current and unknown or unanticipated problems, he stated as an example the Charleston, West Virginia, event, when the city turned off its water supply because of a chemical event. He asked how we can continue to address high priority agents *and* prepare for unforeseen hazards and proposed that the solution is to stick to the core problems: (1) take a systems view of response, (2) build scale into research incrementally, and (3) work closely together.

Dr. Sayles emphasized that disaster response is complicated and should be viewed with a systems approach. Mitigation steps could affect the feasibility of later cleanup. He stated we should view response as an interconnected system so it will have broader applicability, noting that the decontamination step itself can affect the amount of laboratory work.

Dr. Sayles described a second concept—deal incrementally with complexity and scalability. He stated that scientists subscribe to this concept: Begin at the small scale to develop detailed, controlled, repeatable data, and scale up, from piloting at small scales, moving to larger scales, and then to full scale. Incremental steps allow us to generalize the results. From bench to pilot to field scale, the results can more easily be extrapolated to those unforeseen problems. Dr. Sayles confirmed that EPA is dedicated to this process and to the field-scale demonstration level. He described the field-scale distribution system they built, which they can contaminate, change the temperature, and clean up, stating it is a nationwide resource for water research.

The third principle Dr. Sayles discussed is collaboration. Operational demonstrations attract researchers, end-users, and agencies to participate and learn from each other, which yields a common understanding of the science and challenges to application. He then presented some examples of unanticipated events:

- 2014–2015: Ebola. Although Ebola was not a problem for the United States, the country has experienced issues of waste management, cleanup of facilities and vehicles, and wastewater treatment.



Extrapolating the systems view, scalable approaches, and field-scale demos allowed us to bring our work to bear on these problems.

- Midwest: highly pathogenic avian flu. Millions of birds had to be culled, buildings needed to be decontaminated. Although not part of our research, we were able to extrapolate.
- Tulane primates: At the Tulane primate center, an environmental release of *Bacillus* resulted in the death of some primates. We had not worked with that organism and we had no specific sampling methods or proposed approaches for cleanup; we helped address the problem because we relied on the premise of broader applicability.
- Flint, Michigan, drinking water system: EPA has had a big role in getting that system decontaminated and back running. Our distribution system modeling capability can help distribution centers prepare for disasters for water security purposes. Flint needed a robust drinking water system model to help them understand why residual chlorine was inadequate and why the water was old in parts of the system. We are currently editing our models to help Flint.

Dr. Sayles closed by stating that we have a wide-area problem (e.g., biological events, nuclear release) and asking how we prepare for such a daunting task. He said we are on the right track, working on analysis, methods, and fate and transport to focus on scaling up and taking a systems view. In the coming years, as we develop the ideas of doing a field-scale demonstration of a wide area, we need to work together. He advised we continue to think about the work in an incremental, scalable way.

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### Questions, Answers, and Comments

- Q Brendan Doyle:** In addition to preparing for the unknown, what are the top three emerging threats that this group needs to address?
- A Jonathan Herrmann:** Nuclear detonation and dirty bombs, biologicals that we have not thought about or that leapfrog from animal to human, and a black swan event that nobody can anticipate.
- A Gregory Sayles:** I worry about those things that we do not know will happen. Something could be well intentioned but have negative implications. We need to do our best to think more broadly, because we do not know what is coming.

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## An Overview of the UK Government Decontamination Service's Science and Technology Program

8:50 am

**Dudley Hewlett** | *Department for Environment, Food and Rural Affairs, United Kingdom*

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### Abstract

The UK Government Decontamination Service (GDS), part of the Department for Environment, Food and Rural Affairs, facilitates rapid access to assured recovery capabilities for all public bodies in the UK recovering from the effects of CBRN incidents. An overview of the research undertaken by GDS across all the major threat areas will be given.

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### Questions, Answers (Q&A), and Comments

- Q Cayce Parrish:** There's an issue of having different quality assurance (QA) objectives for other partners like the industry or defense department. Have you run into the issue of having different data quality objectives?
- A Dudley Hewlett:** By exposing all of that information to group peer review—we don't take people's words. We have checks and balances in place, but there is always an integration issue. In terms of operational deployment, we have a system in the United Kingdom where each government department has a chief scientific advisor. Then in an incident, we have an organization, COBR, who are the strategic national leads for operational response, and an underpinning, the Scientific Advisory Group for Emergencies (SAGE). The information we have goes there (both COBR and SAGE). This is a group of high-power people looking at situations practically and in broader, more general terms. Data quality objectives are not discussed explicitly, but a peer-review mechanism is in place and assists with defining the next steps through SAGE.

- Q John Lipscomb:** Can you talk about the data you use for health risk assessment? How you get them, and how you use them to set decontamination standards in regard to choosing from contractors with really great expensive methods and those with less expensive but good-enough quality?
- A Dudley Hewlett:** Those risks are assessed dynamically, not beforehand. When something happens, there are various information feeds, so it depends on what the situation is. For example, in the Alexander Litvinenko incident, we had good data about what he was exposed to on the day he died. Then, there are various organizations that go out and support the police and collect data that are initially fed back to police command, but very rapidly also to a 24/7 capability system in the UK called Emergency Coordinated Scientific Advice (ECOSA) who can look at the data and see if the release poses a threat or not. Emergency management protocols then kick in and actions have to happen. Once the situation is stable and people are no longer at risk of being exposed, then a recovery working group is set up, with a specialist Science and Technology Advice Cell (STAC) generally led by Public Health England with the main priority of protecting public health. In that case, the issue was how much of the substance was mobile in the environment. This working group set a limit of substance that if it was found and was mobile, then it's a threat; if not, then it is okay. We give that to our contractors and work with them to analyze available technology that can reduce levels of that contamination. In that specific instance (Polonium (Po)-210), we knew the technology would work. Another example is the Ebola outbreak. There was no assay for Ebola, so we used interim recovery guidance produced by the government to guide our contractors.
- Q Willie Harper:** To what extent can you pursue your modeling objectives with widely available things like MATLAB, Microsoft Office, etc., and to what extent do you use highly specialized custom packages/code to do the modeling you referred to?
- A Dudley Hewlett:** Some of the modeling I was referring to was on an Excel spreadsheet. It was very simple math. Other systems, for other purposes like wide-area biological releases, use very specialized data feeds. It is more of a big, mixed picture.

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## 4. General Session 1 (cont.): Program Overviews, Responses, and Field Studies

Auditorium C-111

Presentations and Q&A moderated by Hiba Ernst and Mario Ierardi | U.S. EPA

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### Current Status in Fukushima and Study on Volume Reduction and Recycling

10:00 am

Kiyohiko Eino | *Japanese Ministry of the Environment*

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#### Abstract

On March 11, 2011, East Japan was struck by the largest earthquake ever recorded in or around Japan. It triggered enormous tsunamis that caused immense, widespread damage. The tsunami caused accidents at the Tokyo Electric Power Company (TEPCO) Fukushima Daiichi Nuclear Power Plant, which resulted in the release of large amounts of radioactive materials into the environment. This remains the greatest environmental challenge in Japan.

Ministry of the Environment, Japan (MOEJ) introduces the current efforts on off-site cleanup in Fukushima and the progress of Interim Storage Facility (ISF) and volume reduction and recycling of contaminated soil generated by decontamination. The major topics are as follows.

#### Decontamination

MOEJ is conducting decontamination on the basis of decontamination implementation plans in the 11 municipalities in Fukushima Prefecture designated as the Special Decontamination Area. The target for completing whole-area decontamination in the remaining municipalities (except for designated difficult-to-return areas) is the end of March 2017.

As of the end of March 2016, 93 municipalities in 8 prefectures in the Intensive Contamination Survey Area had formulated decontamination implementation plans of their own supported by MOEJ. The implementation of decontamination in all municipalities is planned to be completed by the end of March 2017.

#### Interim Storage Facility

The ISF will be established as a centralized facility for safely managing and storing soil containing radioactive materials generated from decontamination work in Fukushima Prefecture, and designated waste exceeding 100,000 Bq/kg being stored in Fukushima Prefecture, until final disposal is conducted.

#### Recycling and Reducing Volume of Contaminated Soil

Necessary measures should be taken for the final disposal outside Fukushima Prefecture within 30 years after operations start at the ISF. In preparation for final disposal outside Fukushima Prefecture, it is important to raise the proportion that can be recycled and reduce the amount requiring final disposal to the greatest extent possible through the development and use of technology that reduces the volume of contaminated soil. Consequently, MOEJ is investigating a strategy for the development of technology applicable to recycling and volume reduction and is conducting demonstration projects for newly developed technologies.

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### Questions, Answers, and Comments

Note: Mr Eino's responses were clarified as part of the post-conference communications with the presenter

- Q Mario Ierardi:** Thank you for coming so far to share and for all of the work you have done with the recycling criteria. It is very groundbreaking and we are learning a lot from you. The relationship you've developed with Sang Don Lee is helping us move forward. What are you seeing as the impacts of your work in handling waste with the remaining operating nuclear plants and how are you informing/involving the public in your work as you move forward?
- A Kiyohiko Eino:** We provided decontamination information on the website of MOEJ and had many communication activities concerning decontamination works with residents in the Fukushima prefecture. We would like to continue similar efforts for our future work.
- Q Sang Don Lee:** When you go to the website, there are multiple documents to learn about stakeholder involvement and how they engage stakeholders and how the local environment is supporting local people in decontamination. Now I have a question. When the Japanese government uses contaminated soil for recycling, are there any regulations to using those materials in construction?
- A Kiyohiko Eino:** About the recycling location, we think it is natural to use contaminated soil within the Fukushima Prefecture, but MOEJ is studying whether the soil can be used all over Japan in a soil recycling scheme.
- Q Paul Lemieux:** What criteria do you have on the soil when you decontaminate? If it is clean enough, can you put it back where it came from, or do you recycle it all?
- A Kiyohiko Eino:** The level for the clearance, 10  $\mu$  Sv/y, 100 Bq/kg for cesium.
- Q Victor Medina:** You were discussing recycling soil by putting it on embankments and covering it with asphalt. Would incorporating it directly into asphalt be an alternative method?
- A Kiyohiko Eino:** We are checking to use soil under certain shielding measures.
- A Sang Don Lee:** I want to go back to Paul's question as to whether those materials can go back to the original location. In Japan's Special Act, if you conduct the decontamination, the material from the decontaminated action should go to the storage site. The law is there are multiple criteria in Japan right now because of this unprecedented incident. So Japan's Special Act says that if you conduct decontamination in a certain area, regardless of decontamination level, those materials have to be moved to a storage site first. Depending on the location, Fukushima Prefecture, then the decontaminated soil will be moved to the storage site.
- Q Brendan Doyle:** Are you cleaning up everything, or do you do a cost-effectiveness analysis first to see how much it costs to clean it up and then figure out if it should be cleaned up, demolished, and replaced?
- A Kiyohiko Eino:** The cost of cleanup, treatment of contaminated soils, and final disposal is under consideration.

10:45 am

Shawn Ryan | U.S. Environmental Protection Agency

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### Abstract

The anthrax incidents in 2001 marked a new reality—the need for capabilities to protect human health and the environment from the intentional release of chemical, biological, and radiological materials. In response, the U.S. Environmental Protection Agency (EPA) stood up and aligned specific assets to coordinate agency, interagency, and international activities; support environmental response and remediation actions; and develop capabilities to improve hazard assessment, mitigation, and cleanup.

Since the Amerithrax incidents, research developments and response activities have demonstrated enhancements in the ability to deal with environmental contamination involving chemical, biological, and radiological materials.

Preparedness and actual responses to incidents involving natural anthrax, unattenuated *B. anthracis* samples, ricin toxin, *Burkholderia*, Ebola virus, chemical spills, and radiological releases have benefitted from coordination, research, and support developments.

This presentation will highlight some of the research, support, and coordination efforts within EPA and discuss how these efforts have been used to prepare for and respond to recent incidents. EPA's National Homeland Security Research Center's capabilities will be discussed, as well as transition of products that have been used to enhance preparedness for environmental remediation.

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### Questions, Answers, and Comments

**Q Attendee:** What about DoD anthrax samples?

**A Shawn Ryan:** Typically, samples were meant to be irradiated (nonpathogenic) and were sent to numerous university laboratories and BSL-1 facilities around the country, so laboratories thought they were getting killed spores, but there was potential for viable spores. Laboratories realized that the irradiation process wasn't fool-proof, so live spores were a concern. EPA received questions about laboratory decontamination of sensitive equipment. We worked with the Office of Emergency Management (OEM), the Office of Chemical Safety and Pollution Prevention (OCSPP), and the Centers for Disease Control and Prevention (CDC) to develop decontamination guidance for sensitive equipment. There were no products purposely registered for sensitive equipment or suitable for the scales we were facing. Using a lot of the research we have done here and that others have done, we were able to come up with guidance for those laboratories. Dr. Worth Calfee and Mr. Francisco Cruz were on site at CDC for questions related to those protocols.

**Q Brendan Doyle:** There is conversation at interagency meetings about plugging scientists and engineers into the hot-wash process. Can you provide examples from the incidents you mentioned where there were lessons learned that feed directly back into research planning?

**A Shawn Ryan:** The Ebola guidance is a good example. Marshall Gray had done some research on personal protective equipment (PPE) decontamination that could relate to Ebola—that was put wholesale into the plan, and there were a lot of comments from that hot-wash about what worked and what might be improved. That came back, and we tested other things. We really involve program offices and regional folks in our research; they call a lot and involve us.

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## Jack Rabbit II Chlorine Release Field Experiments

11:15 am

Shannon Fox | *Department of Homeland Security*

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### Abstract

Millions of tons of chlorine are produced, shipped, and consumed in the United States every year due to its critical role in manufacturing (plastics), public health (water treatment and sanitation), medicine (pharmaceuticals), and other important industries. Large volumes of chlorine are shipped daily as a pressurized, liquefied gas via rail in 90-ton railcars and via highways in 20-ton tanker trucks, frequently through highly populated areas. Chlorine gas is a potent toxic inhalation hazard (TIH), and the potential of a containment breach and large-scale release represents a significant risk to life and health.

In order to more fully understand and address such potential scenarios, the U.S. Department of Homeland Security (DHS) Science and Technology (S&T) Chemical Security Analysis Center (CSAC) and an interagency team of partners from government, industry, and academia successfully conducted a series of 13 large-scale outdoor chlorine release experiments, known as Jack Rabbit II (JR II), in the summers of 2015 and 2016 at Dugway Proving Ground, Utah. Sponsored by DHS CSAC, the Department of Defense (DoD) Defense Threat Reduction Agency (DTRA), and Transport Canada, these experiments involved the release of 5 to 20 tons of chlorine each trial, and were performed to fill critical knowledge, data, and capability gaps to support and improve chemical release modeling, risk assessment, industrial safety, and emergency response.

This briefing will present an overview of the JR II program and cover the participating partners and stakeholders, experimental design, test execution, and the resulting data and analysis. High-definition, high-speed, and infrared video footage of the chlorine releases will be shown, which was captured from multiple vantage points during each experiment. Findings from initial studies and analyses of the cloud movement, behavior, and concentration/time profiles will also be presented, along with the implications for hazard prediction and atmospheric transport and dispersion modeling, risk assessment and mitigation, and emergency preparedness and response.

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### Questions, Answers, and Comments

Q No questions or comments.

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## Keynote Speaker: Perspectives from EPA's Leadership on Homeland Security Research

12:45 pm

Stan Meiburg | *U.S. Environmental Protection Agency, Acting Deputy Administrator*

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### Summary

Dr. Gregory Sayles introduced Dr. Stan Meiburg, EPA's former Acting Deputy Administrator, who stated he was delighted to see such great attendance at the Conference. Early in his career, Dr. Meiburg worked in Region 4 where they endured Hurricane Katrina and the oil spill and has been involved in many disasters. He expressed his pleasure that the Conference brings together researchers and responders—both of whom have to be involved. He stated the need for an interactive relationship so that responders learn from researchers and vice versa. He was pleased about the international and interagency participation.

Dr. Meiburg complimented the Conference Organizing Committee for its flexibility and congratulated them for putting the Conference together. He noted the Research Triangle Park facility is the second largest EPA installation, next to the Washington, DC, headquarters and brought greetings from Administrator Gina McCarthy.

Dr. Meiburg emphasized that all EPA responses should be based on science and stated that EPA routinely seeks the scientific basis from this community for very complex response situations. He cited various examples of such responses: a drinking water emergency caused by an algal bloom in Lake Erie in Toledo, Ohio; the Deepwater Horizon incident; ricin in a mail facility near the capital; biological attacks in 2001; a chemical release into the drinking water system in Charleston, West Virginia; a municipal water system incident in the midwestern United States.

He further emphasized that EPA must respond to such disasters with the best science they have. He expressed that seeing the science pursued even in times of limited budgets is encouraging. Dr. Meiburg stated that EPA uses the lessons they learn; for example, they created the Homeland Security Research Center, dedicated to addressing homeland security risks for both natural and manmade disasters. The data and tools this center produces have been extraordinarily valuable as EPA prepares for current and future responses and strengthens their capacity to respond to *any* threat to the nation.

Dr. Meiburg hopes the Conference would not just consider scenario-based responses, but also think about capability-based responses. He noted EPA is trying to do that by building a connection between researchers and responders. For collaboration to work, people who know each other are needed, as is the ability to communicate how and why the science is useful, especially to the public.

In working as a liaison to CDC, he learned that organizations have somewhat different cultures and speak somewhat different languages. Part of the collective job is cross-cultural communication, which develops through interaction. He noted that, as valuable as technological communication tools are, there is no substitute for building real relationships.

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### Questions, Answers, and Comments

- Q Brendan Doyle:** If we had to replay the Flint, Michigan, drinking water crisis all over again, what would you do differently?
- A Stan Meiburg:** There is not a short answer to that question. The Flint experience taught us how important collaboration and community is. The timeline reveals that the chief regret is not seeing signals earlier than we did. For EPA, we took from that how important it is to elevate something if you see something wrong. It is not a sign of failure to say that you have a problem that you do not know how to solve. That hand raising gives other parts of the organization opportunity to contribute.

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## 5. General Session 1 (cont.): Program Overviews, Responses, and Field Studies

Auditorium C-111

Presentations and Q&A moderated by Matthew Magnuson and Christopher Gallo | *U.S. EPA*

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### Demonstration of Radiological Decontamination and Mitigation Technologies for Building Structures and Vehicles

1:00 pm

Sang Don Lee | *U.S. Environmental Protection Agency*

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#### Abstract

The U.S. Environmental Protection Agency in collaboration with the Department of Homeland Security conducted the “Wide-Area Urban Radiological Contaminant, Mitigation, and Cleanup Technology Demonstration” in Columbus, Ohio, on June 22–25, 2015. Five wide-area radiological decontamination technologies (including strippable coatings, gels, and chemical foam technologies) were demonstrated on an urban building. Decontamination technologies were applied to remove the contaminants from the building’s surfaces by physical, chemical, or other methods, which could reduce the radiation exposure level. In addition, several radiological contaminant mitigation technologies were demonstrated, including building and vehicle wash technologies, as well as several approaches to contain wash water and radioactive particles. Both demonstrations were conducted using a 75-year-old brick building and the surrounding area (including parking lots). No radioactive contaminants were applied during either demonstration, as the objective was to duplicate and implement realistic operational conditions for these technologies. Surrogate contaminants such as particle tracers were used in several demonstrations. Example technology application techniques/accessories included an articulating boom lift, repelling boatswain chair, standalone surface material structures, high-volume foam applicators, fire truck foam applicator, a vehicle wash tent for vehicles, particle tracers

to simulate radiological contaminants, and liquid containment approaches of varying degrees of technological sophistication.

During the demonstration, operational information was collected including decontamination rate, contaminant mitigation and containment capacity, user friendliness of each technology, the required utilities (electric, water, etc.) for each technology, skill level of workers required, and the cost. The condition (color, texture, integrity, etc.) of each building material present on the structure along with all structural components such as gutters, windows, doors, etc., was carefully examined and documented. All demonstrations were open to individuals, organizations, and local, state, federal, tribal, and international governments that may be involved with implementing or planning radiological incident response. The demonstrations provided a unique opportunity to see more than 15 different technologies for decontamination and radiological contaminant mitigation. This presentation will show how the demonstration was conducted and discuss the outcomes.

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### Questions, Answers, and Comments

- Q Attendee:** Did you look at how the New York sanitation department made the World Trade Center debris go away in two days? It went from six feet of debris in some areas to zero within two days.
- A Sang Don Lee:** No, but I will consider that working with New York City. For this municipal equipment, we selected five regions—one of them is New York City—the candidate city we want to work with.

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## Water, Water Everywhere: Managing Contaminated Water from Chem-, Bio-, and Rad- Decontamination

1:25 pm

Hiba Ernst | *U.S. Environmental Protection Agency*

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### Abstract

The water sector faces the important challenge of unintentional or intentional contamination of water and wastewater with high-consequence pathogens, which could include *Bacillus anthracis*, antibiotic-resistant bacteria, emerging viruses, and others. This presentation will explore how contaminated water might be generated and will highlight EPA's responsibility for water sector infrastructure protection. Further, this presentation will discuss potential issues wastewater utilities might face when they are confronted with large volumes of biocontaminated water. EPA research to help wastewater utilities deal with some of these issues will be presented. This research ranges from treatment of contamination to understanding its fate and transport through the wastewater collection and treatment systems to its impact on activated sludge processes. This information will help utilities and environmental responders determine not only the extent of contamination but also the effectiveness of potential decontamination responses and management strategies for biocontaminated water.

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### Questions, Answers, and Comments

- Q Brendan Doyle:** Tomorrow, I will present a panel where we looked at the history of Hamilton, New Jersey, and how they responded to Amerithrax. That was truly science-in-the-field, boots-on-the-ground; everybody was trying to figure everything out all at once. When we interviewed the Mayor and the New Jersey Department of Environmental Protection, they said that community acceptance of the treated wastewater was still a huge issue. Could you comment on whether the Water Environment Research Foundation (WERF), the trade association and the wastewater guys are doing anything to try and get people to understand that once the water is treated it doesn't have to be taken across three states to be disposed of?
- A Hiba Ernst:** Basically, what they're doing as part of the education is trying to have better guidance. They worry the water is not safe, and they worry about the exposure of operators to possibly contaminated water. There are two possible approaches: one is continuing the communication and trying to explain to people that if you treat it a certain way and follow guidance that it may be safer, but it also has a lot to do with communication among regulators and actual water resource and recovery agencies.
- C Matthew Magnuson:** That sums it up. One slide noted a need for uniform guidance. That is in fact what they're working on, and we're hoping we can help them with that.
- C Attendee:** Ebola was decontaminated by being burned, and people wouldn't even take the ash. It's not science; it's psychology.

- C Hiba Ernst:** I think a lot of education and communication are key to help acceptance. But you're right, it's a psychological issue. It's the same in Flint where people can be afraid to use the water and so the water sits in the distribution system and the water quality deteriorates. Trust is important.
- Q Shannon Fox:** Eight years ago, we worked with EPA at the DHS CSAC to model scenarios of municipal/local water supplies being contaminated intentionally from back flushing, which represents a much more dangerous method of contamination. You would need an enormous amount of material to contaminate a reservoir, but only a small amount for that. What sort of mechanisms are in place to alert to such an event before people started dying?
- A Hiba Ernst:** The detection area has been really well studied by the Agency in NHSRC and OW. We did a lot of work on testing the response of water quality monitors to various contaminants and we found the water quality detectors do a very good job—especially the chlorine detector. We also have software that helps optimize placement of sensors throughout the distribution system, as well as event-detection software that you can train to the water quality based on the variability, so that would sound an alarm in an event a contamination is introduced. In the end, sampling is still your best confirmation. Adoption of Surveillance and Response Systems is an area has been better studied than other areas like in wastewater and management of contaminated water.

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## Toward Cleanup and Recovery of Underground Transit Systems from a Biological Agent Event

1:50 pm

Don Bansleben | *Department of Homeland Security*

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### Abstract

Subway system owners have identified a need for federal guidance on cleanup and recovery strategies and methods from the intentional or accidental release of a harmful biological pathogen in the system. The Department of Homeland Security (DHS) Science and Technology Directorate (S&T) is sponsoring the multiyear Underground Transport Restoration (UTR) project through partnerships and collaborations with underground transit systems around the nation and other federal agencies. The UTR project is developing guidance and a recovery framework for mass transit systems, informed by tests in the operational environment. This presentation will provide an overview of the UTR project, followed by more detailed presentations by the UTR project team.

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### Questions, Answers, and Comments

- Q Sanjiv Shah:** Is UTR morphing into something else as it is ending in 2017?
- A Don Bansleben:** One thing we're looking at, because of the problem with quickly detecting if something's been released (that's obviously a big focus for DHS), there's the BioWatch Program managed by DHS that has collectors across the nation, but that process might not alert you for hours. We will be setting up a test bed and testing technologies that will allow making more low-regrets decisions more quickly so that we can understand if something's happened in the system and how we might confine the spread of contamination. That's where we're going in the next couple of years.
- Q Malik Oliver:** For technology transfer, there are so many different parts for UTR: decon, barriers, etc.; how do you plan to streamline the process of transferring technology from the federal level to state and local levels? How will MTA (Metropolitan Transportation Authority) stay up to date with the latest in decontamination?
- A Don Bansleben:** We will obviously share everything that we're doing with them. New York City is probably the most advanced—they have a HAZMAT (hazardous materials) team and conduct drills. They would certainly be part of any recovery process. The federal government is going to be on the front line because of the widespread nature of the contamination, particularly EPA—it would overwhelm local resources. That is one of the reasons we are partnering very closely with EPA, because they will be on the front lines. We will share this with stakeholders and get them to tell us what they think, what's important to them, what lines they want to open first, what infrastructure needs to be operating before trains can run again, and what we need to do to educate our workforce. It's a difficult problem but we're



trying to get our hands around what works and what doesn't work and then share that information. Then, they need to make decisions on their own in terms of investments they may want to make like training, or stockpiling things like isolation barriers.

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## Fumigation of a Subway Railcar Using Methyl Bromide to Inactivate *Bacillus anthracis* Sterne

2:15 pm

Jasper (Joe) Hardesty | Sandia National Laboratories

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### Abstract

We report on the fumigation study of a subway railcar by the Department of Homeland Security with the Environmental Protection Agency, Sandia National Laboratories, University of Florida, and Lawrence Livermore National Laboratory.

This study addressed decontamination of rolling stock (subway trains) in the context of an overall response to restore a subway system, as part of the Underground Transportation Restoration project. Using surrogate *Bacillus anthracis* (Ba) Sterne strain spores, we evaluated the efficacy and practicality of methyl bromide (MeBr) fumigation to inactivate Ba from contaminated railcars.

Spore substrate samples were produced from railcar materials (aluminum, vinyl, fiberglass, Mylar®/polycarbonate, nylon carpet, and rubber). Each sample was inoculated with  $\sim 10^6$  colony forming units of Ba Sterne spores; and two samples of each material were placed at 20 locations inside and outside the railcar.

Ethylene vinyl alcohol tarps were used to tent the railcar, configured to fumigate exterior and interior surfaces. The railcar was fumigated at 212 milligrams MeBr/L air, 75 °F, and 75% relative humidity (RH) for 36 hours.

Temperature and RH differences were minimized by fans and humidifiers.

Ambient air monitoring included four stationary photoionization monitors, plus hand-held monitors for hourly checks of the full perimeter. Following fumigation, an activated charcoal scrubber was used to reduced MeBr concentration inside the tent from  $\sim 55,000$  ppm to  $<20$  ppm in 5 hours.

Post-fumigation results from laboratory analysis of samples showed:

- >0 of 80 samples (BIs) contained viable spores on aluminum and fiberglass,
- >1 of 40 samples (BIs) contained viable spores on Mylar®,
- >1 of 40 samples (BIs) contained viable spores on rubber,
- >2 of 40 samples (BIs) contained viable spores on carpet,
- >8 of 40 samples (BIs) contained viable spores on vinyl seat material.

Time-series samples withdrawn during fumigation showed viable spores on some samples withdrawn between 6 and 24 hours. Average efficacy (all materials) at 24 hours was  $\geq 2.5$ -log reductions (LR). At 30 hours, no viable spores were found on 12 of 13 coupons, with viable spores from 1 (of 2) fiberglass coupons. Efficacy at 30 hours was  $\geq 6$  LR for all materials except fiberglass, with 5.5 LR.

The test demonstrated that MeBr is an effective and safe method to decontaminate railcars and provided information for planning scale-up to meet the needs of transit agencies recovering from a biological incident.

Recommendations for MeBr fumigation of a railcar for Ba are to maintain conditions above 75 °F, 75% RH, and 212 mg/L for 48 hours and to spray highly porous materials with pH-adjusted bleach before fumigation.

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### Questions, Answers, and Comments

**Q Victor Medina:** Did you consider anything other than methyl bromide?

**A Jasper (Joe) Hardesty:** Yes, we considered many options. We initially looked at many dozens of systems/applications, then did a downscale where we narrowed it down to five different options as a rough cut. Then, we dove deeper into those based on criteria we had established. We initially looked at

many dozens of systems/applications. Methyl bromide was chosen by large consensus as the best system for this test.

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## 6. Concurrent Sessions 1: Underground Transport Restoration

Auditorium C-111

Moderated by Shawn Ryan and John Martin | U.S. EPA

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### Investigation of Sampling and Analysis Protocols for Underground Transport Restoration

3:15 pm

Staci Kane | Lawrence Livermore National Laboratory

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#### Abstract

Analysis of samples from characterization and clearance following a widespread bio-attack is a likely bottleneck to rapid restoration. Sample analysis is even more challenging for an attack involving underground transportation systems that contain complex chemical and biological backgrounds (“subway grime”). Current sampling and analysis protocols were investigated for their ability to rapidly and accurately detect the presence of viable *Bacillus anthracis* spores from subway samples (using the Sterne strain as a surrogate). Sample types included vacuum samples from train car HVAC filters and sponge-stick surface samples, as well as air filters from Hi-Vol PM-10 collectors potentially used for aggressive air sampling. Protocols were assessed in terms of potential interferences, limit of detection (LOD), and modifications that could improve method accuracy and sensitivity. In some cases, analysis was evaluated separately from sampling by spiking Sterne spores onto field samples or mock samples with added subway debris. For HVAC filters, spores were quantitatively loaded by dry deposition onto exposed filters and vacuum sampled, and resulting vacuum cassettes were extracted and analyzed. Clean samples and buffer-only controls were spiked or loaded with spores and processed in parallel. The Rapid Viability (RV) PCR method, co-developed with U.S. EPA, which uses the change in real-time PCR response before and after incubation to detect viable spores, was tested along with traditional plate culture analysis. In addition, samples were extracted for DNA analysis by real-time PCR. For all methods, LODs were assessed. Results showed culture analysis was challenged by the presence of Sterne-like indigenous colonies and often required PCR analysis of enrichment cultures for positive detection, especially for train car floor wipe samples and vacuum samples of HVAC filters with spiked spore levels  $<10^3$  per  $\sim 50$  in<sup>2</sup> section (5” c 3 pleats); however, lower LODs were noted for train car seat samples. Small modifications to RV-PCR protocols enabled detection of viable spores from complex subway samples including HVAC filter vacuum samples; increasing the growth medium volume and adding extra PCR enzyme enabled the 10-spore level LOD (10–50 spores) after only 9 h incubation. Proposed changes to current spore lysis, DNA extraction/purification, and PCR analysis protocols were shown to improve PCR detection in dirty samples (100 mg dust) by about one order of magnitude (to  $\sim 500$  spores/mL).

Together, these findings provide guidance for selection of sampling and analysis protocols for characterization and clearance of subway facilities following an anthrax attack. Remaining knowledge and technical gaps for sampling and analysis from subway environments are discussed.

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#### Questions, Answers, and Comments

- Q Richard Rupert:** I am a little confused. In your first or second slide, you said the only way you could really tell that you had viable *Bacillus anthracis* spores was with PCR (polymerase chain reaction).
- A Staci Kane:** We do a time-course PCR. Sorry if I did not make that clear. From the same sample, we take an aliquot at the beginning, before the spores are germinated, and an aliquot at the end and look for the change in PCR response. I should have mentioned the method does not extract the deoxyribonucleic acid (DNA) from spores. It only extracts DNA from vegetative cells. The spores have to germinate and outgrow before we will detect the DNA. We will see spore coat DNA if we have really high spore levels, otherwise, we are only seeing DNA from live cells.

- Q Richard Rupert:** I guess you could grow the plate out. The problem is that you have other critters in there that are growing. Did you try heat shocking?
- A Staci Kane:** We talked to people about heat shock and there is a concern that you lose some of your target and also that you are not getting rid of all of your background. A lot of our background is other bacillus spores. That is more of the problem. In our method, we include 30% ethanol when we extract. When we do a split sample for culture and RV-PCR analysis, of course, we do not do that. Ethanol will get rid of the same gram negatives, but you still have background from non-target spores. PCR analysis is not bothered by non-target organisms.
- C Paul Lemieux:** Tomorrow, Doug Hamilton is going to give a talk on culturing stuff out of really dirty matrices (e.g., landfill leachate and raw sewage). He has been comparing heat shock to a chemical method. We would love to see you try it on PCR. We have also been working with chromogenic media where the anthracis, or whatever you are working with, code blue and the others do not. I am just putting a plug in for what is going on tomorrow.

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## Advances in Sampling and Situational Awareness Using Augmented and Virtual Reality Devices

3:40 pm

Robert Knowlton | *Sandia National Laboratories*

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### Abstract

A need exists for a comprehensive decision support system to aid with sampling design, sample collection, data management, and data analysis to support rapid situational awareness for decision makers. A number of individual tools exist to support these needs and can be used as an ensemble but not always in an efficient manner. This need is both for sampling associated with chemical, biological, and radiological (CBR) response and recovery actions (e.g., characterization and clearance sampling), as well as for forensic data gathering. New technology in the form of affordable augmented reality (AR) and virtual reality (VR) devices has the potential to revolutionize our approach to data gathering and situational awareness.

Sandia National Laboratories (SNL) is on the leading edge in developing custom applications for sampling and situational awareness needs using AR and VR devices. In the AR application space, a new wearable headset (~\$3,000) that projects holographic information on the visor is used to document sample collection activities and to display infrastructure information to the user.

The device has voice and hand-gesture controls that provide the user hands-free operation. The headset can be worn under Personal Protective Equipment (PPE) headgear (e.g., Powered Air Purifying Respirator [PAPR] hood) and therefore does not need to be subjected to decontamination procedures after exiting a contaminated zone. The AR device has the ability to augment the data collection activities associated with interrogating suspicious packages with equipment such as the X-ray Tool Kit (XTK). AR can also project holographic displays of a scene of interest in a home team, Unified Command, or emergency operations venue. In the VR application space, a new visual-depth sensor coupled with a tablet computer (~\$5,200) is capable of creating a 3D point cloud of interior spaces in a fairly short time period, which facilitates a 3D virtual walk-through. This 3D representation of a scene of interest can be shared remotely with a home team, Unified Command, or emergency operations venue for more rapid situational awareness.

The new AR and VR hardware will likely revolutionize the way first responders perform their activities, providing a safer mode of operation and increased situational awareness for decision makers. These tools are being integrated into SNL's Site Exploitation System for Situational Awareness (SESSA) decision support tool. Examples of these applications will be shown.

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### Questions, Answers, and Comments

- No questions or comments.

### Abstract

The release of highly toxic materials (e.g., a chemical or biological warfare agent) within a subway system could result in widespread contamination of the system. We have tested a potential method for containment and neutralization of airborne droplets or particles of these toxic materials following their release in a subway system. By creating charged sprays of a mild decontamination chemistry (i.e., an activated peroxide formulation) and introducing it into the cloud of toxic material, the material can be rapidly knocked to the ground and neutralized. This approach has been demonstrated for knockdown and neutralization of biological pathogens, liquid aerosols of chemical materials, and vapors in a 512-cubic-foot test chamber at Sandia and then in a mock subway system during the Operational Technology Demonstration (OTD) conducted as a part of the U.S. Department of Homeland Security, Science & Technology Directorate's Underground Transport Restoration Project. In the chamber tests, a cloud of *Bacillus atrophaeus* spores (an anthrax simulant) was introduced into the chamber at a concentration of  $10^6$  CFU/L. After mixing, the mild activated peroxide was deployed as a charged spray for 1 minute through a series of nine electrostatic spray (ESS) nozzles located in an array at the top of the chamber. The total spray volume deployed was 2 L, and the concentration of the decontamination solution was  $\sim 138$  g/m<sup>3</sup> in the chamber. The results, averaged over four locations, demonstrated a 5-log knockdown and kill of the simulant immediately after the spray was stopped and a 6-log knockdown within 15 minutes. Similar tests were conducted with chemical warfare agent simulants and achieved greater than 4-log knockdown within 1 minute and 5-log knockdown within 15 minutes after the end of the charged spray deployment. For the OTD test, the system consisted of a series of 20 ESS nozzles mounted along the top and sides of the tunnel in the mock subway system. A flow of air at  $\sim 20$  feet/minute was generated across the spray knockdown system using negative air machines. *Bacillus atrophaeus* spores were released on the upwind side of the spray knockdown system and a series of four dry filter units (DFUs) was deployed on the downwind side to measure the concentration of spores that were able to flow past the system. A control test was also conducted to determine how many spores reached the DFUs when the spray knockdown system was not deployed.

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### Questions, Answers, and Comments

- Q Richard Rupert:** Is the exposure such that people could be in that area?
- A Mark Tucker:** The concept is that we would put this where people are not. It is not necessarily harmful to people. The concentration of peroxide is about the same as the brown bottles at the pharmacy. The concept is that you would put it in tunnels and places that people are not actually occupying. You would not put it in the station, but rather in the tunnels down from the station.
- Q Richard Rupert:** But you could put it where people were at in case there was a terror attack and somebody put something off in that area, correct?
- A Mark Tucker:** You could, but I think there would have to be some FDA (Food and Drug Administration) approval and things to intentionally expose people.
- Q Richard Rupert:** After you were done with this, did you collect any samples on the ground to see if you could actually see the spores on the ground?
- A Mark Tucker:** No, the only samples that were collected were the DFUs and the plastic pool that went out 15 feet or so from the spray knockdown. Those were the only places where we collected samples.
- Q Richard Rupert:** Did any of your experiments look at reaerosolization to see if the spores were still viable when pushed up?
- A Mark Tucker:** Not that I recall.
- Q Worth Calfee:** It seems like something like this could be useful in the remediation phase of a subway cleanup where you closed off your subway but you need a phased recovery where you block off sections. Did you determine efficacy as a function of particle size of your agents? They were nebulized, so there was an associated droplet size, correct?

- A **Mark Tucker:** No, in our aerosol chamber test, the spores were actually deployed as a powder, so they were dry. The liquid is nebulized. I do not think we changed the droplet size of the simulant. We may have done some of those experiments early on. We chose a droplet size that was representative of what we thought an attack might be.

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## Decontamination Options in a Subway Environment Following a Biological Release

4:30 pm

Lukas Oudejans and Shannon Serre | *U.S. Environmental Protection Agency*

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### Abstract

Contamination of an underground transportation system (e.g., a subway tunnel, station, and/or rolling stock) following an intentional release of a biological agent such as *Bacillus anthracis* will require rapid, widely available, and cost-effective decontamination methods. As part of the Department of Homeland Security's (DHS) Underground Transport Restoration (UTR) Program, the U.S. Environmental Protection Agency (EPA) evaluated multiple methodologies for the decontamination of subway and railcar materials contaminated by a biological agent. Two fumigation (chlorine dioxide [ClO<sub>2</sub>] and methyl bromide [MB]) and fogging (peracetic acid [PAA] and aqueous hydrogen peroxide) approaches were investigated to decontaminate various subway building and railcar materials under more realistic subway environmental conditions and in the presence of dirt and grime on various surfaces.

Fumigation conditions (temperature, relative humidity [RH], ClO<sub>2</sub> concentration, and dwell time) all have a marked effect on the efficacy of the ClO<sub>2</sub> fumigant to decontaminate concrete, ceramic tile, and painted steel. Lower temperatures (11–13 °C), combined with the RH near 75%, reduced the ClO<sub>2</sub> effectiveness significantly. Initial results for MB fumigation of similar subway materials indicate that such loss in efficacy at similar lower temperatures does not occur. Fogging of PAA was effective on many of the railcar materials tested but was ineffective for the subway railcar carpet, unsealed concrete, and axle grease (with spores mixed in); and moderately effective for the interior subway car fiberglass side panel material, and the clean and dirty railcar grease (spores left on top of grease). Changes in temperature from 20 °C down to 10 °C did not significantly impact the efficacy under the tested PAA fogging conditions in most of the cases tested.

This presentation will discuss these studies and their role in the selection of the decontamination systems for use during the recently completed UTR operational technology demonstration (OTD).

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### Questions, Answers, and Comments

- No questions or comments.

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## Developing Guidance for the Rapid Return to Service of Underground Transportation Systems Following a Biological Agent Attack

4:55 pm

Robert Fischer | *Lawrence Livermore National Laboratory*

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### Abstract

The Department of Homeland Security in collaboration with the Environmental Protection Agency (EPA) is in the final phase of a multiyear effort to develop a comprehensive remediation and restoration program for the Rapid Return to Service (RRS) of underground transportation systems. The Lawrence Livermore National Laboratory, along with several other U.S. Department of Energy (DOE) laboratories, has been tasked to develop this pre-incident RRS program with active support by EPA. A key component of the project is to develop actionable guidance documents at both the national and transit agency specific levels. The overall guidance strategy has been developed and is in process of being vetted through a series of workshops and tabletop exercises with participating transit agencies and key stakeholders. The guidance documents are designed to be compatible with the National Incident Management System (NIMS) and will follow established Office of Science and Technology Program (OSTP) response outlines. Progress on the Underground Transportation Restoration (UTR) decision framework will be discussed. In conjunction

with the development of the decision framework, a companion web-based software tool is in development. A conceptual model of the software tool will also be demonstrated as part of the discussion on guidance and strategy development.

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### Questions, Answers, and Comments

- No questions or comments.

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## 7. Concurrent Sessions 1: Water Infrastructure Protection and Decontamination

C-113

Moderated by Jim Goodrich | *U.S. EPA*

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### Water Utility Decontamination Preparedness Tools

3:15 pm

Veronica Aponte-Morales | *U.S. Environmental Protection Agency*

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#### Abstract

Drinking water and wastewater systems face major challenges when confronting a contamination incident—whether accidental or intentional. These challenges include isolating and treating contaminated water, as well as decontaminating water utilities' infrastructure to enable its recovery and return to service. The decontamination and recovery process of a water system following a contamination incident will vary on a case-by-case basis.

Therefore, water utilities and responders require decision-making tools that can be adapted to specific incidents as appropriate. To address the needs of the water sector, EPA's Water Security Division (WSD) is developing tools and other resources that can aid water utilities and responders in their decision-making analysis.

Preparedness is a key strategy to enhance response and decision-making during a contamination incident, resulting in a reduction of detrimental impact.

This presentation will highlight two tools EPA's WSD is currently developing to address decontamination preparedness. The first tool is Decontamination Preparedness and Assessment Strategy (DPAS) for Water Utilities (DPAS). DPAS is an interactive tool that walks the user through the three pertinent phases of remediation and cleanup, namely, characterization, decontamination, and clearance. In addition, the tool provides worksheets/templates for the user to populate and generate a customized remediation and cleanup strategy document. It also provides information on the progression of roles and responsibilities, and DPAS identifies resources that support decontamination efforts.

The second tool is the Water Utility Decontamination Preparedness and Assessment Tabletop Exercise Toolkit (Decontamination TTX Toolkit). This tool assists water utilities with developing, customizing, planning, and facilitating their own decontamination tabletop exercises. The following are benefits to conducting tabletop exercises:

- Increases familiarity with decontamination activities.
- Builds relationships and improves coordination between and among utilities and the response partners.
- Identifies areas for improvement in their emergency response plans and standard operating procedures.
- Gains familiarity with free tools and resources that can support decontamination preparedness.

The Decontamination TTX Toolkit consists of the following components: (1) injects – pre-scripted messages that provide information about the issue; (2) breakout groups – representative of all the organizations participating in the exercise; (3) hot-wash – facilitated discussion to capture feedback about any issues, concerns, or proposals to improve preparedness or enhance future exercises; (4) case study(ies) – portraying a real-life situation to provide experiential learning and add value to the discussion.

The presentation will also highlight other potential products currently under development to enhance preparedness, such as the work WSD is performing in collaboration with EPA’s National Homeland Security Research Center, other federal agencies, and water sector organizations.

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### Questions, Answers, and Comments

- Q Jeff Szabo:** When tools are published on the website, how do utilities get access?
- A Veronica Aponte-Morales:** The protocol is to send out an announcement – I’m not sure if there is a specific mailing list. We also provide a webcast to explain how to use the tools, which is a way of announcing it ourselves.
- C George Gardenier:** I believe these are intended to be publicly available on the water security website. You wouldn’t need to formally request to access them there.
- C Pierre Lauffer:** From an asset-management planning standpoint, you may want to consider cost for recovery and preparedness—in the long run, that may need to be a component. Water treatment systems specifically require cost considerations.
- A Veronica Aponte-Morales:** Thank you.
- Q Attendee:** You mentioned the incident in Pittsburgh—why did it take so long?
- A Veronica Aponte-Morales:** They went through stages. After a month, people could flush toilets, but not consume the water for nine months. Because it was difficult to set a clearance goal for when the water was safe to consume. People could still smell the chemical, and it was perceived as not safe.
- Q Brendan Doyle:** Do you beta-test these models with different scales of water-utility operators? Some small utilities with limited capacity may have issues with this.
- A George Gardenier:** We do try to beta-test our tools with utilities of various sizes, but we are not trying to disseminate a mathematical model. This is to help utilities generate documents to supplement emergency response plans, so this wouldn’t require a lot of computing capacity to implement, but we do seek feedback from utilities of various sizes.

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## Assessing the Effectiveness of Coliform Decontamination in Aircraft Drinking Water Systems

3:40 pm

Jeffrey Szabo | *U.S. Environmental Protection Agency*

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### Abstract

In 2009, EPA promulgated the Aircraft Drinking Water Rule (ADWR). The purpose of the rule is to ensure that safe and reliable drinking water is provided to aircraft passengers and crew. The rule sets a schedule for disinfection, flushing and coliform/*E. coli* sampling, in addition to instituting best practices and operator training. This is necessary since flight crews will fill aircraft water tanks from any airport as needed, and the quality of the water can vary (especially at international airports). If coliforms or *E. coli* is detected in an aircraft water system, the rule sets forth corrective actions and public notification that must take place, which requires costly time out of service. However, it is currently unknown where or how coliform bacteria may persist in an aircraft water system, and if disinfection and flushing procedure will effectively remove coliforms from the water system.

In this study, a full-scale reproduction of an aircraft drinking water system was constructed at the Test and Evaluation (T&E) facility in Cincinnati, Ohio. The water system was conditioned using tap water with a mixture of free chlorine and chloramines, which was periodically dispensed through an attached lavatory faucet to simulate passenger use on an airplane. After conditioning, the system was contaminated with coliforms. Disinfection was undertaken using two common airline industry methods: chlorine dioxide at 100 mg/L (or higher) for 2 hours, and ozone at 1 mg/L (or higher) for 5 minutes. After disinfection, the water system was flushed until no disinfectant residual remained.

Results show that coliforms were not persistent on the aircraft plumbing surfaces, and no coliform positives were detected after disinfection and flushing. The one exception was the aerator inside the lavatory faucet, which was positive for coliforms after disinfection with ozone. Levels of heterotrophic plate count (HPC) bacteria in the aerator remained elevated after disinfection with ozone or chlorine dioxide. These data indicate that the faucet aerators could be a source of coliform contamination that may result in coliform-positive samples taken under the ADWR.

Further experiments conducted on disinfection of aerators with glycolic acid and quaternary ammonia (both commonly used by the airlines) showed no detectable coliforms on coliform contaminated aerators after 30 minutes of soaking in the disinfectants.

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### Questions, Answers, and Comments

- Q Bob DeOtte:** When you tested the aerators, you took them out and sampled? Or drew water through them?
- A Jeffrey Szabo:** We put them in a big vat of coliform-contaminated water, took them out and then put them into either sterile water or disinfectant, and did that twice. With the disinfected ones, we didn't find coliform, but in the sterile water we did.
- C Bob DeOtte:** As a former director of public works and superintendent for a water department, that was always a weak point of sampling; if you didn't run the water long enough, you would almost always come up with something.
- C Jeffrey Szabo:** Sure, you've been in an airplane bathroom, people do their business and touch the sink and they could very well get something on there if you don't disinfect the outer surfaces adequately.
- Q George Gardenier:** I'm glad to see disinfection methods worked after the fact. I have a question about planes being taken out of service with coliform detection. Does the airport have to investigate?
- A Jeffrey Szabo:** Not to my knowledge, no. It falls pretty much on the air carriers.
- Q Victor Medina:** Does lower pressure going to higher elevations affect chlorine dissolving in the water?
- A Jeffrey Szabo:** The pressure in the tank should be the same because of the compressor. The elevation shouldn't matter.

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## Field-Scale Water Infrastructure Decontamination and Wash Water Treatment

4:05 pm

Jim Goodrich | U.S. Environmental Protection Agency

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### Abstract

The U.S. EPA Water Security Test Bed (WSTB) supports full-scale drinking water distribution system research on a variety of drinking water treatment topics including biofilms, water quality, sensors, and homeland security-related contaminants. In 2015, the WSTB was used to perform the following experiments:

- Four mobile disinfection technologies were tested for their ability to disinfect large volumes of biologically contaminated "dirty" water from the WSTB. *B. globigii* spores acted as the biological contaminant. The four technologies evaluated included: (1) Hayward Saline C™ 6.0 Chlorination System; (2) Advanced Oxidation Process (AOP) Ultraviolet (UV)-Ozone System; (3) Solstreme™ UV System; and (4) WaterStep Chlorinator.
- The WSTB pipe was contaminated with Bakken crude oil, and decontamination was performed by flushing with clean water and with addition of a surfactant.

The following is a summary of conclusions based on the testing performed at the Idaho National Laboratory WSTB:

- Results from the water treatment experiments indicate that disinfection of large volumes of water contaminated with *B. globigii* spores is feasible. All treatment units achieved at least 4-log removal of spores from the lagoon water over the course of the experiments, with some units achieving 7-log reduction. It is likely that larger volumes of water may need to be disinfected in a real-world scenario, but all of the tested mobile treatment systems can be scaled up or multiple units can be put into place. Data generated from this study do demonstrate that disinfection of contaminated water in the field is more challenging than disinfecting clean drinking water due to the disinfectant demand present in real-world wash water, the potential for low temperature, and disinfectant dissipation due to sunlight.
- Data collected during the crude oil contamination experiment suggest that flushing the pipe with clean water was an effective decontamination method. Benzene detected in the WSTB pipe from the oil contamination dropped below the EPA prescribed Maximum Contaminant Levels (MCLs) with clean water flushing, and no other benzene, toluene, ethylbenzene, and xylene (BTEX) components were detected in the water. Surfactant was injected because it was assumed a priori that oily components could persist in the water phase or on the



infrastructure surfaces. This was not the case, but online sensor data and visual observation of foaming in the water samples indicated that surfactant may have persisted in the dead-end portions of the WSTB pipe for weeks after the initial injection.

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### Questions, Answers, and Comments

- Q Stuart Willison:** Is there potential for leaching into PVC (polyvinyl chloride)/washing machine line, hot water heaters? The second part is looking at flushing lines in fire hydrants or before they get to their homes, how can you capture the water if it's flushed from fire hydrants—is there concern for it to go back to the sewer system?
- A Jim Goodrich:** We do have parallel lines, plastic, copper, and lead lines, and plans to look at water heaters/tanks. Another issue is aerosolization. Putting Bakken crude through—you can smell it. In terms of flushing—if it's going back into the ground, it could run off into creeks/watersheds, or back into the sewer system. That's a whole other aspect—what do you do with that water? Do you have to bring in tankers? Put water in the tank to recirculate/treat? Frack tanks that fracking companies use are on flatbeds. Recirculating water in those to treat are possibilities.
- Q Cayce Parrish:** I understand the practicalities for the aboveground setup—how do you account for temperature fluctuations in your study design?
- A Jim Goodrich:** The first experiment we did it was summer and still very warm. We had problems with the temperature—desert conditions. We've talked about covering it or insulating the pipes. Other experiments have been done in cooler weather with limited temperature change. It is a concern that we need to address.
- A Hiba Ernst:** We are hoping to have a covered pipe in line with another that's not and look at variability. We've got a list of things we're planning to do, we just need to prioritize.

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## Installation of Routine and Heightened Biosecurity Equipment and Protocols at Beef Cattle Feed Yard in the High Plains

4:30 pm

Robert DeOtte | *West Texas A&M University*

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### Abstract

Highly infectious diseases of livestock such as foot-and-mouth disease (FMD) are of particular concern to the Texas Panhandle and the greater High Plains. The states of Texas, Oklahoma, Kansas, Nebraska, Colorado, and New Mexico account for approximately eighty percent (80%) of fed beef (cattle ready for harvest) in the United States. Approximately twenty-eight percent (28%) of fed beef are within 150 miles of West Texas A&M University (WTAMU), located in Canyon, Texas. To create an opportunity for quick response, we have developed routine and heightened biosecurity protocols and installed an undercarriage and wheel wash at a beef cattle feed yard in the Texas Panhandle.

The unit had to match cost objectives, be able to wash vehicles quickly using minimum water (the feed yard holds approximately 55,000 cattle and receives 70 to 80 trucks per day), which is necessary: 1) because even at only 10 minutes per truck, it would require 13 h to wash them, 2) because the Panhandle is a semiarid region with only a nonrenewable underground water source, and 3) because it eliminates the need for wastewater treatment. The unit will be used on a routine basis for internal traffic with the expectation that maintenance costs of vehicles (front end loaders, pickup trucks, feed trucks, and other operational equipment) will be reduced, thereby providing an incentive for other feed yard operators to make a step forward by installing equipment that can be used immediately in a heightened biosecurity incident.

On 17 August 2016, personnel from DHS, USDA APHIS, USDA NRCS, IIAD, and WTAMU were able to see the unit in operation, and it adequately satisfied the requirement that a visible improvement in cleanliness of the vehicle was apparent after use of the undercarriage wash. As a result of this work, USDA NRCS is interested in developing protocols for installation and operation of undercarriage and wheel wash systems at livestock and poultry facilities.

Further, NRCS is currently exploring mechanisms by which further research may be conducted on the wash unit installed in the Texas Panhandle.

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### Questions, Answers, and Comments

- Q John Hall:** It looks like an unmanned facility—is there any operator risk at all?
- A Robert DeOtte:** No. The concrete barriers are only there to keep trucks from running off track and to protect the electric eye. The driver stays inside.
- Q Doug Ferguson:** Is this system amenable to, if there was a disease outbreak, could you just pump it with bleach and spray each truck?
- A Robert DeOtte:** Yes, but that would be corrosive. Something I didn't mention: we installed this in one day, concrete took two days, so three days of installation total. And these are available from the manufacturer.
- Q Brendan Doyle:** Are the cattle vaccinated for anthrax?
- A Robert DeOtte:** No. They are vaccinated for other things but not anthrax. In Texas, we have a place called the "anthrax triangle" where anthrax is endemic. Farmers and cattle in this area have built up antibodies.
- Q Rebecca Phillips:** For the waste-disposal issue, what do you do with the waste dirt?
- A Robert DeOtte:** We use it for fill dirt—it's okay for that.
- Q Rebecca Phillips:** For three gallons to wash each truck and 80 trucks per day, that's a lot.
- A Robert DeOtte:** That's only on a nonroutine basis—that would be for an outbreak. Routinely, they would only do a couple of dozen trucks per week.

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## Biocontaminants in Wastewater: Interactions Between *Bacillus globigii* Spores and Mixed Cultures of Activated Sludge

4:55 pm

Willie Harper, Jr. | *Air Force Institute of Technology*

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### Abstract

**Background:** Introduction of spores into the water cycle may pose a potentially dangerous threat to public safety. Biological weapons like spore-forming organisms are of interest to the DoD and the water quality community. Biocontaminated wastewater could result from incidents such as intentional injections carried out by an adversary or contamination of washdown water used in the aftermath of an attack. This water may reach wastewater treatment plants through runoff or discharge into the wastewater collection system. Therefore, it is necessary to understand how the activated sludge process could be impacted by biocontaminated wastewater. This work investigates both the effect of *B. globigii* spores on activated sludge activity, and the effect of activated sludge exposure on the properties of *B. globigii*.

**Results:** Spores decreased the maximum O<sub>2</sub> uptake rates and discernibly altered the shape of the respirometric profiles at 2 x 10<sup>3</sup> and 2 x 10<sup>5</sup> spore CFU/mL. However, metabolic activity was not stopped, and the spores did not cause statistically significant (t-test, p < 0.05) changes in the cumulative O<sub>2</sub> uptake and CO<sub>2</sub> production levels. When 2 x 10<sup>7</sup> spore CFU/mL was added, respiration was initially inhibited (typically), followed by a dramatic increase in both O<sub>2</sub> uptake and CO<sub>2</sub> production. This remarkable rise in microbial activity may be driven by the utilization of spores as substrate by activated sludge organisms and/or by partial spore germination. Syto 9 nuclear staining of spores exposed to active sludge indicates that a small percentage of spores might have germinated. Post-test agar plating of spores after activated sludge exposure showed colony formation ability similar to spores without sludge exposure, suggesting that spore viability remained unchanged during the treatment. Bright field and fluorescence microscopy both showed that spores were both "free-floating" and adsorbed to the surface of the floc particles. Atomic force microscope (AFM) images also showed that spores grown on sludge feed formed multilayered instead of monolayered clusters.

Conclusion: Spores impact the activated sludge activity profile in the concentration range between  $2 \times 10^3$  and  $2 \times 10^5$  spore CFU/mL but not at  $2.0 \times 10^1$  spore CFU/mL. The highest tested spore concentration,  $2.0 \times 10^7$  CFU/mL, triggered metabolic activity that is novel and possibly related to spore germination or the metabolism of *B. globigii* by activated sludge. Experiments demonstrate that spores remain viable after exposure to activated sludge and that some may germinate during treatment.

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### Questions, Answers, and Comments

- Q Attendee:** How did you determine germination?
- A Willie Harper:** We used an epifluorescence method that allows us to expose the spores to a probe. If the probe penetrates the cell, it's an indication that the spore shell isn't there anymore. Then, there's an automated counting method to count the fluorescent dots in those images.
- Q Victor Medina:** What was the role of ethanol?
- A Willie Harper:** If a person were to store these spores in ethanol (which is common) and then add that solution directly into a system, the ethanol can cause an effect and drive respiration. But if you added the spores as a powder or washed them first, then the spores wouldn't interfere with the activity of the sludge.
- Q Ryan James:** What would happen if spores were stored in water and not ethanol? Would that affect germination rates?
- A Willie Harper:** I think you would see a germination rate around 1–1.5% based on our other results. That sounds low, but 1% of a million is still a lot, so that's not good news.
- Q Robert DeOtte:** So you saw the collapse at the highest, at  $10^7$ , and not at the lowest?
- A Willie Harper:** Yes, and that had more to do with the volume of ethanol. The more spores we added the more ethanol we add. This is a concentrated solution of ethanol, so we're still only talking about a few microliters of ethanol, but at some point the amount of ethanol is so much that you see an effect on respiration.
- Q Robert Deotte:** So if I were to dump these things down a drain and they got into the sewer and it reached activated sludge?
- A Willie Harper:** I don't know if the ethanol effect would be seen at the wastewater treatment plant, because it would be mixed with a lot of other things going through.

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## 8. General Session 2: Chemical, Biological, and Radiological Research Efforts

Auditorium C-111

Presentations and Q&A moderated by Timothy Boe and Lawrence Kaelin | *U.S. EPA*

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### EPA's Selected Analytical Methods for Environmental Remediation and Recovery

8:15 am

Romy Campisano | *U.S. Environmental Protection Agency*

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#### Abstract

The Environmental Protection Agency Homeland Security Research Program's (HSRP's) Selected Analytical Methods (SAM) for Environmental Remediation and Recovery is a compendium of methods for use in analyzing environmental samples for chemical, pathogen, radiochemical, and biotoxin contaminants. SAM is a unique document that identifies a suite of methods for each contaminant based on analytical technique, type of analyses (e.g., presumptive, confirmatory), and matrices (e.g., water, particulates). During an incident when multiple laboratories are conducting analyses, the use of the same method provides comparable data (e.g., same instrumentation, data quality objectives) and eliminates the need to convert or extrapolate data generated using different methods; thus allowing stakeholders to assess the situation and make decisions in a timely manner.

SAM methods have been put into a searchable, online database that is updated regularly as new methods become available. In addition to updating the analytical methods, sample collection techniques are also evaluated and included in Sample Collection Information Documents. These companion documents will help ensure that samples taken in the field are in representative condition and of adequate quantity to go through the sample preparation and analytical process in the laboratory. Several companion documents have been developed to accompany SAM to aid the analytical methods of the field to laboratory sample collection process. In addition to the Sample Collection Information Document (SCID), these series of companion documents include Rapid Screening and Preliminary Identification Techniques and Methods, and Laboratory Environmental Sample Disposal Information Document. Collectively, these documents will help EPA's field personnel and EPA's Environmental Response Laboratory Network respond to incidents together with smooth transitions of development of plans, sample collections, selection of field and analytical methods, decontamination of equipment, and waste minimization/disposal, from cradle to grave.

These documents have undergone continuous review since 2003. HSRP is currently updating the selected analytical methods and sample collection information documents. This is a major task using workgroups with members across EPA, other federal agencies, and industries. There are four workgroups focusing on chemicals, radiochemicals, pathogens, and biotoxins. Changes include adding emerging analytes of concern; new sample types; and latest state-of-the-art methods, conventional methods, and their usability by adopting a tiered approach to match the analytes and the analytical methods.

Together, these findings provide guidance for selection of sampling and analysis protocols for characterization and clearance of subway facilities following an anthrax attack. Remaining knowledge and technical gaps for sampling and analysis from subway environments are discussed.

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### Questions, Answers, and Comments

- Q Mario Ierardi:** What do you see happening with waste and integrating that in the website and search efforts in the future?
- A Romy Campisano:** The radiological group is the forerunner—I know they're considering waste and what effects some of the decontamination agents might have on analysis and whether that should be adjusted for. The chemical group isn't making a special waste group yet, but there are considerations being integrated as best we can. Most have not added waste in as a separate analytical type. As methods become available, we can integrate those.
- Q Timothy Boe:** Have you thought about making your data available via a decision-support tool like Visual Sample Plan (VSP)?
- A Romy Campisano:** We haven't yet. The tool is very simple. All you need is a web browser—no special software or add-ins are required. But we would love to integrate with other tools and make it more widely available in the future.

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## Basic Research for Next-Generation Decontamination Technologies

8:40 am

Stephen Lee and Wendy Mills | *U.S. Army Research Office*

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### Abstract

The U.S. Army Research Office Reactive Chemical Systems Program seeks to achieve a molecular-level understanding of interfacial activity and dynamic nanostructured and self-assembled chemical systems to provide unprecedented hazardous materials management capabilities. This Program is divided into two research thrusts: (i) Interfacial Activity, which supports research aimed at understanding the kinetics and mechanisms of reactions occurring at surfaces and interfaces, and the development of new methods to achieve precise control over the structure and function of chemical and biological molecules on surfaces; and (ii) Synthetic Molecular Systems, which focuses on designing and integrating multifunctional, stimuli-responsive, and dynamic behavior into completely synthetic molecular and chemical systems. Research in this program may ultimately enable the design and synthesis of novel materials and processes that give the Soldier new and improved protective capabilities.

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## Questions, Answers, and Comments

- No questions or comments.

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## Hazard Mitigation Science and Technology Program for the DoD Chemical and Biological Defense Program 9:05 am

Charles Bass | *Defense Threat Reduction Agency*

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### Abstract

The Defense Threat Reduction Agency (DTRA) manages science and technology investments for the DoD Chemical and Biological Defense Program with a mission to expand our knowledge of threat agents and transition technologies into joint acquisition programs. Hazard Mitigation, a major sub-program area, funds research to find new technologies and methods with the goal to save lives, limit the spread of contamination, return equipment to normal mission operation, and enable operations at reduced levels of protection. The research portfolio spans a range between near-term, mature technologies to far-term, higher risk research. Projects are directed along four thrusts: equipment decontamination, personnel decontamination, resistive and responsive coatings, and wide-area decontamination of *B. anthracis* spores.

Significant progress has been made in the development of decontamination technologies that are transitioning to DoD acquisition programs. Recent work has improved sensitivity, readability, and shelf-life stability of a blister agent disclosure spray and demonstrated ways to reduce cost of production through tobacco expression of a critical enzyme. Additional performance data have been documented for hot-humid air biological decontamination against vegetative bacteria and viruses. Results have led to exploration of spore germination technologies as a means to decrease decontamination times and reduce required operating temperatures. New, nonaqueous decontamination formulations have been developed that exhibit superior performance in laboratory-based testing with chemical warfare agents on relevant material coupons. These formulations have the potential to reduce the logistical burden of military decontamination operations.

These efforts are integrated with current and planned acquisition programs to address capability shortfalls identified by the military services. Research takes place at DoD service laboratories, private industry, and academia. DTRA provides a critical link by managing these efforts to ensure that needed capabilities are delivered to the warfighter.

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## Questions, Answers, and Comments

- Q Cayce Parrish:** For wide-area germination, how effective is the germination agent in covering the area? What about nonporous areas?
- A Charles Bass:** The most challenging surface was turf. We did lots of research with spray application by agricultural spray systems designed to treat surfaces like turf. We came up with some strategies for dry mulching. It depends on the surface and the application method. We will take this to demo a turf area within the next year. We've only looked at small representations of turf so far.
- C Sanjiv Shah:** Based on comments from Dr. Sayles and Dr. Meiburg yesterday and also on a push from Congress for DOD, DHS, and EPA to collaborate, there is a technical coordination workgroup under which DHS, DOD, and EPA signed an MOU (memorandum of understanding) to collaborate in chemical/biological defense and research development. There are a few sub-group leaders here, as well as senior program coordinators. Mark Malatesta and Joe Cartelli from DoD, Markham Smith from DTRA, myself [Sanjiv Shah], and Eric Koglin are the senior coordinators for EPA, and Dr. Andy Long is the senior program coordinator from DHS. So please collaborate! Whatever collaboration starts from this moment on, keep your senior program coordinators informed so we can pass on that information to the Strategic Steering Group, which is made up of David Hassell, Dr. John Fisher from the U.S. Department of Health and Human Services (DHHS), and Dr. Greg Sayles from EPA, so they can forward this information to Congress.

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## 9. Concurrent Sessions 2: Biological Agent Detection

Auditorium C-111

Moderated by Brendan Doyle | U.S. EPA

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### Bioluminescent Reporter Phage System for *Bacillus anthracis* Detection and Clearance Monitoring Following Environmental Release

9:50 am

David Schofield | Guild BioSciences

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#### Abstract

Due to the large contamination footprint that would result from an airborne release of *Bacillus anthracis* spores, there is a need for environmental detection and clearance monitoring technologies that are high throughput, cost effective, and importantly for clearance, specific to viable spores. We are developing a “bioluminescent” reporter phage system for environmental detection and clearance monitoring of *B. anthracis*. The reporter phage methodology is based on integrating the genes encoding bacterial luciferase into the phage genome to create species-specific “light-tagged” phages.

In the absence of a host, the reporter phage by itself is unable to produce a bioluminescent response. If viable cells are present, the reporter phage binds to specific receptors on the target cell, infects, and uses the host’s transcriptional and translational machinery to produce the luciferase enzyme. Following the addition of an aldehyde substrate, “light” is emitted that can be readily detected and measured. The ability of the detection system to detect spores from environmental samples (water, surfaces, soil) will be presented. The challenges that are faced when working with complex samples and mitigation strategies used to overcome these challenges will be discussed.

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#### Questions, Answers, and Comments

- Q Sanjiv Shah:** Great presentation and I’m glad a lot of progress has been made since we spoke three years ago. Yesterday, you might have seen Staci Kane’s presentation where she collected samples from subway cars with a lot more matrices. Those are the real world challenges. Soil is of course a challenge, but subway cars, freighters, and other things are also challenges. So, what can be done to maintain the accuracy of the detection and improve the sensitivity? I’m most interested in the post-decontamination part of the response.
- A David Schofield:** There will be a tradeoff. While we try to keep the methodology as simple as possible, there is a tradeoff in terms of how low we can go; low meaning  $< 10^3$ /g. In complex matrices, such as a soil, I think we will have to do some spore extraction or some sort of magnetic bead protocol whereby the complex is mixed with a spore-specific peptide or something, to maybe collect the spores. I think it comes down to a tradeoff between how complex that sample is and the level of detection we need. If contamination by  $10^4$  or above? We can do it in situ, but to get a low LoD level, we’d have to do some sort of extraction.
- Q Sanjiv Shah:** Great answer. What happens is, when we talk about large numbers of samples and availability of laboratories to analyze those samples, it can take up to 72 hours. In my mind, if you can increase incubation time to 4–6 hours and then do cleanup as you mentioned, I think we still have a better analytical method.
- A David Schofield:** That signal should keep going over time. Potentially, as long as the bug amplifies, the signal will get stronger and we can get a lower level of detection.
- Q Richard Rupert:** Thanks for an excellent presentation. I have a question related to the reader’s views of the results and making a call of positive or negative or looking at the luminescence.
- A David Schofield:** It’s a laboratory-based test; we have negative controls. Now we have to make that cutoff of what a true positive and negative are. We aren’t there yet.
- C Richard Rupert:** So every time you do the testing, you have to run some positive/negative controls and, based on those values, you have to determine whether the test sample is positive or negative?
- A David Schofield:** Unless we have an internal illumination control, we’re not quite to that stage yet. I’d like not to have positive or negative controls, but I’m not sure if we can do that.

- C Richard Rupert:** Are the readings one reading at a time or batch readings?
- A David Schofield:** This was all done in 96-well microplates, which is how we can get that high throughput. We can also use a portable luminometer, where it's a single read. Right now, we can go through 96 samples in about 4 minutes, so it's pretty quick.
- Q Worth Calfee:** The lux operon is controlled by a core sensing and is a repressible expression—did you run into any natural attenuation by your mixed samples being repressed?
- A David Schofield:** We've taken out the controls allowance, and the only thing we have in there is a promoter driving lux A and B. We've separated those elements so, technically, it shouldn't happen.

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## Rapid, Quantitative Biological Indicator System with *Bacillus thuringiensis* Al Hakam Spores

10:15 am

Yoojeong Kim | Triton Systems, Inc.

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### Abstract

Biological agents pose high threats because they are invisible and odorless and a relatively small amount can infect a large population when released in a densely populated area. For the same reasons, assuring safety after cleaning decontaminated sites can be challenging. Currently available technologies require considerable labor, and results typically cannot be obtained before 24–48 hours up to seven days. Therefore, a system that can detect the effectiveness at a shorter period in a less labor-intensive manner can lessen the burdens of decontamination. Desired traits for such a system are: 1) suitable simulants for *Bacillus anthracis* spores, 2) various materials for spore strips, 3) simple and rapid, 4) quantitative, and 5) portable. Our rapid and quantitative biological indicator (BI) system with *B. thuringiensis* (Bt) Al Hakam spore strips assesses the viability of the spores quantitatively within 12 hours. The assay evaluates the ability of the spores to germinate and carry out protein synthesis as a measure of the viability of the spores. It is based on the activity of an enzyme that is packaged in dormant spores of Bt Al Hakam. This enzyme in dormant spores is either not active or not accessible to an assay substrate. When the spores germinate, the substrate is taken up by the spores and is hydrolyzed by the enzyme into a highly fluorescent compound. The enzyme activity and, thus, fluorescence generation are further enhanced by promoting outgrowth and vegetative growth of the spores. A single spore can be detected within 8–10 hours, whereas  $10^7$  spores can be observed in ~1.5 hours. Triton's rapid, quantitative BI system is capable of estimating the spore population within  $\pm 1$  log and allows a reduction in the time to verify 7-log destruction by 12–36 hours, when compared to most of current BIs. It also enables quantification of the outcome to accelerate the development of new protocols for military and commercial health care applications. It provides not only decontamination assurance in the field, but also the capability to model the decontamination kinetics for emergency responses or developing new decontamination systems for biological agents.

A part of this work was funded by the Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD) through the CBD SBIR Phase II Contracts, W911NF-12-C-0048 and W911NF-16-C-0074. The content of the information does not necessarily reflect the position or the policy of the Government.

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### Questions, Answers, and Comments

- Q Worth Calfee:** Can you comment on how the results of your BIs (biological indicators) compared to Tony Buhr's surface samples?
- A Yoojeong Kim:** All the samples were killed; they were injected with the assay solution and incubated for 12 hours. A typical fluorescence curve of the samples is shown in the left-hand side graph which shows no fluorescence increase during the 12-hour incubation period, indicating they were all killed.
- C Worth Calfee:** But the samples, there were positive recoveries, correct?
- C Tony Buhr:** There were a few.
- C Worth Calfee:** My point is, would this have overestimated the efficacy of the treatment?
- C Tony Buhr:** The places where the Triton System examined, we also had corresponding complete decontamination at those spots. The only places there were positives were in other areas where we swabbed. [Added post conference]: The only positives were from swabs and those numbers were

extremely low, and we believe those few survivors were cross-contamination issues. The hot humid air decontamination was successful with > 7 log spore inactivation per meter squared as indicated by all sampling methods, swabs, coupons and Triton BIs.

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## Detection and Identification of Environmental Microbes Contamination Using Novel LC-ESI-MS/MS Method

10:40 am

Rabih Jabbour | *U.S. Army, Edgewood Chemical Biological Center*

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### Abstract

The potential of a biothreats attacks or epidemic outbreak of environmental biological agents represents a challenging situation for responding personnel.

A mixture of emerging biothreats requires its detection and identification without prior knowledge of the sample. There is a need for technologies that can rapidly detect and accurately identify environmental pathogens in a near real-time approach. One technology potentially capable of meeting these needs is a high throughput mass spectrometry (MS)-based proteomics approach. This approach utilizes the knowledge of amino acid sequences of peptides derived from the proteolysis of proteins as a basis for reliable bacterial identification. Bioinformatics tools that provide bacterial classification can be used to evaluate this novel proteomics approach. This technique is a strong complement to the conventional genomic-based technologies used in microbial detection for biological decontamination of environmental samples.

The proteomics-based method does not require specific reagents or primers to perform the analysis of susceptible environmental samples and rather depends on the physical detection limit of the mass spectrometry system.

Results showed that bacteria can be identified in water samples collected from different water and air sources across the globe. The MS proteomics approach showed strain-level discrimination for the various bacteria employed. The proteomics-based method showed ability to characterize unknown environmental samples containing mixtures of bacteria to the respective genus, species, and strain levels when the experimental organism was not in the database due to its genome not having been sequenced. Such an MS-based proteomics approach has potential to be utilized for various applications including food safety, environmental monitoring, biosurveillance, and clinical analyses. This presentation will discuss the advantage of this novel proteomics method and will address its applications to environmental samples.

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### Questions, Answers, and Comments

- Q Worth Calfee:** Proteomics requires the isolation of proteins from your consortium of organisms in your sample and not all organisms or proteins can be extracted equally. There are all kinds of sample processing and sample selection things that can affect the protein strand you end up with. How do you overcome those challenges, and can you speak to the sensitivity and limits of detection of this method?
- A Rabih Jabbour:** The good thing about proteins is that the dry cell weight is approximately 60–70% made up of proteins for a bacterial strand. The question you ask, “How can you make sure the protein is equal for all bacteria?” We don’t. Whatever we are extracting, we were able to identify what they were looking for. The beauty about this one is there are some bacteria you cannot culture. Since you cannot culture, you cannot get the DNA from them, but you can collect them and get the protein out of them and identify them so it is easy in that sense. In terms of detection, we are only limited by the mass spectrometer that we are using. If the mass spectrometer is very sensitive, we will see more proteins, if not, we will see fewer. We are field testing a portable, commercially available mass spectrometer; so far, there is no mass spectrometer in the field that can identify the bacteria. It’s had to be in the laboratory until now.



### Abstract

Rapid and accurate screening of potential biothreat samples remains challenging, despite efforts to improve technology since the Amerithrax attacks over 15 years ago. Many biodetection kits are commercially available, from general indicator tests (e.g., protein only) to more specific agent tests (e.g., polymerase chain reaction (PCR) tests), but little third-party performance testing information is available. To meet this challenge, Pacific Northwest National Laboratory (PNNL) has developed a cost-effective and statistically rigorous methodology for evaluating biodetection instruments and assays. These methods are currently being drafted as American Society for Testing and Materials (ASTM International) standards and include multiple standard specifications for biodetection equipment and assay performance testing. An overview of the draft ASTM standard will be given, including the different testing modules, use of two performance tiers, and different levels of rigor. Structuring the standard in this way allows for the assessment of instrument performance over a range of metrics, rather than a simple pass/fail. While assessments using the highest level of rigor and performance metrics are clearly desirable, the flexibility of the standard allows the option to assess performance at slightly lower metrics while significantly reducing testing time and cost.

PNNL demonstrated the efficacy of this approach by assessing over three dozen portable commercial-off-the-shelf (COTS) biodetection technologies for the detection of *Bacillus anthracis* (“anthrax”) and ricin. In over 5,000 tests, we evaluated a wide range of technologies including PCR systems and immunoassays, as well as general biological indicator tests. Results demonstrate that the biological indicator tests provide limited utility but may be beneficial when combined with a more specific technology such as immunoassay or PCR. The biodetection technologies vary in performance, as well as cost, size, and ease-of-use. The standard development and testing efforts provide the testing and first responder communities with a unified testing approach that results in quantifiable performance metrics to guide appropriate procurements and optimal use to improve first responder bioresponse preparedness.

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### Questions, Answers, and Comments

- Q Sanjiv Shah:** Nice presentation. When you sampled the data for exclusivity, did the DNA get combined together?
- A Rachel Bartholomew:** Correct. What I didn’t mention were some of the assumptions we made when we were designing our standard. One of those is the assumption that all of the exclusivity samples were equivalent, so when they were tested, they were tested individually, but we actually pooled the data results.
- Q Sanjiv Shah:** I am an E-54 committee member, but somehow I am not familiar with this.
- A Rachel Bartholomew:** We are using E-54.1. I can get you hooked up with the chair for you to provide input. We have several standards that are either new or up for renewal, so that would be great.
- Q Marc Roberts:** Question regarding your standards. It looks like you have a bio-identifier; you’re testing everything paired with the bio-identifier along with the PCR assays that were provided with it, is that true? Is there any plan to assess/certify identifiers that are assay agnostic versus assays that are identifier agnostic? Some companies are starting to come out with an identifier that will work with anybody’s PCR assay and vice versa.
- A Rachel Bartholomew:** Do you mean identify ready-made PCR on an open platform? So, the POKKIT is an open platform that we looked at. The TCORE4 isn’t in the market anymore, but the TCORE8 has a cartridge you can put your own assays into. For now, we are looking just for those commercially on the market because we were looking at the end user as the first responder and they are going to be buying things that are premade, not a homemade assay. However, you could use this approach to evaluate and assess a homegrown assay.
- Q Marc Roberts:** Right, but what I meant by that is if someone’s assay or identifier is tested with certain assay identifiers does that mean is it only certified for the combination? Or can it be used on a similar device?

- A Rachel Bartholomew:** That's a good question, I guess we haven't thought about that yet, but I think it is possible. The full idea is to make this as modular as possible so that you can take the pieces and parts that make the most sense, but I think what you have to make clear in your results is how it was tested and which pieces and parts of the different modules or performance tiers were utilized so that it's very clear at the end what type of performance data is present.
- Q Kodumudi Venkatswaran:** You mentioned 47 samples and then 1 failure out of 79. Do you mean that you needed to replicate, after a failure you increased and replicated to get the 79?
- A Rachel Bartholomew:** It's 47 replicates in total. We started out with triplicates; for example, on our exclusivity panel, we did 13 samples and triplicates of those samples. Then, for the additional number of samples, our statistician randomly assigned different samples to make up that difference to 47. If we had a failure, we had her generate more of a randomization, and we added additional samples to our test. It was not 47 replicates of each sample. That was total. It is a much smaller effort that needs to be done for a given platform.
- Q Kodumudi Venkatswaran:** Do you have any plans for day-to-day operator variations?
- A Rachel Bartholomew:** We don't right now, but we know that is something that is critical. Even day to day, we see changes. It's something that we are beginning to think about, that is a great point.

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## 10. Concurrent Sessions 2: Chemical Agent Research

C-113

Moderated by David Bright | U.S. EPA

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### The Chemical Terrorism Risk Assessment

9:50 am

David Bradley | Department of Homeland Security / Leidos Contract Support

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#### Abstract

The Chemical Security Analysis Center (CSAC) is the Department of Homeland Security's primary resource for conducting science-based hazard and risk analyses and characterization of threat posed to the nation from an intentional or catastrophic accidental release of chemical materials. One of the tools CSAC has developed is the biennial assessment of risk associated with such a catastrophic release. The chemical terrorism risk assessment (CTRA) is a probabilistic risk assessment that allows the threat, vulnerability, consequences, mitigation techniques, and their associated uncertainties to be processed together to yield a comprehensive evaluation of risk to the nation for the compounds of concern. With each new CTRA, additional chemicals have been added to this list, starting with 57 chemicals in 2007, and in the next CTRA, more than 180 chemicals will be assessed.

Included in the CTRA are chemical warfare agents, toxic industrial chemicals, pharmaceuticals and other chemicals of high concern. The CTRA evaluates potential terrorist attacks to six target classes, including 37 representative indoor, outdoor, food, water, dermal, and chemical supply chain targets. By characterizing the likelihood and severity of potential threats, the results from the CTRA aid policy makers, risk managers, and other officials in making risk-informed decisions regarding pre-event planning, detectors, countermeasures, consequence management plans, and emergency response capabilities. In addition, the CTRA identifies knowledge gaps and key uncertainties and can guide focused research efforts. This presentation will give an overview of the CTRA methodology and will highlight potential uses of the CTRA results to inform detection and decontamination research and development efforts.

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#### Questions, Answers, and Comments

- Q Cayce Parrish:** How do you weight relative importance of medical responses to consequence-management, and is that kept standard across all your runs?
- A David Bradley:** We don't do any weighting. We just model the medical response. To this point, we've only been concerned with public health consequences. When we factor in economic impacts, things like decontamination and decontamination costs at least will be considered. I'm not sure if we'll ever look

at potential exposures to workers as part of the decontamination process, but we will consider the decontamination costs. I really can't speak to the economic model, but there are some standard methods that are being adopted to examine relative cost of looking at injuries vs. decon, but I can't speak to those details.

**Q John Lipscomb:** Where do you get the information on human-health risk assessment you use to inform consequences and what quality expectations are there for those data?

**A David Bradley:** We've had a group that's developed toxicity information within our organization, while relying on other sources. There's an active program at Edgewood Chemical Biological Center (ECBC) that's a major resource for us. It's an ongoing process and we're continually trying to improve those estimates because they are so critical to our risk values.

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## The Chemical Agent Reactions Database (CARD)

10:15 am

David Morton | *Department of Homeland Security / Battelle Contract Support*

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### Abstract

The Department of Homeland Security's Chemical Security Analysis Center (CSAC) was established in 2006 to be a critical interagency resource on information related to chemical threat materials. As part of this mission, CSAC has been routinely requested to assess the feasibility of synthesis of different threat chemicals, and to provide possible signatures related to byproducts or degradation products.

To meet this evolving need, CSAC created the Chemical Agent Reactions Database (CARD), an electronic database containing synthesis and degradation reaction pathways for over 650 different chemical threat materials. The CARD currently contains over 2400 individual reactions for over 2000 different reaction pathways.

Key features built into the CARD include the ability to search structure/substructures and related reactions, chemical names and their synonyms, chemical classes, customer directed taxonomy, chemical properties, molecular weight, formula, and Chemical Abstracts Registry number. The CARD displays search results that contain the complete reaction pathway, experimental details, reaction classification, and access to the original reaction reference.

Although the CARD was originally established for easy access to chemical reaction information, it is now being used extensively for making assessment regarding attribution, such as identifying reactions that have specific byproducts, use certain hardware/reaction vessels, etc. Planned enhancements in future versions include the incorporation of commonly accessed spectra and spectral signatures, especially those for commercial chemical detectors.

Keywords: Chemical Agent Reactions Database, Chemical Warfare Agent, Chemical Threat Agent, and Chemical Attribution Signature

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### Questions, Answers, and Comments

**Q Paul Lemieux:** On the chemical reactions, does it have any of the kinetic information you could use in modeling?

**A David Morton:** Not yet, I don't know a good source for that. But if people have that fate and transport information, that's stuff we would really like to use.

**Q Lukas Oudejans:** You have access to the ECBC literature on decontamination, does that imply that you are going to or have already included that?

**A David Morton:** Much of that is included. For example, if you took mustard and there was sodium hydroxide or bleach, it would show you all of the decontamination products. And the technical report to support that will be available, and that could have the kinetics information.

**Q Larry Kaelin:** Will the unclassified version have the same kind of information on unclassified compounds?

**A David Morton:** Correct. It will have all the same searching capabilities and any new requirements. None of that is classified. We want to move the platform to as many different areas as possible. One idea is to put it on the Homeland Security Information Network (HSIN), which is a Sensitive Security

Information/Law Enforcement Sensitive (SSI/LES)-level site, and would issue passwords to those who needed access, similar to what Dr. Shannon Fox does with Jack Rabbit. Any government official or contractor support would have access.

**Q Matthew Magnuson:** Is your intention to just compile reports or direct the reader to the best method among all the reports?

**A David Morton:** As far as the quality assessment report-to-report, for example, we may have several reactions that have multiple synthetic approaches to them, or they may have decon-efficiency data or toxicity data. We will take the responsibility to “rack and stack” based on information from the CTRA and other stakeholders on the “goodness” of data. The user will be informed about this data quality so they can take that into account. Yes, we intend to do that.

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## Chemical Hot Air Decontamination of CWA-Contaminated Materials

10:40 am

Joseph Myers | U.S. Army, Edgewood Chemical Biological Center

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### Abstract

The Joint Program Manager for Protection (JPMP) has recently funded an effort to evaluate a process that decontaminates chemical warfare agents (CWAs) without the use of harsh chemistries (e.g., bleach, sodium hydroxide).

Such a technology would be suitable for sensitive electronic equipment, such as aircraft instrumentation, without adversely affecting the surrounding environment. Decontamination of a material may be performed by either detoxification (neutralization) of the CWA, or removal of the CWA from the material. The Decontamination Sciences Branch (DSB) of Edgewood Chemical Biological Center (ECBC) has developed a method to evaluate Chemical Hot Air Decontamination (CHAD) at a laboratory scale using test panel methodology.

Contaminated samples were placed into an environmental chamber at CHAD conditions (170 °F, two air changes per hour), and samples were removed at specified time points to develop decontamination profiles for each contaminant-material combination. The CHAD process was shown to be effective at removing both blister and nerve agents (sulfur mustard [HD] and VX) from a wide range of material types (paints, polymers, bare metal, fabric, and adhesive-backed nonskid strips) over a week-long treatment period. The mechanism of removal of the CWA from the materials may be evaporation, hydrolysis, thermal degradation, or a combination of all three mechanisms.

Humidification of the air supplied to the chamber is also being evaluated as a method to reduce the time required to reach objective levels for the CHAD process by increasing the rate of hydrolysis of the contaminants.

Approved for public release; distribution unlimited.

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### Questions, Answers, and Comments

**Q Stuart Willison:** Did you look at other byproducts?

**A Attendee:** We did, and they seem to go away right along with the VX. We did monitor for byproducts during this process, but no byproducts were detected.

**Q Larry Kaelin:** Were any of the materials tested more porous materials? Like concrete, wood, carpet?

**A Joseph Myers:** Not to date, but there’s no reason to think that this process wouldn’t work for those materials.

**Q Lukas Oudejans:** Great work, but where did the VX go? Because you extracted the material and that’s all you were analyzing, that’s fine, but the VX did probably not degrade 100% – have you looked into that?

**A Joseph Myers:** We did a previous project where we looked at vapor off-gassing. VX is susceptible to thermal degradation, so we assumed any losses were due to that. But there is significant vapor that comes out of the chamber. We did measure it, but there’s significant thermal degradation as well.

**Q Tony Buhr:** I didn’t catch the size of the facility that you did the experiments in. Would you anticipate if you scaled up that you would have more difficulty maintaining the temperature?

- A Joseph Myers:** Absolutely, you would have a very difficult time maintaining temperature at a larger scale. For a facility with complex features, it would be difficult.
- C Wenxing Kuang:** We did a test and found that most of the VX penetrates porous materials, but we couldn't detect and could not extract anything at 120 °F, but it will slowly release after cleanup.
- A Joseph Myers:** We have high confidence in extraction methods, it's just solvent extraction.
- C Wenxing Kuang:** We were using carpet and concrete.
- C David Morton:** Concrete and grout have historically had issues. ECBC, Battelle, and Science Applications International Corporation (SAIC) have done studies where they couldn't detect anything for weeks, but would put mice in the chamber and they would die. It may be slow to come back out, but if you can't detect it, you don't know it's clean. I would caution that you need to make sure that if it's going to come out that your procedure gets it.
- C Wenxing Kuang:** We did a mass/balance analysis to see if it was still inside. After a week it looked clean, but after a month, a clean coupon could detect something.
- C David Morton:** Even if you can't detect it, an animal could get a toxic dose.
- Q Attendee:** We all love the idea—it's a great technology. In reviewing the earlier Joint Biological Agent Decontamination System (JBADS) presentation [Charles Bass], you made a statement about electronics and aviation. I know pilots who wouldn't fly away with their plane at 168 °F. Has the Air Force or anyone said they would be willing to use this idea that the electronics are safe?
  - A Charles Bass:** The JBADS tested if the airplane was able to fly. And it was at that temperature for multiple times six days at a time, so they could clear the airplane to fly.
  - A Mark Morgan:** They started it and taxied it. Absolutely if you can't get another pilot to do it – pilots that understand what's going on have no problem with it.
  - C Tony Buhr:** The full aircraft hangar size with all the humidity and temperature probes, so it has been scaled up to hangar size.
  - C Lukas Oudejans:** With very high humidity—50% absolute humidity—with porous materials, wouldn't it result in mold formation?
  - C Charles Bass:** First they bring up the heat, then the humidity, then there's no resulting mold.
- Q Matthew Maddox:** In that JBADS procedure, is the aircraft left intact or the components removed and the part subjected to this?
  - A Charles Bass:** The whole aircraft was intact and placed into a thermally insulated hangar.
- Q Lawrence Kaelin:** Are you considering scaling this up to do a large volume space, introducing humidity and heat? Sixty °C is pretty hot and can affect structural integrity. Have you done tests?
  - A Joseph Myers:** Most of our efforts focus on military – like planes, and everything there is rated for those temps.
- Q J. Neil Daniell:** For mercury removal, they would heat up a house to the 95 °F range – have you considered doing your tests at lower ranges?
  - A Joseph Myers:** Yes—that should be upcoming shortly because lower temperatures would mean less wear-and-tear on materials. But to date, this is where we are.

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## Natural Attenuation of VX following Application onto Nonporous and Porous Materials

11:05 am

David See | Battelle

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### Abstract

Although more persistent than other chemical warfare agents, recovery of VX deposited onto materials still decreases over time. This natural attenuation might be associated with chemical degradation, volatilization, and/or the binding of VX within the material. The influence of material type and temperature on VX attenuation was the focus of this investigation, with the purpose of evaluating natural attenuation as a low-cost, nonintrusive decontamination method. Testing was also conducted to study the influence of air exchange and the potential redistribution of volatilized VX.

Research was conducted first using five nonporous materials (glass, sealed concrete, painted drywall tape, ceramic tile, and galvanized steel) and secondly using five porous/permeable materials (unsealed concrete, plywood, rubber, plastic, ceiling tile). Material coupons were challenged with a 2-microliter droplet (1.9 milligrams) of VX. The coupons were held at 40% relative humidity at 10 °C, 25 °C, or 35 °C for predetermined times, which ranged from 30 minutes to 35 days. The coupons were then removed, extracted in solvent, and analyzed for VX using gas chromatography (GC)/mass spectrometry (MS).

Natural attenuation increased with increasing temperature. Based on nonporous materials, at least 90% VX attenuation occurred within 35 days at 10 °C, 7 days at 25 °C, and 2 days at 35 °C. Attenuation was slower with porous materials. The porous materials achieved 90% attenuation within 35 days at 10 °C (except for rubber, plastic, and ceiling tile with <80%), 28 days at 25 °C, and 7 days at 35 °C. Testing at 25 °C with nonporous materials was conducted both with the air inside the chamber recirculated, as well as with the air exchanged completely every hour throughout the test duration. Both conditions generated similar results; all other tests were conducted only under the air exchange condition.

With regard to redistribution, VX applied to glass coupons appeared to volatilize and then redeposit on adjacent unchallenged nonporous materials (up to 5.7 micrograms of VX was recovered after 7 days at 25 °C). During the testing with porous materials (only), efforts were undertaken to semiquantitatively detect VX degradation products (e.g., diethyl dimethylpyrophosphonate) using GC/MS. These relatively nontoxic degradation products were recovered from all porous materials except unsealed concrete and rubber. Unsealed concrete was associated with inherently low VX recovery, even after only 30 minutes, which may be due to agent binding within the concrete and/or the formation of other undetected degradation products. Data generated from this testing suggests that, given sufficient time, natural attenuation can significantly reduce VX surface contamination levels.

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### Questions, Answers, and Comments

- Q Victor Medina:** Could you speculate about photochemical contributions for materials outside?
  - A David See:** We used only an LED (light emitting diode) for this study in our chamber to minimize potential UV degradation. There's certainly some credibility to that.
- Q Lawrence Kaelin:** Would you consider increasing the air exchanges to reduce some of that offgassing?
  - A David See:** Certainly, but it's not something we evaluated for this. We didn't see any statistically significant difference between our air exchange condition and non-air exchange condition, but exchanged only at 1 chamber volume per hour. Therefore, increasing the air exchange rate would allow us to evaluate that.
- Q Lukas Oudejans:** David is presenting a poster this afternoon. Results for the sealed concrete showed us that if you repeated extraction, you would get additional VX, which shows penetration into the sealant material. Then, there's another study that shows migration under paint layers to porous surfaces below, so if you wipe it, you don't see it, but it's still there and probably will come out if you do that far.

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## 11. Concurrent Sessions 3: Environmental Resilience / Biological Agent Sampling & Methods

Auditorium C-111

Moderated by Sarah Taft and Leroy Mickelsen | *U.S. EPA*

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### Environmental Resilience: Exploring Scientific Concepts for Strengthening Community Resilience to Disasters

12:30 pm

Brendan Doyle | *U.S. Environmental Protection Agency*

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#### Abstract

Disasters can spread contamination, pose health risks, interrupt a community's drinking water, and impose burdens on waste management systems and other environmental services. Disruptions to environmental services such as

these affect a community's ability to recover from extreme events and can pose risks to human health, economic well-being, and local environmental quality. Building environmental resilience can protect communities from the impacts of disasters and is a key part of achieving long-term sustainability.

Measuring environmental resilience is part of this process. It can help federal, state, and local decision-makers determine their best course of action. However, current strategies to assess community resilience to disasters do not comprehensively address environmental systems and services.

NHSRC's Community Environmental Resilience Index (CERI) project began in 2013 as an effort to explore what resilience means for protecting public health and the environment as communities develop strategies to strengthen their resilience to natural and manmade disasters. This research helps advance resilience science by focusing on how environmental and ecological systems interact with social and economic systems.

The CERI project team's efforts have resulted in three work products and a path forward for researching environmental resilience: EPA Pursues Interest in Developing Community Environmental Resilience Indicators and Indices; Environmental Resilience: Exploring Scientific Concepts for Strengthening Community Resilience to Disasters. These two reports provide a working definition of environmental resilience, refined criteria for developing measures and indicators, and basis for seeking collaborations with community resilience leaders and experts. An Inventory of EPA's Tools for Enhancing Community Resilience to Disasters offers a catalog of EPA planning and decision tools for protecting public health and the environment while enhancing their community's sustainability and resilience for the future.

By partnering with key stakeholders, we seek ways to field test homeland security solutions for natural disaster recovery and resilience planning; and beta-test Dashboard concepts that sort out which tools may be applied to different types of CBRNE and natural disaster threats, risks, and challenges.

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### Questions, Answers, and Comments

- Q Jonathan Hermann:** Have you had a chance to tap into some of the work that has been done by the DoD on climate change and impacts on the base of resilience?
- A Brendan Doyle:** We didn't have any DoD representatives involved in the inter-agency Community Environmental Resilience Index workshop that we hosted in 2014 regarding their resilience/climate adaptation plans and strategies, but we have had DoD representation in other inter-agency meetings where community resilience was being discussed. Our EPA colleague Susan Julius has advanced some interesting research into indicators of community's resilience to climate change. I don't recall any specific technologies being cited in her work. We are trying to find places where someone has an interest in pursuing this line of thinking. That is a good tip, and we will explore more
- C Paul Lemieux:** There is the Sustainable and Healthy Communities (SHC) part of ORD that is working on a geographic information system (GIS) tool to look at the potential of sea level rise and climate change impacts on facilities. I don't know how they are tied into DoD efforts, but I know there are some things going on tied into water resilience. Have you looked at that?
- A Brendan Doyle:** We participated in a conference last spring with ResilientVirginia.Org and had several folks from the Hampton Roads Navy Installation there talking about how they'd like to adapt EPA's EnviroAtlas for that purpose, to map where they were expecting sea level rise and having to relocate base housing in and around the Hampton Road installation.

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## The Application of Biological Agent Sampling Methods to a Wide-Area Incident

12:55 pm

Colin Hayes | *ERG*

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### Abstract

A large-scale aerosol release of a persistent, disease-causing biological agent could result in the contamination of a wide geographic area, including outdoor surfaces, indoor surfaces, and underground surfaces. Potentially, there are several unknowns associated with the characterization and clearance sampling during the response to such an

incident. The biological agent and its characteristics, the mechanism of contaminant release, amount of contaminant released, and a plethora of environmental and meteorological factors are completely separate, yet interconnected processes that greatly influence the extent and level of contamination. Similarly, decisions related to the sampling strategy (e.g., sample medium, sampling area, spacing) will affect the cost, time, amount of waste generated, and personnel (i.e., resource demand) required to characterize and clear the contaminated area. To what degree sampling and, more specifically, variations in the sampling strategy, interact and contribute to overall resource demand, following a wide-area biological incident, is still largely unknown.

To address this gap, the U.S. Environmental Protection Agency is undertaking a study to assess the current state of knowledge regarding sampling methods that may be used for characterization sampling following a wide-area biological incident, specifically focusing on *Bacillus anthracis* (Ba) contamination. Available data obtained from the literature for current sampling methods and data from recent operational field studies are used to inform an analysis of the application of wide-area sampling strategies. By analyzing the combination of variables that inform the development of a sampling strategy and variations in resource availability, we can begin to evaluate the impacts of those variables on the response to a hypothetical wide-area incident. A discussion of the results and findings of this study, to include current gaps and future research opportunities, will be presented.

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### Questions, Answers, and Comments

- Q Howard Walls:** Let's just assume it's a spore release. The spores may not distribute themselves statistically over surfaces and there may be places where they are more likely to stick and live. In your urban outdoor area, you had 1% for grass, but what if you don't have a whole lot of grass and that is where most of the spores end up residing? So you don't need to sample acres of concrete you just need to sample the grassy areas. My other comment is that your numbers are overwhelming. We have to come up with something smarter than statistical sampling that would take into account things like reaerosolization and transport of the aerosol and where does the stuff want to go? So you don't have to sample very many things, you just have to sample a few things well.
- A Worth Calfee:** So the point of applying this to the wide area with the current rules wasn't to map out a sampling plan, it was to understand where we start from and where the limitations are. Then, using that model to vary the different inputs like the size of your sampling area and the probability to see where the best gains to the approach are. Also, one of our findings was the need to understand fate and transport in a wide area and where we can target sampling.

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## Novel Methods for the Characterization of Viable *Bacillus* Spores from Wastewater and Landfill Leachate

1:20 pm

Douglas Hamilton | *ORISE Research Participant with U.S. EPA*

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### Abstract

The intentional dissemination of *Bacillus anthracis* (anthrax) via the U.S. Postal Service in 2001 highlighted the extent to which different materials in a building might be contaminated. Subsequent research activities and planning exercises have addressed wide-area response and remediation of biologically contaminated zones. Characterization of the extent of contamination is challenging due to the diversity of sample matrices that may be collected and the presence of native organisms in the samples. Current analytical methods used by response laboratories include extraction of the target organism from field samples that typically arrive as swabs, wipes, and filters. Culture methods serve as the analytical "gold standard" for sample characterization, providing information about the extent of contamination and the effectiveness of response and recovery efforts. Characterization of the sample can be hindered by the concurrent growth of native organisms, which could be several orders of magnitude greater in concentration than the target organism. Sample processing methods that reduce or eliminate background organisms while preserving spore viability would enhance sample characterization.

This study compared heat treatment (pasteurization) and a novel chemical treatment to isolate *Bacillus* spores from complex sample matrices, wastewater, and landfill leachate that have high concentrations of native flora and diverse chemistry. Three members of the *B. cereus* group (*B. atrophaeus* subsp. *globigii* [Bg], *B. anthracis* Sterne [BAS] and *B.*



*thuringiensis* var. *kurstaki* [BTK]) were selected as target organisms for this study. Heat treatment and chemical isolation methods were optimized and successfully reduced background organisms, improving spore recovery and quantification of samples. Sample characterization was enhanced by the use of chromogenic media that contain substrates that result in visually striking blue colonies. Only organisms with particular biochemical processes are capable of utilizing certain chromogenic substrates, facilitating the identification of targets and discriminating against non-target organisms. The combination of sample treatment methods that reduce background organisms, coupled with media that help identify particular targets, identified optimum sample processing methods for Bg, BAS and BTK. This study provides information on surrogate selection, sample processing, and analytical methods useful for spore studies using nonsterile sample matrices.

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### Questions, Answers, and Comments

- Q Brett Amidan:** A lot of your bar charts had recovery efficiencies over 100%. Why is that the case?
- A Douglas Hamilton:** Statistically speaking, you're going to fluctuate around the center. So for each one of the data points presented, when you are going for percent recovery, there are five samples, giving you five means and five standard deviations. You have a calculated propagated error associated with those measurements. The controls are calculated the same way. Considering the uncertainty associated with each measurement it is not uncommon to calculate a percent recovery slightly over 100%.
- Q Brett Amidan:** Should you truncate them to 100% if they are getting over?
- A Douglas Hamilton:** You wouldn't want to reduce your data quality by truncating the values.
- Q Brett Amidan:** Did you have a measure of the variability that you expected in that denominator?
- A Douglas Hamilton:** When using the spread plate technique, the spores tested had roughly a 10% variation among plate counts with all the media tested. This was within expectations.

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## Comparative Efficacy of Decontamination Technologies for *Bacillus anthracis* and *Bacillus atrophaeus*

1:45 pm

Vipin Rastogi | U.S. Army, Edgewood Chemical Biological Center

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### Abstract

Comparative sensitivity (or resistance) of the spores of *Bacillus anthracis* (Ames), *Clostridium difficile*, and *B. atrophaeus* (Dugway Proving Ground-prepared ATCC 9372) to three commercial sporicidal technologies (vaporous hydrogen peroxide [VHP], chlorine dioxide gas [CD], and pH-amended liquid bleach) was evaluated. Comparative decontamination efficacy of these technologies has previously been evaluated for building interiors by the U.S. EPA's Office of Research Development. However, until now, no direct side-by-side laboratory efficacy studies had been conducted to compare the relative resistance of the Dugway *B. atrophaeus* spores (Bg) to the resistance of *B. anthracis* Ames spores or *C. difficile* spores. The main objective of this study was to evaluate the validity of using Dugway-prepared *B. atrophaeus* spores as a surrogate for spores of the Ames strain of *B. anthracis* in decontamination testing. A surrogate is considered suitable if its resistance to the test chemical is equal to or slightly greater than the resistance of the organism being modeled. A secondary objective was to determine the relative resistance of *B. anthracis*, *B. atrophaeus*, and *C. difficile*. Understanding the relative chemical resistance of *Bacillus* spores and *C. difficile* spores will enable prediction of sporicide performance against *Bacillus* spores based upon the vast body of hospital disinfection/decontamination data generated for *C. difficile*.

Small-size coupons of glass and pinewood (2 × 5 cm) were inoculated with ~7 logs of spores. Spore recoveries from glass coupons ranged between 10 and 25 % for *C. difficile* and 40 and 70 % for the two *Bacillus* spore types. The spore recovery from pinewood was significantly lower. For the two *Bacillus* spore types, the recoveries ranged between 25 and 40 % for *C. difficile* and recovery was ~5 % for the *Bacillus* spores. Overall, >6 logs of spores were recovered from glass and pinewood for all three spore types. Sporicidal efficacy results demonstrate that for all three technologies, *B. atrophaeus* spores showed a resistance to decontamination comparable to the *B. anthracis* Ames spores on both glass and pinewood surfaces. Interestingly, while the *C. difficile* spores kill profile by bleach and CD gas was comparable to the other spore types on both glass and pinewood, sensitivity of this spore type to VHP was different on glass vs. pinewood.

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### Questions, Answers, and Comments

- No questions or comments.

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## 12. Concurrent Sessions 3: Radiological Agent Research - I

C-113

Moderated by Sang Don Lee | *U.S. EPA*

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### Modeling Decontamination Strategies in the Aftermath of a Nuclear Detonation

12:30 pm

Matthew Clay | *U.S. Department of Health and Human Services / Leidos Contract Support*

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#### Abstract

In the wake of an improvised nuclear device (IND) detonating in a U.S. city, fallout is one of many concerns to those evacuating. We examine existing modeling of the effects of nuclear detonations, layering in prompt injuries, evacuation, and the exposures that accumulate during evacuation. We examine the risk of beta-radiation-induced cutaneous radiation injury (CRI) resulting from both direct skin and clothing contamination by fallout, as well as beta groundshine from people walking through fallout-covered areas. We calculate both the acute radiation syndrome (ARS) and CRI injuries that individuals may accumulate in the wake of a detonation.

While best practice calls for individuals to shelter in place in the aftermath of a detonation, many people are likely to attempt to self-evacuate and become contaminated. We examine the effect of different types of decontamination on the eventual CRI hazard on individuals and the overall effect on the numbers and types of CRI injuries. Individuals may self-decontaminate over the course of their evacuation (shaking off particles), perform expeditious decontamination when sheltering in place, or receive definitive decontamination when reaching an assembly/rescue area.

Part of the analysis is an examination of data gaps and their relative importance on the final outcome. The retention of fallout on bodies and clothing and the efficacy of different decontamination are both gaps, and their relative importance on the number and severity of casualties will be examined. The goal is to not only present information on the importance of decontamination CONOPS (Concept of Operations) for post-IND detonation, but also to help inform future research and development (R&D) efforts so as to prioritize the most important data gaps.

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### Questions, Answers, and Comments

- Q Matthew Magnuson:** On the 1950s film you showed—was that a demonstration of a good decontamination technique?
- A Matthew Clay:** I personally would recommend stripping off your clothes instead of brushing off your clothes. But how do you encourage people to run inside and strip? That's not what most people would do. Chemical incidents run into [the] same problem. There are changes from the 1950s we could improve on.

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### In Half a Half-Life of Cesium-137: NHSRC Research for Radiological Remediation

12:55 pm

Matthew Magnuson | *U.S. Environmental Protection Agency*

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#### Abstract

Release of radionuclides may result from radiological dispersion devices, nuclear detonations, or nuclear power plant accidents. Over the past 70 years, organizations such as the Department of Defense and the Department of Energy have conducted radiological research specific to their requirements.

Over the past 15 years, NHRSC has conducted research to address needs not met by existing programs, including research to support EPA's mission for protecting water systems and cleaning up wide-area, urban areas after a radiological release.

Applied research results are available in over 90 reports, journal articles, analytical methods, and operationally focused tech briefs, most of which are available at <http://www.epa.gov/hsreach>. This presentation will summarize and highlight some accomplishments, current projects, and future directions.

This research includes an end-to-end systems approach, which recognizes that what happens early affects what goes on later. Also, the end-user and stakeholder's input are incorporated when developing the products. A few examples in four broad topics include:

- Fate and Transport: radionuclide transport in urban environments, impacts of fires in contaminated forests, and fate in water and wastewater systems.
- Detection: laboratory methods for urban materials and water, wide-area survey, and online water monitoring.
- Decontamination: urban surfaces, water/wastewater infrastructure, commercially available chemical technologies, mechanical removal methods, gross decontamination methods, and low-tech methods.
- Waste Management: onsite treatment of contaminated water, screening/segregation, volume prediction and reduction, cost estimation, and relationship between decontamination and waste management activities.

The variety of tools, technologies, and data currently available and being developed can help optimize EPA's response and recovery activities during a wide range of site-specific conditions and requirements.

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### Questions, Answers, and Comments

**Q Victor Medina:** I'm curious about the idea of doing simulants/materials other than cesium. Cesium is pretty soluble and tough to generally treat or capture. Is there any reason to think other radionuclides could be more challenging?

**A Matthew Magnuson:** We did start with cesium as the most challenging one. We tried to focus on other radionuclides that can also be mobile subsequently. With cesium salts, you just add water and it becomes highly mobile. There certainly is interest in other radionuclides that can be mobilized and there are techniques to mobilize those.

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## RN Decontamination of Military Sensitive Equipment

1:20 pm

Marc Desrosiers | *Defence Research and Development Canada*

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### Abstract

The North Atlantic Treaty Organization (NATO) Joint Chemical, Biological, Radiological and Nuclear (CBRN) Defence Capability Development Group's Hazard Management Panel has identified the decontamination of sensitive equipment in military CBRN operations as a significant problem with no current practical solution. Sensitive electronic and optical equipment, for example, is critical to mission success and would not survive typical military decontamination methods, which may include the use of aggressive solvents and oxidizers along with mechanical scrubbing. Defence Research and Development Canada (DRDC), in collaboration with its NATO partners, is studying techniques for sensitive equipment decontamination, which are specific to radiological and nuclear (RN) agents.

Initial steps in this sensitive equipment decontamination study included identifying what in-service military equipment is considered "sensitive" and gathering information on existing decontamination methods that could be used on such equipment. Based upon guidance from the Canadian Armed Forces, Commercial Off-The-Shelf (COTS) cleaning methods were also considered.

DRDC has conducted small-scale trials to test selected existing and proposed methods in order to characterize their performance in terms of both decontamination efficiency and safety for use on sensitive equipment.

Non-radiological contamination trials using stable caesium chloride, cobalt and iridium metal, and strontium titanate are now complete. These simulants were used to determine whether the techniques used to contaminate and decontaminate the test equipment would cause damage to the equipment, and if so, to what degree. Visual inspection of the test equipment using optical microscopy both before and after decontamination gave a qualitative indication of the performance of the various techniques and also provided insight into what parts of the equipment the contamination tended to adhere to most strongly. The survivability of the equipment was performed via visual inspection as above and function tests.

With the non-radiological trials complete, DRDC has started evaluating the different techniques using radioactive materials to contaminate test equipment under various environmental conditions. DRDC participated in recent experiments led by Germany's Bundeswehr Research Institute for Protective Technologies and CBRN Protection (WIS) looking at the effectiveness of the German Armed Forces' RN decontamination foam on various test pieces, including but not limited to sensitive equipment, with water-based decontamination used for comparison. Based on post-decontamination function tests, the foam outperformed the water, giving better decontamination results and causing less damage to the sensitive equipment.

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### Questions, Answers, and Comments

- Q Ryan James:** What was the particle size you were using?
- A Marc Desroisiers:** It was a fine powder, we didn't measure it but it looked to be about 100 microns. We do the "shake and bake" method and shake off the residual, so we only tested what was on the surface.
- Q Sang Don Lee:** You tested the individual methods, is there a plan to combine all the methods?
- A Marc Desroisiers:** We haven't finished testing all the methods, so we have more to do. We are just making sure we don't damage the equipment or make it non-operational. The second part is to look at the efficiency of decontamination. We are just looking at which is the best method and let the operators decide.
- Q Bruce Akers:** As an ex-soldier, I am wondering why mess with a method for the rifle since there are no electronics, it's just a mechanical piece. Soldiers will just step in a hot shower to decontaminate.
- A Marc Desroisiers:** Some operations are not traditional, and showers might not be available. Rifle is a contentious issue and whether or not it is sensitive. It is a mechanical system but a precise system, and there is a need to protect the oils. Also, because cesium chloride is a salt, we are wondering whether it will rust it out. Yes, we are looking for operational and an expedient method to decontaminate.
- C Bruce Akers:** A soldier is just going use a spray bottle and surfactant. Their goal is to strip the weapon and re-oil before putting it back together.
- A Marc Desroisiers:** We are taking advice from our operators, and they are looking at details from "operation to extraction" where they won't have the ability to properly take apart weapons.

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## A Novel Approach for Evaluating Cost Effective Decontamination Options for Remediating a Radiologically Contaminated Site

1:45 pm

Jim Mitchell | *U.S. Environmental Protection Agency*

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### Abstract

Starting in July of 2015, we have been investigating a novel approach in determining cost-effective decontamination options for remediating the Advanced Medical Systems (AMS) site in Cleveland, Ohio. The AMS site manufactured cobalt-60 (Co-60) sealed sources until production ceased in 1991. The manufacturing facility, which is located adjacent to a densely populated residential neighborhood, remains radiologically impacted. Using a gamma-ray imaging device, a number of areas of elevated activity were identified at the facility. Based on a review of site characterization results, previous decommissioning plans and costs, previous research, and other relevant documents, a novel approach was developed to aid decision makers in selecting the most appropriate decontamination technology and to evaluate the impact of decontamination decisions on the overall resource demand. To accomplish this, a spreadsheet is used to incorporate two novel methods: 1) transformation of 2-

dimensional (2D) gamma ray radiation field information onto a 3-dimensional (3D) model for estimating surface area and surface contamination; and 2) an approach for estimating the impacts of decisions on overall resource demands. This presentation will describe efforts taken to evaluate cost-effective decontamination options for remediating the AMS site, develop a spreadsheet for evaluating mechanical decontamination technologies and the associated resource demand, and summarize the outcome of these efforts.

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### Questions, Answers, and Comments

- Q Mario Ierardi:** Great presentation. From the aerial image it looked like a residential area.
- A Jim Mitchell:** Yes, the AMS site is in a residential neighborhood.
- Q Mario Ierardi:** Are there concerns about outside of the building?
- A Jim Mitchell:** Yes, another objective of the site investigation was to determine if the contamination on the inside of the building is migrating and causing a threat to human health and the environment.
- Q Mario Ierardi:** Was the facility secure?
- A Jim Mitchell:** No. We (EPA's Emergency Response Program) did take emergency actions to secure the building after numerous break-ins. Copper has been stripped out of the building twice. We put iron bars up on windows and welded doors shut, added concrete walls to other possible entryways and partially fixed the electrical. Water does enter the building and make its way into the controlled areas, but there is no evidence contaminated water is making its way to the outside environment.
- Q Mario Ierardi:** For the calculator tool, was that developed off the S&T team?
- A Sang Don Lee:** Timothy Boe is the creator of the calculator, specially designed with Jim Mitchell's data. Right now, it's very specific toward this AMS situation.
- Q Mark Roisier:** Why does it show two hot spots?
- A Jim Mitchell:** Those are just different concentrations of activity from two different locations.
- Q Mark Roisier:** Was there overall contamination around [the hot spots]?
- A Jim Mitchell:** Yes, but we wanted to focus on imaging from the forward field of view. We also used lead shielding around the sides of the Germanium Gamma-Ray Imaging (GeGI) High Purity Germanium (HPGe) detector to shield out contribution from other directions.
- Q Mark Roisier:** We have the same instrument. Some images take pixels around to drop background, which decreases sensitivity. Does that affect your estimate of activity?
- A Jim Mitchell:** Yes, it does but since we were in a highly contaminated environment we were not as concerned with background subtraction. Dr. Matt Kiser at PHDS performed the data analysis and hot spot estimates.

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## 13. Concurrent Sessions 4: Biological Agent Research

Auditorium C-111

Moderated by Worth Calfee and Shannon Serre | *U.S. EPA*

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### Fate and Transport of Spores in Urban Environments: Understanding the Impact of Precipitation on Decontamination

3:40 pm

Anne Mikelonis | *U.S. Environmental Protection Agency*

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#### Abstract

The fate and transport of pollutants in urban settings is dictated by numerous complex environmental processes. Following a wide-area anthrax incident response, activities (decontamination, sampling, and consequence management) may last for a considerably long duration. During this time period, a number of different precipitation events may occur that influence the migration path and size of the contaminated zone. Response strategies and resource management can benefit from a better understanding of the impacts that shifting weather conditions have

on sampling, decontamination activities, and public health so that reassignment of supplies and personnel can be adjusted accordingly.

This presentation will discuss the removal and transport of *Bacillus* spores from concrete surfaces following rain events using two methods. First, bench-scale washoff studies of surrogate spores (*Bacillus atrophaeus*) from concrete surfaces under simulated overland flow and rain will be presented. These results will highlight the influence of flow rate and rainfall intensity on spore removal. Secondly, these results will be linked to their potential application in EPA's Stormwater Management Modeling Software (SWMM). The presentation will discuss existing washoff functions available in SWMM and highlight alternative fits for the collected data from the concrete washoff study. Further, the presentation will introduce ongoing research to use SWMM as a decision support tool during remediation efforts. Aspects such as techniques to increase the resolution of drainage zones, hotspot prediction, and integration of surface containment technology locations will be discussed. Despite many interrelated variables, a better understanding of movement of pollutants is critical to protect human and ensure environmental welfare.

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### Questions, Answers, and Comments

- No questions or comments.

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## Composite Sampling Efficiency for Clean and Grime Coated Surface

4:05 pm

Brett Amidan | Pacific Northwest National Laboratory

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### Abstract

Following the anthrax incident in 2001, research efforts have focused on improving sampling plans, sample collection, extraction, analysis, and response. This study looked at the application and efficiency of composite sampling. Composite sampling allows for samples from multiple sites to be combined, with only a single analysis needed. This sampling and analytical reduction reduces labor cost and sample turnaround time. This study evaluated the effects of composite sampling on the recovery efficiencies (REs), false negative rates (FNRs), and limit of detection (LOD) of *Bacillus* spores. Spores were collected following the Centers for Disease Control and Prevention (CDC) surface sampling procedure for *Bacillus anthracis* using a cellulose sponge. A statistical experiment was designed to test: 1) three composite methodologies (single medium single pass, single medium multipass, and multimediate post-sample); 2) four clean surface materials (stainless steel, vinyl, ceramic, and painted wallboard); 3) three grime-coated (dirty) surfaces (stainless steel, vinyl, and ceramic); and 4) number of sample locations composited (4, 8, 16). Tests were performed using a range of low concentrations of *Bacillus atrophaeus* Nakamura spores (ranging from 5 to 100 colony forming units (CFU)/coupon) and on surfaces that were clean, loaded with grime, and loaded with grime and a biological mixture. RE was statistically higher overall using the post-sample composite method compared to single medium composites for both clean and grime-coated materials ( $p$ -value  $< 0.0001$ ). Although there were significant differences in RE between clean and grime-coated surfaces ( $p$ -value = 0.0418), this difference is best explained by the significant interaction between surface material and presence of grime ( $p$ -value = 0.0017). Vinyl tile had significantly lower RE when sampled from clean surfaces when compared to the other surface material; however, when sampled in the presence of grime (with or without the biological mixture), the vinyl tile had the highest RE. The other surface materials were not as affected by the presence of grime. FNR and LOD analyses showed similar results. This study concluded that post-sample compositing is the most efficient composite sampling method, especially in the case of low concentrations of contaminant.

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### Questions, Answers, and Comments

- Q Richard Rupert:** On the vinyl thing, you may be seeing static electricity. We did a lot of sampling with anthrax some years ago and we had a lot of problems with static electricity. We also did whole tables using one swab. You talked about false positives, and that's why you used low concentrations. What did you find in the false positive aspect?

- A Brett Amidan:** Our goal was to try to measure what we think a false negative rate would be. A lot of times that is done with an LOD of 90 and so here is a plot of what we found. Of course this is all in the laboratory, so not in the real world.
- Q Worth Calfee:** Do you think recovery efficiency and limited detection or false negative rate is more important than buying down the number of samples? I understand trying to develop a robust method with high recovery efficiency and low levels of detection to support it when you are faced with a wide-area problem, but maybe the single media multispot method has utility over these because you have one stick to test and one to analyze in the laboratory? Maybe that advantage is more important than growth of recovery efficiency. Have you given any thought to that? To changing up the paradigm of what is an acceptable method? Not just based on laboratory results, but a bigger perspective on utility in a wide area.
- A Brett Amidan:** It's not something we've studied, but I think it could be studied. As I showed, we have some idea of our LOD 90, our false negative rate. As we understand, our false negative rate that's going to have an effect on the number of samples you need. If you have a bigger false negative rate, you need more samples. However, if you're able to go through them more quickly and perform more samples because you're doing that method, then that may be more advantageous than the gains in false negative rates you might lose. That would be an interesting thing to work at. Here we have a pretty good indication of what those are. In our case, we had some measures, so I think it could be an interesting exercise.
- Q Richard Rupert:** Is the false negative rate related to the concentration of the spores? This is the lower spore end? The five CFUs?
- A Brett Amidan:** Let's look at this plot; this might help you more. Here we see the 5–10–20, and so forth. Then we interpolate across that to come up with those numbers. Those are interpolated using the 5–100 range that we tested in.
- Q Richard Rupert:** By interpolate, do you mean deposit?
- A Brett Amidan:** It's taking what was our false negative rate; we have a bunch of runs at 5, 10, 25. We take the results of those and plot those down and then we look at that line and pick the point that crosses the gray line there, it uses all the 5–100.
- Q Leroy Mickelsen:** Increasing the number of sample spots, are you taking one sponge stick and using that multiple times or using a new sponge stick for each location and combining those and doing one analysis? I think there might be an issue with drying out that sponge stick if you use it across 16 locations.
- A Brett Amidan:** We did not use a single medium across 16 locations, but we did do it with four and eight. A single media/single pass and a single medium/multipass would only use one sponge stick across four or eight surfaces. Each surface of that sponge stick touched all four or eight coupons.
- C Leroy Mickelsen:** And by the end of the eighth coupon, it wasn't all dried out?
- A Brett Amidan:** In our case, it was workable in the laboratory. Whether it would be in real life, that's a good question.
- C Leroy Mickelsen:** Maybe if the last one was the one that was contaminated, the liquid might be dried out, and it might not pick up.
- A Brett Amidan:** It's possible. We randomized the single contaminant location areas, so there may have been some issues with that. One thing we got out of this was that using four coupons to do a single media cross, you can also do four more with another one and so on and composite those in a post-sample composite. Combining these, you could get a whole bunch and do all of those in one analysis.
- C Leroy Mickelsen:** You could do that and maybe cut your sample in half. Combine all of them and then if you have positives you still have the other half to try and figure out which one was positive.
- Q Sang Don Lee:** Like Leroy mentioned, losing media is critical. The wet wipe, as long as that liquid medium is partitioned between those two, you can use that sample. I think that is partly related to those different results on the vinyl and other surfaces. The vinyl is the hydrophobic surface, meaning that your liquid media is not going to be wet enough compared to ceramic tile or stainless steel, it has the chemical on the surface. Drywall may absorb more water than other materials. In the end, for the same area that you are trying to sample, you may have a different impact on the sampling. My question: What are your recommendations based on

your findings if it happens again (e.g., 2001)? Using the single method, at the time was a wet wipe, now we have sponge sticks and results of a composite sampling approach. Without knowing what is happening at the site, somehow the strategy should come—where is the sample, how many composites you have—based on your results. What could be done differently if we went back to 2001?

- A Brett Amidan:** I'm going to assume, under that condition, that we are looking for something that will be hard to find. In that case, you may want to know exactly what is where and the composite might not be the best way because you won't be able to keep track of the location. If your goal is just to detect, then a composite sample is a good thing. We should find ways to employ that composite sampling. If it is small amounts, the multimedia method of compositing is going to give you the best results if you are worried about your false negative rates. Usually you're more worried about false negative rates when it's a small amount of contaminant. I think you have to consider all of those things to put together a good strategy. Composite sampling can be used to knock down the number of samples during the analysis part, if not with media.

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## Streamlining Documentation of Sampling and Analysis Plans and Data Quality Objectives for Biological Contamination Events

4:30 pm

Erin Silvestri | U.S. Environmental Protection Agency

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### Abstract

Data quality objectives (DQOs) are used to ensure that environmental data of known and documented quality are collected for the intended use. However, the DQO process can be confusing and difficult to incorporate into the Sampling and Analysis Plans (SAPs) used during contamination events. In addition, in the event a contamination event occurs, development of SAPs might need to be done quickly, but thorough documentation of how samples are to be collected and analyzed can be time consuming. EPA's Homeland Security Research Program is collaborating both across the agency (with several regions and offices) and outside the agency to develop an online tool that will provide a standardized approach to transparently document microbial DQOs for field and analytical data collected during a biological sampling event. The tool is intended for use by data collectors, on-scene coordinators, and environmental unit leaders and will step users through development of an SAP while also incorporating DQOs into the plan. The tool will include drop down menus, custom fields, flags for action items or delegation, use of previous SAPs stored in the tool as a template for new ones, examples of how to fill out sections, and information bubbles. The final output will be a complete sampling and analysis plan with integrated DQOs, which can be routed for approval. This tool does not replace the use of the Visual Sampling Plan tool or use of a statistician to determine number and location of samples. This presentation will discuss the features of the tool to get potential users familiar with what is being developed. In addition, the presentation will allow time for comments in order to help improve it prior to final production.

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### Questions, Answers, and Comments

- Q David Charters:** Have you run this by the policy people?
- A Erin Silvestri:** We spoke with the person in the Office of Environmental Information, who was the main contributor to EPA QA/G-4 Guidance on Systematic Planning Using the Data Quality Objectives Process [John Warren].
- C David Charters:** You need to run it through those people because there are requirements for everyone in Superfund. There is a standard format that every quality assurance project plan has to follow and that the contractors have to follow.
- A Erin Silvestri:** This is not the quality assurance project plan. What you're seeing is the wire-frame, this is not what the final plan will look like, it's hard to show the entire plan in a presentation.
- C David Charters:** I suggest you go through some of the Superfund QA people who are going to be applying this because there are a lot of requirements in Superfund that need to be incorporated.
- A Erin Silvestri:** We do have the regional Quality Assurance manager [Nora Conlon] at Office of Environmental Measurement and Evaluation in Region 1 who is helping us.



We also are using the G5 guidance to guide the tool [EPA QA/G-5 document titled Guidance for Quality Assurance Project Plans (2002) and EPA QA/G-5S document Guidance on Choosing a Sampling Design for Environmental Data Collection (2002)].

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## Environmental Impact of Synthetic Biology

4:55 pm

Chris Warner | *U.S. Army Corps of Engineers*

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### Abstract

Rapid advances in Synthetic Biology have led to a great deal of excitement surrounding potential products and solutions that could fundamentally change many sectors, from energy and food production to health care and defense.

Unlike conventional mechanical, electrical, or chemical systems, which only work in the area they are administered, Synthetic Biology products such as engineered organisms can autonomously self-propagate in their environment, allowing them to diffuse throughout their intended application area and solve problems on a larger scale. This enables Synthetic Biology to offer unprecedented solutions to complex problems. This advantage comes with a significant concern regarding the potential environmental risks and impact of these technologies. While existing regulations and assessment for use of genetically modified organisms may be suitable for some Synthetic Biology applications, the potential impacts of various Synthetic Biology applications are unknown. A comprehensive assessment of hazards associated with specific Synthetic Biology entities and functions, as well as their potential interactions with the environment, is needed. While significant resources are being devoted to developing these technologies, much less attention has been given to understanding the ramifications of these technologies on the environment, as evidenced by a recent National Academy of Science report that highlighted the uncertainty of releasing Gene-Drives into the environment.

Release of these organisms/products, either intentionally or otherwise, may cause catastrophic damage. There are a number of methods in development that can be implemented to track the fate, transfer, and transferability of Synthetic Biology technologies, yet these may not be sufficient to ensure our security. We will discuss some current frameworks and metrics used to track synthetic biology technologies, as well as the manner in which synthetic biology challenges our security infrastructure.

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### Questions, Answers, and Comments

- Q Willie Harper:** You mentioned TSCA earlier, the Toxic Substances Control Act. Can you comment a bit more on what has happened and needs to happen with respect to that Act as it pertains to the regulation of products of synthetic biology?
- A Chris Warner:** I think right now, it's somewhat piecemeal, it varies on what are the product's attributes are and which organization it is filed under, in terms of FDA, U.S. Department of Agriculture (USDA), EPA—those are the three major ones right now. It depends on the application and the technology. This is a great question, and this is a huge source of concern right now. The coordinating framework for the assessment of biotechnologies at OSTP level is undergoing a reassessment, specifically with these types of products that are being developed. No one has the answer right now to where we are heading, but the need is out there. Some of the underlying regulatory science for how these work and how they function needs to be elucidated to a better extent before comprehensive regulations are in place.
- Q Peter Setlow:** You bring up some interesting things. In the 1970s, the recombinant DNA was raising its terrifying head, and there was a huge meeting where all the worries and concerns were laid out. And the whole scientific community, not just regulatory agencies, everybody came together to try to determine the concerns, how can we deal with them, what should we worry about, are there things we should say are off limits? Is anyone doing this in this area or is it going to be done from the top down? Or from the bottom and the top?

- A Chris Warner:** Great question. There's actually been a moratorium on germ line editing for genetic engineering. One of the problems is other organizations or state actors have already violated those—it is a voluntary moratorium.
- C Peter Setlow:** But it's more than that. Someone in a laboratory can say 'If I can get rid of this particular pest,' so much can be done now through Clustered Regularly Interspaced Short Palindromic Repeats/CRISPR-associated (CRISPR/Cas) editing, if they wanted to eliminate all the mosquitos, they could do it. It must come from both the scientific and regulatory community.
- A Chris Warner:** I know the scientific community is looking at what is going to be policy and how it can be implemented. These are very legitimate concerns; it could lead to catastrophically dangerous situations.
- Q Megan Howard:** Two points: Have you looked at any of the data function research of concern suggestions that have come out of the infectious disease community with regard to engineered infectious agents and the control and recommended advisory that the White House put out recently? Secondly, I think many of us can see, in terms of biological decontamination, how genetic editing on this scale can easily be deployed in the field, but do you foresee a future where that would be something we could effectively deploy in the field without causing more problems than we fix?
- A Chris Warner:** I'm amazed by how many talks over this Conference have been bench to pilot, you get errors or unforeseen consequences, and then from pilot to full scale you can get effects that you never anticipated. I imagine that in the development of this field, we're going to see those types of effects. It is critical that we bound these experiments so that if there are unanticipated consequences, those are controllable and not catastrophic. I do think that the benefits of these technologies do merit further investigation and will ultimately be more cost effective in specific application areas. These could be game changing in many areas. How do we ensure that the development process and the research dollars are spent well? As a community, that is the question we need to ask ourselves.
- C Worth Calfee:** In biological instances, a potential environmental impact.
- Q Megan Howard:** That's why I brought up the DURC (dual use research of concern) policy, because the recommended procedures mirror it and it is meant to be in partnership with it. I've worked with avian influenza and other diseases, so this is at the forefront for me. I think that type of application process and monitoring is where the scientific community has questions.
- A Chris Warner:** I think infectious disease is a great start, it gives us a framework and a model to build off of, but there are differences in some of these technologies we need to identify.

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## 14. Concurrent Sessions 4: Radiological Agent Research - II

C-113

Moderated by Terry Stilman | *U.S. EPA*

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### A Water-Based Formulation for Rapid Response after a Radiological Incident

3:40 pm

Wenxing Kuang | *Environment and Climate Change Canada*

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#### Abstract

A rapidly deployable, water-based formulation has been developed for use in early-phase mitigation after a major radiological or nuclear incident in an urban area. This work presents bench and pilot test results and discusses the outcomes from the field application of the technology. This early-phase mitigation technology can be performed within a very short time by first responders such as firefighters, using standard equipment. This technology will reduce the level of radioactivity and create safer conditions for subsequent response operations. The formulation is designed to enhance the removal of radionuclides from contaminated surfaces and to prevent their re-deposition. The formulation can be applied as an aqueous solution or as an additive combined with foam using existing dispensing equipment, for example, with a firefighting truck for wide-area coverage, or with regular garden sprayers for small contaminated areas. The mitigation formulation has been tested and optimized on common porous building

materials (concrete, brick, limestone, and asphalt) using nonradioactive surrogates including cesium (Cs) and cobalt (Co). A high efficacy of activity removal was confirmed in laboratory and pilot-scale tests using radionuclides: 71% removal of Cs-137, 63% removal of Co-60, and 94% removal of Americium (Am)-241 on concrete.

When the radiological incident involves fire or flammable chemicals, the formulation can easily be mixed on site with Class A foam (regular firefighting foam), Class B foam (for flammable and combustible liquids), or other types of firefighting foam. The operational readiness of this technology was established in a decontamination technology demonstration trial in Columbus, Ohio, in June 2015. The trial was organized by the U.S. Department of Homeland Security and U.S. Environmental Protection Agency and hosted by Battelle Inc. to evaluate the operational factors of the selected response and recovery technologies following a major radiological or nuclear incident. For each of two tests (formulation mixed with foam A and foam B, respectively) on a 100-square meter section of a five-story brick building, approximately 400 liters of liquid waste consisting of foam and rinse water was generated and the time required for one application was <2 minutes. The liquid waste was collected in a portable pool-type container and later transferred into waste drums. De-foamer was added to diminish foaming. First responders who participated in this evaluation provided positive feedback on the formulation, noting its rapid deployability and ease of application.

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### Questions, Answers, and Comments

- Q Michael Kaminski:** The data you're getting back is high! Can you talk about the active ingredients in the two foam formulations?
- A Wenxing Kuang:** Universal decontamination formulation has already been proved for all hazardous substances—chemical, biological, and radiological. We modified the formulation that was developed by the Department of Defense (DoD), and already commercialized for chemical and biological decontamination, we just modified to add the component to “catch” the radiological material. For the mitigation formulation, it's just for radiological cleanup. It is also compatible with firefighting foams, like Class A and Class B foams.

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## Irreversible Wash-Aid, Treatment, and Emergency Reuse System (IWATERS) for Strontium Contaminations

4:05 pm

Michael Kaminski | Argonne National Laboratory

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### Abstract

The Irreversible Wash-Aid, Treatment, and Emergency Reuse System (IWATERS) has been developed to mitigate the release of radioactivity to the urban environment by disseminating, collecting, and processing decontamination wash water. Previously, IWATERS was investigated for the treatment of surfaces contaminated with radioactive cesium. Experiments were performed to investigate the expansion of IWATERS for strontium (Sr) contamination. Bench-scale tests were performed to investigate various counter-ions and chelators to promote ion exchange of strontium from building surfaces.

Desorption results for Cs, Sr, and europium (Eu) from concrete aggregate and concrete, brick, and asphalt coupons using static soak and low- and high-pressure flow with calcium (Ca<sup>2+</sup>)- and barium (Ba<sup>2+</sup>)-rich wash water will be reported along with those from nonporous surfaces such as glass and vinyl siding. Several sorbents were tested for their ability to specifically separate Sr<sup>2+</sup> from these high ionic strength wash waters. The outer sphere complexation behavior of hard Lewis acids like Sr<sup>2+</sup> complicates selective separation of Sr<sup>2+</sup> onto common earth materials like clays, rocks, and soil in the presence of competing counter ions and greatly limits the technical options for strontium-specific sorption. Only zeolite-type, synthetic ion exchangers exhibited sufficiently large K<sub>d</sub> values, while avoiding precipitation processes, for usage in separating radioactive strontium to enable recycling of wash waters with high ionic strength (due to Ca<sup>2+</sup> counter-ions, for instance). Alkali metal salts were also found to be effective counter-ions for decontamination of Sr<sup>2+</sup>, which may facilitate the use of common sorbents, even if their K<sub>d</sub> values are <100 mL/g. In practice, low K<sub>d</sub> values require the use of large quantities of sorbent. Computer simulations were run using the GoldSim Contaminant Fate Module software package to optimize the efficiency of IWATERS for strontium and account for the technical limitations of the sorbents. This modeling allowed greater flexibility to design the wash water recycling system for various end-user specifications including options from rain barrel designs for treating

runoff from roofs and facades to larger options like drainage basins for larger-scale wash-down activities. The presentation will discuss early simulation results and the practical implications of these studies on the design and operation of IWATERS for strontium removal.

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### Questions, Answers, and Comments

- Q Mark Desrosiers:** You showed low-pressure versus high-pressure and it looked like low pressure was better. Is that just a cause of quantity of water? And will you capture the amount of mL/L you are capturing for the high pressure as well?
- A Michael Kaminski:** Yes, that could be the reason. When we did tests at lower pressure than we show here, we saw that decontamination went up and it never did tail off. So we don't know how much more you would have to go up on a volume-per-square-meter basis before you reached a plateau. That's something we're going to study. We just don't have it shown here. Yes, we have data for the collection and we will be doing single path and multiple paths until we get to something that levels off.
- Q Wenxing Kuang:** How do you make sure you don't have radioactive stuff there in the water?
- A Michael Kaminski:** We need some type of monitoring system on the clarification skid that would give us an indication of how many disintegrations per minute (DPMs) we are seeing in the water. Or at least, sequentially between filtration basins, so that we have assurance that levels are sufficiently clean. But I can't tell you what that detector system looks like.
- C Wenxing Kuang:** You need a monitor or sensor to make sure.
- A Michael Kaminski:** I think John Hall can explain the difficulties they've encountered with trying to develop a real-time system. We need some type of monitoring system to provide an assurance that the radioactivity levels are sufficiently clean and the water can be used. We need an in-line detector system that has sufficient sensitivity.

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## Current and Emerging Post-Fukushima Technologies and Techniques for Wide Area Radiological Survey and Remediation

4:30 pm

Mark Sutton | Lawrence Livermore National Laboratory

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### Abstract

Technologies to survey and decontaminate wide-area contamination and process the subsequent radioactive waste have been developed and implemented following the Chernobyl nuclear power plant release and the breach of a radiological source resulting in contamination in Goiânia, Brazil. These civilian examples of radioactive material releases provided some of the first examples of urban radiological remediation. Many emerging technologies have recently been developed and demonstrated in Japan following the release of radioactive cesium isotopes (Cs-134 and Cs-137) from the Fukushima Daiichi nuclear power plant in 2011. Information on technologies reported by several Japanese government agencies such as the Japan Atomic Energy Agency (JAEA), the Ministry of the Environment (MOE), and the National Institute for Environmental Science (NIES), together with academic institutions and industry, will be summarized and compared to recently developed, deployed, and available technologies in the United States. The technologies and techniques discussed may be deployed in response to a wide-area contamination event in the United States. In some cases, additional research and testing is needed to adequately validate the technology effectiveness over wide areas. Survey techniques can be deployed on the ground or from the air, allowing a range of coverage rates and sensitivities. Survey technologies also include those useful in measuring decontamination progress and mapping contamination. Decontamination technologies and techniques range from nondestructive (e.g., high pressure washing) and minimally destructive (plowing) to fully destructive (surface removal or demolition). Waste minimization techniques can greatly impact the long-term environmental consequences and cost following remediation efforts. Recommendations on technical improvements to address technology gaps will be presented together with observations on remediation in Japan.

### Questions, Answers, and Comments

- Q Mario Ierardi:** Those visuals are telling. I'm really interested in the comments about the leaf index—has there been any work on dry deposition above the canopy?
- A Mark Sutton:** It's very seasonal, because of rain and because Cs is soluble, and also because of deciduous tree populations.
- Q Jenny Buckley:** How are they managing the analysis for all of those samples?
- A Mark Sutton:** They have various laboratories. It's a very modern laboratory and can handle large throughput, but it's the same issue we would have here. There's more than one laboratory, there are others, but there is still a problem of bottlenecking with volume of samples.
- A Sang Don Lee:** Going back to Mario's question: About 65% of the contaminated area is forest. Currently, there is no policy to clean up forest areas. The only area cleaned is within 20 meters from residential or commercial areas—to remove litter and prune branches. Contamination is originally deposited on leaves, then moves to bark, then to soil, then to new-growing trees. Contaminants are dynamic and they're moving around. For Jenny's question about the laboratory: Cs is the only contaminant they are focusing on. Criteria for cleanup rely on gamma exposure dose. So air monitoring is the main tool. At the same time, they are taking soil samples—that takes one time covering the entire area 6 months, and they're doing it twice. That's only the central government, which is the Ministry of Environment. Where we visited, they were sharing a laboratory. There are two laboratories in one building monitoring and analyzing samples. The central government has their own laboratory network, and the prefecture government has their own laboratory network, and universities also have laboratories. I'm not sure how they share those data, but they have those independent laboratory systems based on how the government is set up.
- C Wenxing Kuang:** The main thing is because of the height of detection. If you put it at the ground, you would see a big difference, even in the same place.
- A Mark Sutton:** The one at the side of the road is on the ground, but the big difference is that the whole area had already been decontaminated.
- C Wenxing Kuang:** I agree with Sang Don about the uptake in trees.
- Q Mark Desrosiers:** At the time when they did the measurement in the trees—was it just after the event?
- A Sang Don Lee:** The information that Mark showed is from the 2012 testing results. Regarding Wenxing's question: comparing a highway and in front of a hotel—the reading was 10× different. The story I heard is that local government has come up with a cleanup plan and has to request funding. Whoever comes up with a plan first will be reviewed by central government and if approved, then get funding. Fukushima City was waiting because their levels were close to clean. They finally did planning with a new mayor and got funding and cleanup. Why was Fukushima city low compared to the surrounding area? Because it's urban. Urban areas are designed to transport contaminants when it rains. The highway is in the middle of a forest—that's interference from the forest gamma. The road is at the same level as the urban area, but the forest will have higher levels. If the city is contaminated, it will move around quickly. That's not necessarily an advantage because of urban underground system—wastewater system, or underground transport systems. During this session, I am glad we covered everything from human to structural decontamination and the Fukushima incident, and this guarantees a more in-depth discussion next year. Thank you to all the speakers. If you have any questions for any of the presenters, please contact me.

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## Evaluation of Low-Tech Remediation Methods Following Wide Area Rad/Nuc Incidents

4:55 pm

Ryan James | Battelle

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### Abstract

EPA's NHSRC and Battelle have recently completed experiments that have determined the efficacy of a variety of indoor cleaning methods (wet and dry wipes, brooms, wet and dry vacuum, wet and dry Swiffer®, electrostatic pads, etc.) in the removal of radiologically tagged simulated fallout material (RTSFM) from the surfaces of multiple indoor surfaces (granite and laminate countertop, wood and laminate floor, toilet tank covers, painted wood trim, and wood dressers) staged in a pilot-scale experiment. These are indoor surfaces that would be immediately important for decontamination of personal residences during recovery efforts in the event of a radiological attack.

The RTSFM was generated using Arizona road dust in two distinct particle size ranges: less than 10 micrometers ( $\mu\text{m}$ ) and greater than 250  $\mu\text{m}$ . Then, each particle size range was tagged with a unique radionuclide. The smaller particles were tagged with rubidium-86 and the larger particles were tagged with cesium-137. The RTSFM was applied to the indoor surfaces using a dry deposition of RTSFM, as well as an aqueous application referred to as aqueous simulated fallout material (ASFM). Following deposition of the RTSFM and ASFM, the gamma radiation from the contaminated surfaces was measured. The various indoor cleaning methods were then used to decontaminate each different indoor surface. Lastly, the gamma radiation emitted from the "decontaminated" indoor surfaces was measured, and a decontamination factor (i.e., efficiency of radionuclide removal) was calculated. Results will be presented that include the quantitative (i.e., percent removal) and qualitative performance of the cleaning methods on each indoor surface. Percent removals range from 0% to 100%, depending on the combination of surface and cleaning methods.

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### Questions, Answers, and Comments

- Q Mark Sutton:** In the video you showed, are the grid lines drawn or etched onto the surfaces?
- A Ryan James:** They are drawn on.
- C Mario Ierardi:** Thank you and Sang Don for streaming this live while you were doing it! It was very useful to be able to see. Really valuable information coming from these efforts.
- A Sang Don Lee:** I want to try to answer Ryan's question on where the report stands. It's in EPA's clearance process. We've had about a dozen stakeholders on the project team to help conduct this research. Their review is done, but we are going through the technical review, and before that the lawyers have to look at it. So the report is still in clearance. If you give feedback that you want the report, I can push the agency to clear faster.
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## 15. Concurrent Sessions 5: Biological Agent Decontamination

Auditorium C-111

Moderated by Sanjiv Shah and Francisco Cruz | U.S. EPA

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### Hot, Humid Air Decontamination of a C-130 Aircraft Contaminated with Spores

8:00 am

Tony Buhr | Naval Surface Warfare Center – Dahlgren Division

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#### Abstract

**Aim:** To develop test methods and evaluate survival of *Bacillus thuringiensis kurstaki* cry-HD-1 and *B. thuringiensis* AI Hakam spores after exposure to hot, humid air inside of a C-130 aircraft.

**Methods and Results:** *Bacillus thuringiensis* spores were either pre-inoculated on 1 × 2 or 2 × 2 cm substrates or aerosolized inside the cargo hold of a C-130 and allowed to dry. Dirty, complex surfaces (10 × 10 cm) swabbed after spore dispersal showed a deposition of 8–10 log<sub>10</sub> m<sup>-2</sup> through the entire cargo hold. After hot, humid air decontamination at 75–80°C, 70–90% relative humidity for 7 days, 87 of 98 test swabs covering 0.98 m<sup>2</sup> showed

complete spore inactivation. There was a total of 1.67 log<sub>10</sub> live CFU detected in 11 of the test swabs. Spore inactivation in the 98 test swabs was measured at 7.06 log<sub>10</sub> m<sup>-2</sup>.

Conclusions: Laboratory test methods for hot, humid air decontamination were scaled for a large-scale aircraft field test. The C-130 field test demonstrated that hot, humid air can be successfully used to decontaminate aircraft.

Significance and Impact of the Study: Transition of a new technology from research and development to acquisition at a Technology Readiness Level 7 is unprecedented.

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### Questions, Answers, and Comments

- Q Worth Calfee:** Great data. I am curious as to the impact of the exosporium on decontamination. Your data reflect what we see in the laboratory all the time. Environmental conditions and the addition of humic acid have the largest impact overall. I am wondering how one of those nonexosporium-containing spores would have behaved. I am guessing just the same as all of your other surrogates. Has understanding environmental impacts (e.g., organic acids, other things you might find in the real world) suffered at the expense of understanding the genetic homology and things that may not truly affect decontamination susceptibility? Do you think environmental conditions should be studied more? Most of the presentation focused on selection of a surrogate, but in the end, humic acid had the greatest impact.
- A Tony Buhr:** We have accumulated a lot of information over the last 10–20 years, so we can make a good selection on the surrogate. We did not include the traditional surrogates. If we had, I suspect based on other decontamination data that we would have seen a lot more surviving spores. At this point, I would tend to agree that there should be more focus put on studying the debris additives, but we are still trying to convince a lot of people who do the field studies that they really need to quit using Bg and start using these Bt strains so we do not have to filter through the difference of the strains. Does that make sense?
- C Worth Calfee:** Maybe, but there are 50 years of Bg data and when we line it up with the oxidative Bt contaminants, they are just as resistant or slightly more resistant than anthracis and that is the requirement for gauging decontamination efficacy. The surrogate could be cockroaches if they are slightly more resistant, but not less resistant, then that is fine.
- A Tony Buhr:** I do not agree that they are slightly more resistant. I think that they are significantly more resistant.
- C Worth Calfee:** Not for the chlorine-containing compounds.
- A Tony Buhr:** Sure, different decontaminations, different technologies. We did not pursue these alternate surrogates for hot, humid air. If we had, we would probably not have had a successful event due to the parameters. In that case, we would be eliminating a potential technology because we selected the wrong surrogate. The surrogate selection is critical for us to transition to new technologies. I do agree more work needs to be done on studying the potential additives.
- Q Worth Calfee:** Could you comment on the cost and feasibility?
- A Tony Buhr:** The tests were driven by the Air Force. I am not the program manager, so I cannot tell you the total cost of doing all of the testing. DTRA was interested in doing the field test and all of the facilities were already set up for us. They just had to pay for us to go down there and do the actual test. The Air Force paid for the fuel to run it. Obviously, millions of dollars, but I could not tell you the exact number.
- C Mark Morgan:** The relative cost was significantly less than the cost of the C-130. The relative cost is a drop in the bucket, relatively speaking.
- C Worth Calfee:** Did you see the low hydrogen peroxide paper published recently by Joe Wood? That might relate to electronics and off-the-shelf humidifiers.

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## Domestic Self-Help Cleanup of Biological Material in the Indoor Environment

8:25 am

Howard Walls | RTI International

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### Abstract

During the past 60 years, numerous experiments have identified the potential for a biological agent to reaerosolize following an initial release. Because only limited quantitative information has been obtained and the experiments were primarily focused on outdoor environments, it is difficult to predict the reaerosolization hazard that might occur during routine in-home cleaning outside of a heavily contaminated area following a biological attack. This study assessed the potential hazards caused by wet and dry wiping of common indoor surfaces. Experimental variables were the type of surface (glass, wood laminate, and linoleum) and type of wipe (paper towel, electrostatic cloth, and premoistened wipe). Surfaces loaded with an average of  $7.6E+04 \pm 3.0E+04$  CFU/cm<sup>2</sup> of Btk spores were placed inside a custom-built test chamber that applied a uniform, repeatable wiping motion and laminar air flow to collect all resuspended aerosol in two high-velocity all glass impingers. The spore concentrations reaerosolized were independent of the surface and wipe type because of the large variability in the replicate measurements for each combination. General trends in reaerosolization were paper towel > premoistened wipe > electrostatic cloth, and wood laminate > glass > linoleum. Although reaerosolization was detected, the total fraction reaerosolized was <0.02% of the spores deposited on the surfaces. Compared to other cleanup methods and other modes of reaerosolization, wiping appears to reaerosolize the same concentrations as vacuuming and walking. However, sweeping a surface with a broom should be avoided.

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### Questions, Answers, and Comments

- Q Lukas Oudejans:** I was wondering something and you might have already given the answer on the last slide. Your study has not included a cleaning efficacy of the wiping. Do you have that data or is that something you are still going to look into? What happens to the spores you were wiping? Are they actually on the wipe? Is the self-help functional?
- A Howard Walls:** We kept everything and then contractual things changed and we disposed of all the wipes. That is an interesting question that we were hoping to do a follow-up study on, but at the moment that is not the plan.
- C Lukas Oudejans:** We have done that study and results are coming soon.
- C Sanjiv Shah:** If the person wants to burn his house, he should make sure neighbors are not around.

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## Effects of High Intensity Blue Light on *Bacillus* Spores

8:50 am

Joanne Thwaite | Defence Science & Technology Laboratory, United Kingdom

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### Abstract

*Bacillus* spores are metabolically inactive; they are notorious for their ability to survive in a wide range of adverse environments. They are particularly resistant to heat, desiccation, and the presence of a wide variety of toxic chemicals. The use of UV light and gamma radiation for the decontamination of bacilli has been comprehensively investigated; it has been reported that spores are up to 50 times more resistant to UV light than their vegetative equivalents. Other wavelengths of light, especially those within the visible portion of the spectrum, have received little attention until recently. High intensity blue light has been shown to be bactericidal against many species of bacteria and fungi. Blue light has a number of prospective advantages over UV decontamination including improved safety (owing to its lower photon energy), as well as reduced photodegradation of materials. The mode of action of blue light is thought to be mediated via photoexcitation of porphyrins present endogenously in the bacterial cell wall. Upon excitation, these porphyrins produce a variety of reactive oxygen species that lead to a build-up of oxidative damage that ultimately overwhelms the bacterial repair systems resulting in cell death. Little work, however, has been carried out on the effects of blue light against spores.

Here we report data on the antimicrobial effects of blue light against a wide panel of *Bacillus* spores, including *B. anthracis*, *B. cereus*, *B. thuringiensis*, *B. subtilis*, and *B. atrophaeus*. Significant differences in kill rates were determined between the spores of different species, with *B. anthracis* being the most susceptible and *B. atrophaeus* and *B. subtilis* being the most resistant.

In order to elucidate the mechanism of blue light-mediated spore killing, a panel of *B. subtilis* mutants was tested, which had deletions in genes involved in spore coat physiology; the absence of coat pigment (*cotA*), outer coat



formation (cotE), and DNA protection (sspA/B) were all shown to increase the sensitivity of the strains to blue light. A further panel of *B. subtilis* mutant strains, deficient in a variety of DNA repair pathways, was assessed.

Surprisingly, the presence or absence of recA, a major factor in the SOS damage response, had no effect on blue light resistance. However, components of the bacterial response to ameliorate DNA photoproducts were found to be very important in resistance to blue light-mediated damage. These include genes encoding for spore product photolyase (splB), nucleotide excision repair (uvrA/B), and translesion synthesis (yqjH/W).

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### Questions, Answers, and Comments

- Q Sanjiv Shah:** In the last couple of slides, you showed the military applications.
- A Joanne Thwaite:** I did a lot of those studies.
- Q Sanjiv Shah:** Is that published?
- A Joanne Thwaite:** Yes, I will send you the link.
- Q Sanjiv Shah:** When we talk about bacillus, we are always under the assumption that it becomes spores. Do we have some observation that there is some lethal dose or some vegetative bacteria present where it cannot turn into spores?
- A Joanne Thwaite:** When you do the assay, you see it could be many things. As to what is attacking, we are not quite sure.
- Q Sanjiv Shah:** When you did the study with vegetative bacteria, did you use the load press culture?
- A Joanne Thwaite:** As soon as you get spores in the system, you see a longer kill. We tried very hard so that you had the same population at the beginning of the experiment.

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## Use of the OECD Quantitative Method to Demonstrate the Susceptibility of Bacteria and Bacterial Spores to Sodium Hypochlorite

9:15 am

Jordan Zambrana | ASPPH Research Participant with U.S. EPA

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### Abstract

The U.S. EPA in collaboration with the Organization for Economic Cooperation and Development (OECD) is seeking to harmonize the methodology used for testing the efficacy of antimicrobial products. The method under consideration is based on ASTM 2197-11, the Standard Quantitative Disk Carrier Test Method. The OECD Quantitative Method may be used to test a wide range of microorganisms against liquid antimicrobial products. The log reduction (LR) in viable microbes following treatment is generated and used to determine the level of product efficacy. The purpose of this study was to generate the LR for several microbes when exposed to sodium hypochlorite (NaOCl). The selected concentrations of NaOCl ranged from 200 to 5000 ppm. The resulting data were used to demonstrate the relative susceptibility of *Bacillus subtilis* (spores), *Clostridium difficile* (spores), *Mycobacterium terrae*, *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* to NaOCl. Each microbe was tested using the same set of test conditions. Three control and three treated carriers were assayed per microbe for each replicate. The mean log density for inoculated control carriers was 5–6 logs CFU per carrier. Carriers were exposed to 50 µL of a sodium hypochlorite solution and following the contact time, 10 mL of neutralizer was added to the test vial. Two or three replications were conducted for each combination of NaOCl solution and microbe. The LR data demonstrate differences in susceptibility to various levels of NaOCl between the test microbes. The spores of *B. subtilis* and *C. difficile* were the most tolerant followed, in descending order, by *M. terrae*, *S. aureus*, *P. aeruginosa*, and *E. coli*; however, *C. difficile* and *M. terrae* have comparable tolerance to NaOCl up to 1250 ppm. The data also revealed that there is some intraclass difference for gram-negative species in response to NaOCl. While both gram-negative species tested were the most susceptible to NaOCl overall, *E. coli* was significantly more sensitive than *P. aeruginosa*. This study demonstrates the successful use of a standardized quantitative procedure as a tool to study and verify the relative susceptibility of microorganisms to antimicrobial chemicals and may be useful in the validation of the principles of disinfection hierarchy.

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## Questions, Answers, and Comments

- No questions or comments.

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# 16. Concurrent Sessions 5: Livestock Remediation Options

C-113

Moderated by Joseph Wood | U.S. EPA

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## Field Demonstration of Aboveground Burial as a Tool for Managing Animal Carcasses Following a Disease Outbreak

8:00 am

Gary Flory and Robert Peer | Virginia Department of Environmental Quality

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### Abstract

Environmental impacts from carcass disposal are a significant concern globally. Despite a history of costly, ineffective and environmental damaging carcass disposal efforts, large animal carcass disposal methods have advanced little in the past decade. Although vaccination may play a more prominent role in future disease management efforts, an outbreak today will likely be managed with the same carcass disposal techniques used in previous decades and will likely result in the same economic, health, and environmental impacts.

The purpose of this project was to optimize, evaluate, and operationalize aboveground burial as an alternative to existing large animal carcass disposal methods. The system design (see Figure 1) includes a shallow trench excavated into native soil to a depth of approximately 18 inches. Several different internal configurations were evaluated in individual test cells including placing the carcass directly on native soil and the use of a sawdust base followed by a single layer of animal carcasses. Excavated soils were subsequently placed back in the trench forming a mound on which the vegetative cap was established. Finally, the perimeter of the mound was trenched to prevent the intrusion of surface water into the system.

On June 9, 2016, investigators excavated to the bottom of each design to assess the extent of carcass degradation and to conduct borings for subsequent analysis. Soils beneath each design and in two background locations were sampled and analyzed for nutrients to assess the vertical migration of nutrients into the soil profile.

Based on the analysis conducted to date, aboveground burial appears to offer many benefits over traditional burial for catastrophic mortality management. Site design will be critical to the success of this option. Soil characteristics and depth to groundwater are the key parameters to consider to ensure minimal environmental impact. A thorough analysis of the data collected and recommendations for implementing this method will be provided at the Conference.

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## Questions, Answers, and Comments

- Q Bruce Akers:** This is different than composting. Did you look at greater moisture content on the silage vs. chip content when you did the other pits?
  - A Gary Flory:** You definitely have to think about where the moisture is going to go. So we want to look at that from an environmental-impact standpoint, but in terms of functionality, I don't think the moisture content difference between silage and chip content would affect the effectiveness of the technique.
- Q Paul Lemieux:** Is this lower maintenance than composting?
  - A Gary Flory:** You build it, then level it out 12 months later. You'll want to make sure if cracks form that you seal those up within the first month, but other than that there's no necessary maintenance until the leveling after a year.
- Q Matthew Magnuson:** In terms of groundwater contamination—in North Carolina, the water table can be higher than 4 feet down.

- A Gary: Flory:** This is not the ideal alternative. We want to do the more environmentally sound options first (composting, landfilling, rendering), but in the event of a disaster that requires you to bury, and you have a suitable site, then consider aboveground burial. On the coast with sandy soil and the water at 24 inches—absolutely not. But if your other options fail and conditions are appropriate, this could be an option.
- C Robert Peer:** But even in that situation, you would see minimal environmental effects.

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## Viral Biothreat Agent Persistence in U.S. Landfill Leachate

8:25 am

Megan Howard | *Battelle*

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### Abstract

Very little is known about the fate and persistence of viruses in landfills.

The limited capacity of incinerators and hazardous waste sites in the United States and difficulty of sampling/analysis of waste matrices may result in the placement of incompletely decontaminated infectious waste in municipal solid waste landfills following a response to an intentional release of a viral biothreat. The ultimate fate of the agents is of great concern, as they may pose a threat to human and environmental health if residual live virus persists. In addition, assessing viral persistence in a landfill environment will assist the landfill industry in developing waste acceptance criteria for disposal of biowaste. This study evaluated the fate and persistence of multiple surrogate viruses including TGEV (transmissible gastroenteritis virus); Phi6 (enveloped phage); and MS2 (nonenveloped phage). Landfill leachate samples from three municipal solid waste landfills were spiked individually with each virus and incubated at 12 °C or 37 °C. Triplicate replicate samples were tested for viral titer at intervals over a 60-day period. Tested viruses persisted for days to months in leachate, and persistence varied primarily by temperature; survival was longer at 12 °C and decay far more rapid at 37 °C.

Regression analysis identified that temperature was the major determining factor of viral persistence; however, leachate effects on viruses were not identical and varied between landfills. The data suggest that different viral types are affected by leachate in unique ways, and that leachate composition plays a significant role in viral persistence. Study results suggest that viruses may persist in landfill leachate for a lengthy period of time (weeks to months) in mild conditions present in the majority of the United States. Should waste from an incident with viral agents that still contains residual agent be disposed of in a landfill, knowledge of the persistence of the virus in the leachate will allow landfill operations to be adapted to minimize potential exposures to waste management workers and the public.

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### Questions, Answers, and Comments

- Q Joseph Wood:** The D-value means log-loss?
  - A Megan Howard:** Yes.
- Q Matthew Magnuson:** You assumed a linear reactivation?
  - A Megan Howard:** We did plot linearly actually. There is variability in the results—it's a semiquantitative assay. But when we fitted it, the best fit to calculate D-value was linear fit.
- Q Matthew Magnuson:** Is that the best way in virus decontamination, to calculate linearly?
  - A Megan Howard:** Not a lot of virus decontamination work has been done—but they do deactivate linearly. Most of the work has been predominantly on UV inactivation and water treatment.
  - C Matthew Magnuson:** For trying to figure out how long that does persist—if it's not linear, it could be a lot longer.
  - A Megan Howard:** That's why we report persistence and D-values. D-values, I think, may underestimate our survival time; the viral persistence on the top chart here can be up to 113–115 days. The D-value suggests that you lose titer rapidly, but you may still have longer persistence. The other thing to remember is that LOD for these assays is between 40 and 130 infectious units depending on the agent used and style of test; TEGV is 130, which is pretty good. We can improve that LOD, but didn't need to for this study, but you are still looking at enough virus, at that limit of detection, to cause an issue if

someone were to ingest it. For some viruses, the infectious human dose is less than 10. That's particularly true of emerging infections.

**Q Joseph Wood:** Have you thought about using the actual agents?

**A Megan Howard:** Yes, I would love to. But TEGV is a good surrogate for Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS), so there's no need to use the actual agent there. There are good surrogates available that are easily generated and other viruses we could use. It's the choice of surrogate that's really important. Most decontamination work has been done with phage, and its structure is different and acts differently, it affects completely different types of cells, and it will be affected differently in the environment, I know it is for aerosols. We had a longer list of surrogates when this project started and they were down-selected to what we actually used. There's a limited number of laboratories that can test those substances.

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## Current Operational and Economic Considerations Comparing Chlorine Dioxide Fumigation to Heat Treatment for Poultry Barns

8:50 am

John Mason | *The Sabre Companies*

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### Abstract

In early 2016, the United States Department of Agriculture (USDA) indemnified three methods of commercial poultry facility disinfection in the event of a reportable high-pathogenicity avian influenza (HPAI) outbreak. Each of the approved disinfection procedures first requires a thorough dry cleaning of the depopulated barn. A heat treatment method was widely used for disinfection of poultry facilities in 2015, where once-through heaters are ducted into the lowest level of the production facility, sealed in place, and operated to maintain 100 °F–120 °F temperatures for seven total days, three of which must be consecutive. Alternatively, “Wet disinfection with an EPA-approved pesticide” or “Fumigation with an EPA-registered sterilant for porous and nonporous surfaces” can be implemented. In order to evaluate the cost and operational challenges associated with disinfection procedures and limit down-time for producers, two of these three processes, heat treatment and fumigation with chlorine dioxide, were tested in a field-scale experiment under a cooperative research and development agreement (CRADA) between the U.S. EPA and The Sabre Companies, LLC.

The sole EPA-registered sterilant for porous and nonporous materials is Sabre's Diklor G fumigation process, a chlorine dioxide treatment method that requires parameters of a temperature of at least 70 °F, 70% relative humidity, a 9,000 ppmv-h CT (concentration × time) clock, and a structure that is encapsulated or effectively sealed. In the CRADA field test, two depopulated commercial egg layer barns were tested in tandem in North Central Iowa during the month of March 2016 to eliminate weather-related variables.

The two test barns were treated according to the then-current USDA guidance documents and Sabre Fumigation Manual. Biological indicators were employed to simultaneously determine the biocidal efficacy of the respective decontamination processes. Temperature and relative humidity data were also tracked and recorded in real-time as decontamination progressed. Fuel consumption, equipment rental costs, chemical purchases, labor, and other associated costs were rigorously monitored to evaluate the true cost of the disinfection process required by USDA to allow repopulation of infected premises. These factors, as well as length of treatment time and efficacy against surrogate pathogens, can aid the USDA in developing an outbreak response plan, which will help return the affected facilities back into full operation as soon as possible.

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### Questions, Answers, and Comments

**Q Candy Orr:** One of the issues we have is transportation of vehicles. Response vehicles move from site to site. Any thoughts on how the chemical treatment would work for vehicles?

**A John Mason:** We do it a little differently. We are one of the more heavily regulated entities. Currently, chlorine dioxide solution has a 200-ppm terminal no-rinse sanitizer status and requires 1 minute of contact time. We run the vehicles through a car wash, then hit them with 200 ppm of ClO<sub>2</sub>. We will be

submitting data—we found we could get near 6-log kill in about 15–30 seconds. But the prewash is really important. That’s part of the research we’re doing.

**Q Candy Orr:** So you put the coupons in all those corners and hard-to-reach places?

**A John Mason:** Yes.

**Q Paul Lemieux:** Did you guys get a chance to investigate fumigation without removing all the litter and bulk loading?

**A John Mason:** We are continuing to do work on that. We did stick coupons under a quarter-inch of “gook” and under belts and things like that, and did see kill on those. The question is: Do you have to take out the manure? So much money was spent just on getting the manure out. Research is saying that persistence of the organism in manure may not be that long. The research has to be done on these farms and on these actual surfaces, not in laboratories.

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## Validation of Mobile Autoclave Using Temperature and Pressure Variables for Potential Use for Domestic Agricultural Emergencies

9:15 am

Craig Ramsey | U.S. Department of Agriculture

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### Abstract

This is a cooperative agreement project between the USDA-APHIS-PPQ-CPHST Fort Collins Laboratory and the College of Veterinary Medicine and Biological Services (CVMB), Department of Microbiology, Immunology and Pathology (MIP) Fort Collins, Colorado. The goal of the project was to validate a mobile autoclave that is made by EnviroSafe Treatment Solutions. The waste sterilization and disposal study was conducted in June 2016, at Covington, Indiana. The specific study objectives were to: 1) measure autoclave temperatures and pressure during full steam cycle for two soil types and wood chips using five wireless sensor/data loggers while operating at full capacity, 2) determine Scotch broom (*Cytisus scoparius*) seed efficacy for all test material runs, and 3) determine percent moisture content before and after steam treatments for both soils and wood chips. Wireless temperature and pressure data logger/sensors were loaded with the waste material to record internal material temperature and pressure over full steam cycle. The mobile autoclave has 26 paddle blades that rotate at 42 RPM to continuously churn the material during the steam cycle. The USDA-APHIS Regulated Garbage standard of an internal waste temperature of 100 °C for 30 minutes of steam exposure was the target temperature and time parameter used to validate the mobile autoclave.

The temperature and time data from the five wireless sensors were graphed and summarized for all six test runs. The mobile autoclave was able to maintain an internal waste material temperature of 100 °C for 30 minutes, while operating at full capacity. Thus, the mobile autoclave was validated to operate at the APHIS Regulated Garbage standard parameters for three materials while operating at full capacity. The temperature graphs for both soil types and wood chips show a sharp rise in temperature as soon as the autoclave steam valve was opened. All the steam-treated Scotch broom seeds had 0% germination at 43 days after planting, while the untreated control seeds had a 25% germination rate. Percent moisture content (PMC) was reduced by 20 and 75% for wood chips and both soils, respectively, as measured before and after steam treatment. The mobile autoclave met the APHIS regulated garbage standard, inactivated 180 Scotch broom seeds, and reduced percent moisture content for three material types, while operating at full capacity under field conditions.

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### Questions, Answers, and Comments

**Q Ryan James:** How fast did the paddles move?

**A Craig Ramsey:** 42 revolutions per minute.

**Q Robert Peer:** Do you think this has enough throughput to handle 150 thousand birds per day?

**A Craig Ramsey:** We think the mobile autoclave capacity is about 8,000 lb per batch with a daily capacity of about 100,000 lb per day, something like that. Broiler chickens weigh about 5 lb/carcass, so it would take about 2.5 weeks to handle 150,000 chicken carcasses with one autoclave.

**Q Robert Peer:** And how long?

- A Craig Ramsey:** Loading is about 10 minutes, because we're not retrieving canisters, so the full steam cycle is about 60 min (including loading and unloading time) if you want to steam for 30 min for an 8,000 lb batch load.
- Q Joseph Wood:** Is this a prototype or is it used commercially?
- A Craig Ramsey:** The mobile autoclave is a proprietary design, but the autoclave itself is a modified commercial rendering machine. The rotating paddles make it unique so steam can rapidly transfer to high waste volumes. It takes about 6 months to fabricate the mobile autoclave and get the plumbing and motor drives completed. The mobile autoclave is available on a contract basis from EnviroSafe Treatment Solutions.
- Q Paul Lemieux:** Would it work with medical waste?
- A Craig Ramsey:** Maybe. EnviroSafe is focusing on agriculture emergencies, but it might work for leftover Ebola waste.
- Q Paul Lemieux:** They were hoping for mobile treatment for Ebola equipment because it doesn't count as Category A waste.
- A Craig Ramsey:** The EnviroSafe mobile autoclave wasn't ready during the Ebola outbreak, so we don't have much for field testing. But they would like to stay in agriculture, but could maybe do some medical waste contracts as well.
- Q Joseph Wood:** The paddles are stainless steel?
- A Craig Ramsey:** I think so; they are heavy duty.
- Q Ryan James:** Are the paddles sharp, or is it just the beating?
- A Craig Ramsey:** It's just the beating motion that chops carcasses into small pieces that average 1" by 0.5" in size.
- Q Robert Peer:** How much wood chips would you put in with the carcass?
- A Craig Ramsey:** We put about 1 cubic yard with 300 chickens, but it came out to be moist. Not runny.
- Q Nathan Birnbaum:** Did you tell them what regulated garbage was?
- A Craig Ramsey:** USDA-APHIS-PPQ regulates garbage by international airline and cruise liner carriers. A lot of it is steam-treated or incinerated. Regulated garbage is a huge waste disposal job for USDA, but APHIS also oversees waste disposal for large domestic animal emergencies as well.

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## 17. Concurrent Sessions 6: Biological [Ricin] Agent Research

Auditorium C-111

Moderated by Eric Rhodes and Elise Jakabhazy | *U.S. EPA*

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### Developing an EPA-Registered Anthrax Decontamination Product

10:00 am

Brian France | *TDA Research, Inc.*

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#### Abstract

Surfactants, detergents, and emulsifiers are routinely formulated to clean surfaces and remove soils. TDA Research Inc. and our partner, Procter & Gamble, have applied these commercially successful formulation methods to develop a detergent product specifically designed to lift, emulsify, and remove chemical warfare agents from substrates. The result is a concentrated cleaning product that can remove chemical contamination from highly sensitive equipment such as vehicles, aircraft, monuments, and other critical infrastructure. Its key feature is the stable emulsion that is formed when the water-detergent solution is sprayed over the surface; the emulsion keeps the agents in solution so that they do not redeposit even on large surfaces. The product does not contain a reactive chemistry, as this would not be compatible with sensitive equipment; however, the formulation is compatible with reactive chemistries. The agent emulsion from the surface can be washed off the surface and the runoff neutralized using traditional methods,

thus preserving the sensitive surface. Testing has shown that the surfactant formulation is compatible with MIL-PRF-87937D as a Type IV heavy-duty, water-dilutable aircraft cleaner for use on U.S. Air Force aircraft.

The formulation also meets many commercial aircraft specifications for aircraft compatibility. To ensure this decontamination product is available for national security use, we have sought to develop additional, non-decontamination uses. This also ensures its acceptance, as personnel are familiar with its use. A dual-use product is essential to ensure the availability of this critical Government-funded decontamination capability.

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### Questions, Answers, and Comments

**Q Joseph Wood:** So you are planning to register it?

**A Brian France:** Yes.

**Q Joseph Wood:** What kind of concentrations are you getting with the photo-CO<sub>2</sub>?

**A Brian France:** The concentration is a tricky question. Traditionally, we think of generating an oxidant solution. The way this system works is you start with zero and you are generating a very reactive oxidant species. If you generate it in a solution, it basically functions as a transient. You do not build up an oxidant in solution. If you generate it, it looks around for something to oxidize, and it does it and goes back to chlorite and then it can continue to generate that. When you have something in solution for it to oxidize, it is very difficult to measure it. If you put it on a glass surface and you are trying really hard to generate a solution, we can get a couple hundred ppm out of it, but it is not quite the same as a traditional oxidant system.

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## Development of a Sample Processing Approach for Ricin Detection in Environmental Samples

10:25 am

Sanjiv Shah | U.S. Environmental Protection Agency

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### Abstract

There have been several ricin contamination incidents since the 2001 anthrax bioterrorism attacks. The time-resolved fluorescence (TRF) immunoassay is one of the primary screening methods to determine the presence of ricin, the *Ricinus communis* (castor bean) toxin, in environmental samples. However, during the EPA response to the Tupelo, Mississippi, ricin incident in June 2013, unsatisfactory results were obtained due to high-fluorescence backgrounds, such that the TRF method could not be used for samples for ricin analysis collected from surfaces to which chlorine bleach had been applied for decontamination. The assay interferences were attributed to various potential factors including bleach residue, sampling material, and wetting buffer. To mitigate the TRF immunoassay interference issue, the EPA's National Homeland Security Research Center (NHSRC), in partnership with the Lawrence Livermore National Laboratory (LLNL) developed a sample processing approach for surface samples. Using this approach, no TRF assay interference was observed with high concentrations of bleach residue, wetting buffer, and materials from sampling devices (sponge-sticks and macrofoam swabs). Also, the study found that sub-optimal europium labeling of the anti-ricin detector antibody could lead to high fluorescence backgrounds. However, because no sample processing method is being used by the analytical laboratories to remove assay-interfering materials in environmental/surface samples, a centrifugation-based ultrafiltration (UF) protocol was developed. The 10-kDa UF devices did not show loss of ricin even when 2–4 wash steps were performed, whereas, significant ricin loss was observed with 30-kDa UF devices. Using 0.5-mL or 2-mL 10-kDa UF devices, 10- to 20-fold or greater concentration of ricin toxin was achieved based on fluorescence counts.

Incorporation of this sample processing procedure prior to TRF analysis may enable detection of ricin at low concentrations for both pre- and post-decontamination samples because it combines sample cleanup and concentration. Thus, it can lead to high-quality and high-confidence data for informing high-consequence decisions concerning public health during a ricin incident. Moreover, because the sample processing procedure developed in the current effort is intended for use after sample extraction steps, it has the potential to be used with other ricin analytical methods.

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### Questions, Answers, and Comments

- No questions or comments.

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## Detailed Validation of a Laboratory Biosensor Test for Rapid Detection of Ricin Toxin

10:50 am

Kodumudi Venkateswaran | *Omni Array Biotechnology, LLC*

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### Abstract

**Background:** Ricin, a heterodimeric protein toxin that is present in the seeds of the *Ricinus communis* plant, is the biothreat agent most frequently encountered by law enforcement agencies in the United States. Rapid detection of ricin contamination of materials and surfaces is very essential to take appropriate decontamination and restoration efforts. A detailed validation of a rapid biosensor test from PathSensors, Inc., was conducted in a multiphase study. This rapid biosensor test, which uses the Zephyr system to detect ricin in about 20 minutes, is a sandwich immunoassay utilizing biosensor B cells. CANARY® (Cellular Analysis of Antigen Risks and Yields) technology, first developed at Massachusetts Institute of Technology, Cambridge, Massachusetts, is employed in the Zephyr system and uses a genetically modified B cell biosensor with ricin toxin-specific antibodies expressed on the cell surface. This study reports the performance evaluation and validation of the laboratory biosensor test for rapid detection of ricin.

**Methods:** The Zephyr system detects ricin using a luminometer to measure photons emitted by detection label B cells. The ricin biosensor test was optimized for an intended use as a laboratory test. The test's limit of detection (LOD) was determined by testing wide-ranging concentrations (0 to 100 ng/test) of ricin and by Probit regression analysis. In Phase 2, repeatability testing was conducted to evaluate the reproducibility of the test. Other phases of testing performed involve an inclusivity panel, an information panel, a near neighbor panel, a lectin panel, a white powder panel, and environmental aerosol filter sample testing. Various panels for testing were determined by subject matter experts from many U.S. Government agencies.

**Results:** The LOD for ricin was found to be 1 ng/test, slightly better than the previously validated ricin lateral flow assay. Repeatability testing showed more than 99% sensitivity and 100% specificity. Preliminary analysis of the data from other phases of the study indicates excellent sensitivity and specificity of the test. Systematic data analysis of all the phases of the study is being done and will be presented at the meeting.

**Conclusion:** This detailed validation clearly indicates that the ricin biosensor test is a rapid, sensitive and specific, user-friendly laboratory detection method that has great potential for use in many national and international public health and environmental test laboratories.

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### Questions, Answers, and Comments

- Q Sanjiv Shah:** I can imagine the amount of work involved and the money associated. No validation is easy nor cheap. Until EPA has its own adequate laboratory capacity, we rely on others. Logistics is a big deal for EPA. You need a very sensitive method that can only be done in the laboratory, not in the field.
  - A Kodumudi Venkateswaran:** The sensitivity is as good as assays tend to be. I was not trying to push for the sensitivity. For a laboratory test, this will be very convenient. Doing one-at-a-time samples might be a constraint.
  - C Sanjiv Shah:** I look forward to that.
- Q Rachel Bartholomew:** When you talked about crude samples, were those castor-mashed? Did you have precipitate? Did you see different levels of data? Did you incorporate some pure samples?
  - A Kodumudi Venkateswaran:** The inclusivity samples were prepared at CDC. They collected 18 different ones. They did a crude extract. We got inclusivity panels from them, and that is what we tested.



11:15 am

Joseph Wood | U.S. Environmental Protection Agency

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### Abstract

In recent years and in several incidents, mail-handling facilities and homes were contaminated with ricin toxin caused by acts of terror and domestic violence. EPA has the authority to oversee the cleanup of such incidents as needed. The question arises: Can ricin toxin be treated/neutralized promptly and satisfactorily by natural attenuation or simple changes in the indoor environment? NHSRC recently published the results of a laboratory study to answer that question.

The study focused on the attenuation (degradation or loss) of ricin toxin on six types of materials representative of a mail sorting facility and/or indoor building materials. Attenuation tests were conducted under various combinations of temperature, relative humidity (RH), and contact time, using two forms of ricin toxin: a commercially available “pure” preparation and a “crude” form of the toxic material prepared in the laboratory from castor beans. The amount of ricin toxin on material coupons was quantified using a cell viability assay. Attenuation was determined based on the difference in ricin recovered from test and positive control coupons.

The results showed that, while the pure ricin could be attenuated successfully, the crude ricin—the form used in the recent incidents—was generally not as well attenuated under the various environmental conditions studied. That is, the crude ricin was more stable, i.e., more difficult to attenuate, than the pure ricin in most of the tests conducted in the study. For example, there was no significant attenuation in crude ricin after 2 weeks at typical indoor environmental conditions (20 °C/45% RH).

For the pure ricin, heat treatments at the elevated temperatures of 40 °C for 5 days or 50 °C for 2–3 days achieved greater than 96% attenuation on mild steel. In contrast, for the crude ricin preparation, appreciable recovery of the ricin toxin still occurred at 40 °C after 2 weeks. A 7-day heat treatment at 50 °C was required to achieve greater than 98% attenuation of the crude ricin on mild steel. Ricin was attenuated the most on mild steel and the least on wood.

Increasing temperature generally (but not always) improved the degradation of ricin, while RH did not have much of an effect on attenuation. Overall, there were only 7 cases (out of over 200 test combinations of ricin type, temperature, RH, material, and contact time) in which we observed greater than 99% attenuation of ricin.

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### Questions, Answers, and Comments

- Q Kodumudi Venkateswaran:** What was the concentration of the ricin used in the coupons?
  - A Joseph Wood:** The mass of ricin was 250 µg inoculated onto each coupon. The exact concentration I can get for you. I have it over there.
- Q Lawrence Kaelin:** Is there any thought of looking at other biotoxins (e.g., Abrin) creeping up in these types of incidents?
  - A Joseph Wood:** Yes, we have heard input about Abrin and other biotoxins that we probably should be looking at.
- Q Lawrence Kaelin:** Would this approach work or do we have to start from scratch?
  - A Joseph Wood:** It probably would, but it might be good to get some data.

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## 18. Concurrent Sessions 6: Waste Management Practices

C-113

Moderated by Paul Lemieux | *U.S. EPA*

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### The Future of the Waste Estimation Support Tool

10:00 am

Timothy Boe | *U.S. Environmental Protection Agency*

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#### Abstract

The Environmental Protection Agency's (EPA) Waste Estimation Support Tool (WEST) is a GIS-based decision support tool for estimating the characteristics, amount, and residual radioactivity of waste generated from remediation and cleanup activities after a radiological incident, including radiological dispersal devices, improvised nuclear devices, and nuclear power plant accidents. WEST has been in development for over 7 years and has been used in numerous national-level exercises and planning scenarios. Since its inception, WEST has undergone a myriad of updates, routinely ensuring compatibility with Esri's ArcGIS and Federal Emergency Management Agency's (FEMA's) Hazus, a tool for estimating potential losses from earthquakes, wind, and flood events. Furthermore, recent enhancements have added reporting and mapping features and multistate support. Over time, this progress has strained WEST's Excel-based platform.

The inherent limitations of Excel have limited the capacity of WEST and narrowed the scope of potential enhancements.

Recent collaborative efforts between the Department of Homeland Security's (DHS) Science and Technology Directorate (S&T) and EPA will see the introduction of a new software platform for easing memory limitations and new and innovative features for improving the accuracy of waste estimates. This presentation will describe the next version of WEST (WEST 4.0) and how the upcoming enhancements will contribute to improving the planning and response capabilities of the tool.

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#### Questions, Answers, and Comments

- Q Mario Ierardi:** You've really embraced the systems approach. I salute you for this work. Now that you're working with DHS, do you think you may have the ability to utilize satellite information, and secondly, looking to the future, will these kinds of tools be embedded in our emergency outreach?
- A Timothy Boe:** Paul [Lemieux] and I have looked into leveraging external sources. WEST, as it currently exists, can pull in high-resolution satellite imagery, or Google Earth imagery. In its current form, you can use classified imagery to get better surface distribution estimates. The capability is there, but we wanted to make this more streamlined so folks at the state or city levels have access to their data, but folks at a federal level, if they have a clearance, can utilize those data as well. Lastly, part of DHS's support has been to support community outreach. We're working with folks at the city and state level, showing them WEST, and getting input on where we can improve. This is something we are actively working on.
- C Sang Don Lee:** I want to comment about the Japan indoor decontamination. There is a policy about touching personal belongings; also, the contamination is not that high. The local government has reviewed this policy, but the central government has not provided guidance. Indoors is not as contaminated as outdoors. Also the policy, especially cleanup levels, might differ from country to country.
- A Victor Medina:** So far, for example, after a hurricane, the government doesn't get involved in indoor cleanup—that's usually the responsibility of the person themselves—but the indoor waste might eventually be included.

### Abstract

The use of antimicrobial products to treat agricultural/animal facility surfaces contaminated with high-consequence animal pathogens such as highly pathogenic avian influenza is critical to site remediation. Many surfaces are porous in nature, and there is a need to verify the efficacy of antimicrobials using relevant carrier materials. However, laboratory methods have not been fully standardized for this type of assessment. An Interagency Agreement was established between EPA's Office of Pesticide Programs and the Department of Homeland Security's Science and Technology Directorate to address this issue. The feasibility of testing porous materials was evaluated using the OECD Quantitative Method. In the method, materials are cut into 1-cm-diameter coupons and inoculated with 10  $\mu\text{L}$  of microbial suspension (with soil). After drying, each treatment carrier is exposed to 50 to 75  $\mu\text{L}$  (depending on material) of antimicrobial agent and following the contact time, 10 mL of neutralizer is applied, contents vortexed, serially diluted, and the viable test microbe enumerated. The difference between control and treated counts is used to calculate a mean log reduction (LR) value. Materials selected for the project were pinewood, concrete, fabric, and butyl rubber. Feline calicivirus (FCV) and *Mycobacterium terrae* were evaluated as test microbes. Control counts of 5–6 logs per carrier are acceptable for product testing.

For concrete, the addition of 60  $\mu\text{L}$  of fetal bovine serum to the surface prior to inoculation was shown to aid in the recovery of FCV. For *M. terrae*, pretreatment of wood and concrete with 60  $\mu\text{L}$  tryptic soy broth before inoculation facilitated recovery. For wood and concrete, the amount of control and antimicrobial substances applied to each carrier was increased from 50  $\mu\text{L}$  to 75  $\mu\text{L}$  to accommodate the surface area. Acceptable control counts for FCV and *M. terrae* were achieved across all carrier types. Studies on sodium hypochlorite (NaOCl) as an antimicrobial agent were conducted for the FCV. NaOCl was shown to be least effective against FCV on concrete (5000 ppm NaOCl) and most effective on butyl rubber (2000 ppm NaOCl), with LR values of 1.1 and 5.4, respectively. For FCV, pinewood, and fabric coupons treated with 5000 ppm NaOCl displayed intermediate LR values of 2.9 and 4.1, respectively. The quality and repeatability of the data support further development of the OECD Quantitative Method for testing antimicrobial products on porous materials.

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### Questions, Answers, and Comments

- Q Matthew Magnuson:** You mentioned having critical sources and materials. Would the idea be that there would be a vendor that would supply the reference materials?
- A Stephen Tomasino:** Yes, the Biosurface Technologies Corporation, located in Bozeman, Montana, can cut the materials: concrete, fabric, wood. Moving forward, we would standardize the sets of materials for our protocol.
- Q Matthew Magnuson:** So there would be one company?
- A Stephen Tomasino:** Yes, at least initially. However, you don't want a single company to supply critical items such as test coupons.
- Q Candy Orr:** Is anyone interested in marketing claims for prions?
- A Stephen Tomasino:** No, not to date. As you know, that's even more difficult than testing viruses. Are you aware of a company that would like to do this?
- C Candy Orr:** No, being in agriculture, you don't see it very often, but when you do, it's a huge deal with a large fear factor.
- A Stephen Tomasino:** We've been dealing with this through the emergency exemption process, which is not a long-term solution when there isn't a product label claim for treating prions. Part of what we're doing is trying to reduce the need for emergency exemptions so that companies are provided a gateway to product development. No one has put anything forward in the prion area yet.
- C Craig Ramsey:** There is a person at Colorado State, there's someone with the vet school there, who's working a little bit with prions.
- Q Worth Calfee:** It's a low recovery: 7-log (inoculum) minus 4-log (post drying).

- A Stephen Tomasino:** Actually it's not 7 log/carrier per se when the test is conducted, there's die-off during the desiccation process (about 1 log) on all carrier types. The difference between the test culture concentration and the control carrier counts (post drying) is a 1 to 1.5 log difference depending on the material. How important is that to the end user? We aren't looking for a sterilant claim (6 log reduction). Recommended performance standards include an understanding of the risk, e.g., the typical inoculum level in the field. Usually these levels are not well documented in a quantitative fashion; the performance standards may be used to compensate for the lack of information. So I'm comfortable for the time being losing 1.5 logs of viable virus on these materials as long as the target control counts are met. As time goes on, we will try to enhance that recovery. We want to be sure we get high quality methods out to stakeholders that we can recognize as dependable, defensible methods. How important are the viruses and bacteria left behind (not recovered) on porous materials? They're important, but the performance standard (4 log reduction) is critical to the overall infection control process.
- Q Lindsay Gabbert:** Regarding the world of environmental efficacy testing in general. Viral decontamination needs degradation of proteins and RNA, for many of these viruses you're looking at RNA, which is also infectious and might not show up in cell culture systems after exposure to disinfectant. Is there anything that looks at genetic degradation for inactivation?
- A Stephen Tomasino:** No, the OECD method for FCV is a quantitative assay. It's not a molecular or genetic or biochemical assay. As we move forward and understand how many viruses we can test in this approach, it will broaden our understanding of testing viruses in a standardized way. You heard the talk this morning about the microbial hierarchy, perhaps we could select surrogate viruses that would represent groups of viruses in the public health or animal health arena. From a biochemical standpoint, we haven't developed that kind of methodology—are you working in that field? It would be nice to have a tiered approach, but so far, its plaque assays or the CPE approach.
- Q Paul Lemieux:** Is there standard grime material to assess impact of buildup that's on a surface?
- A Stephen Tomasino:** This OECD method includes a three-part soil load added to the inoculum. I think it's possible in diverse environments with materials that can't be cleaned or removed (like hatcheries that aren't cleaned very often) that's a different scenario where the actual burden may have to be changed, and it also needs to be noncytotoxic to the cell lines that you're testing. It's a balance.
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## Treatment of CBRN Decontamination Effluent – A Research Project Exploring Feasibility

10:50 am

Victor Medina | *U.S. Army Engineer Research and Development Center*

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### Abstract

The Army maintains extensive decontamination capabilities (DECON) to mitigate chemical, biological, and radiological (CBR) attacks. The Army currently has no capability to treat and/or recycle the effluent from its aqueous-based decontamination operations. This effluent is extremely hazardous and poses a major handling, logistical, and political burden.

An effective onsite effluent-treatment approach would allow for a more rapid return to operational readiness after an attack and provide better civilian support capabilities in homeland defense scenarios. Furthermore, issues with environmental exposure from downstream or groundwater impacts would also be removed.

The presentation will consist of two parts. The first part will briefly cover our approach to estimate constituents that would likely be found in a decontamination effluent, such as CBRN constituents like chemical warfare agents or radiological particles; associated contaminants like sediments, oils and greases; and decontamination chemicals like surfactants and/or bleach. The second portion of the talk will focus on the development of a treatment system for decontamination effluent, including unit processes for treating the various constituents expected in the effluent. We anticipate having results of testing individual components of the system as well as integrated testing results. We will also present concepts for monitoring and controlling the system, as well as ideas for integrating the system into

existing decontamination scenarios. The presentation will conclude with our plans for continuing and completing the project.

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### Questions, Answers, and Comments

- Q Mario Ierardi:** What was your biological loading in the streams as you were testing?
- A Victor Medina:** None. Right now, there's no biological loading because we take reverse osmosis water and spike it. But as time goes on, you're right, there could be coincidental microorganisms that contribute to organic matter, and we're going to have to address that.
- Q Alvin Ong:** In the treatment for Cs, is it pure Cs-contaminated water?
- A Victor Medina:** The initial studies are pretty much pure Cs chloride but that's not where we want to stop, we want to add in those other components. However, to get started we focused on neater solutions. Maybe next year I could present data on more complex solutions.
- Q Alvin Ong:** Could you be more specific about the three stages?
- A Victor Medina:** It has nine filters. So the water will go through one of the filters, then treated water goes through the second set of filters, and so on. So it's like treating the water three times by reverse osmosis.

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## Carcass Management and Pathogen Transport During HPAI 2015

11:15 am

Lori Miller | *U.S. Department of Agriculture*

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### Abstract

The USDA response to highly pathogenic avian influenza in 2014–2015 was the largest response to an animal disease outbreak in U.S. history, costing over \$950M in federal funds, with industry losses in the billions. Fifty million commercial birds were affected in 21 states at 211 premises. Composting, landfill, incineration, and burial were used to manage infected or exposed carcasses.

This talk will examine the potential exposure pathways from each of the management techniques when applied to a large poultry production operation, the logistical challenges affecting pathogen transport, and the trade-offs between rapid depopulation of infected flocks versus the rate of carcass management. Some of the issues to be covered will include ability of personnel to remove hens from cages, storage of material prior to management, role of vectors during management activities, and resource limitations that reduce speed of carcass management.

One aspect of this talk relates to the fact that the HPAI virus reproduces and multiplies in the system of an infected live animal, but when the animal dies, the virus is no longer able to replicate, and the viral load in the carcass gradually decreases over several days. This means that the maximum amount of virus is generated by a live infected animal, and after the animal dies, the amount of viable virus in the carcass drops over time.

There are techniques available to humanely euthanize entire barns of birds in less than a day; however, it takes many days to remove the carcasses from the cages. Post mortem, the virus load drops over time, but the attraction of vectors such as insects and scavengers increases. This raises the question: Is more virus released to the environment when the birds are alive and shedding maximum amounts, or is more virus spread after death when more vectors carry it to other susceptible hosts?

In the absence of data to answer that question, one must assume both avenues are significant. The approach of rapid depopulation addresses the first concern about virus shedding from live birds; however, the issue of vector transport of virus post mortem must be considered to address the second avenue.

The talk will cover the methods used in 2015 to contain and stabilize carcasses, and qualitatively assess the pathways for virus transmission during the process.

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### Questions, Answers, and Comments

- Q** Lori Miller was unable to attend.

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## 19. Poster Session

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### Impact of Fumigation Using Methyl Bromide with Chloropicrin on Electronic Equipment

Alden Adrion | *U.S. Environmental Protection Agency*

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#### Abstract

Damage to high-value electronic equipment such as sensitive medical, security, or infrastructure-control systems is a major concern during the fumigation of buildings contaminated with a bio-threat agent such as *Bacillus anthracis*. Previous work demonstrated the negative impacts of fumigation with chlorine dioxide and hydrogen peroxide on electronic equipment. Unlike hydrogen peroxide and chlorine dioxide, methyl bromide is not an oxidizing agent and is expected to be less corrosive to metals found in electronic equipment. The present study evaluates the impact of fumigation using a mixture of 98% methyl bromide and 2% chloropicrin (added as a warning agent) on electronic equipment. Desktop computers, used as surrogates for high-value equipment, were exposed to 300 mg/L of the mixture for nine hours at 75% RH and 37° C. The impact of fumigation on computer functionality was assessed using visual inspection and PC diagnostic software. Additionally, mechanisms of damage were investigated through visual inspection and through Energy-Dispersive X-ray spectroscopy (EDS). Fumigated computers incurred substantial damage compared to those exposed to the fumigant-free control condition. Major subsystems affected included computer power supplies and disc drives; including mechanical and optical components. Chlorine, but not bromine, was detected by EDS on the corroded metal surfaces of damaged components, implicating chloropicrin in most of the observed damage. Neither chlorine nor bromine, however, was detected on damaged optical drive beam-splitters made of metal-doped silica. The absence of detectable chlorine combined with the possibility that either chemical could cause damage without detection by EDS, motivates ongoing work to evaluate the impact of methyl bromide fumigation without chloropicrin. Continuing work will also evaluate the impact of methyl iodide, a fumigant having similar efficacy but not subject to restrictions placed on ozone-depleting substances. The results of this study will inform application of fumigants in the field and suggest areas of further laboratory research.

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### Updates and Developments to EPA's Water Contaminant Information Tool (WCIT)

John Bain | *U.S. Environmental Protection Agency*

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#### Abstract

In the event of a natural, intentional, or unintentional water contamination incident, a quick and effective response is crucial to limiting its impact on water systems and public health. Responding to a contamination event requires accurate information on the nature of the contaminant and how to properly treat it. The Water Contaminant Information Tool (WCIT) is a dynamic and valuable resource designed to provide this information to responders, and address new risks and unforeseen issues as they arise. WCIT is a secure, online database that contains vital information, such as analytical methods, drinking water and wastewater treatment processes, and medical information, on priority contaminants of concern for drinking water and wastewater systems. Here we report recent updates to existing contaminants in the database, additions of new contaminants into the database, and the plan for the launch of an updated version of WCIT that will be more user-friendly and accessible on mobile devices. WCIT is constantly updated with information on priority contaminants to help utilities and other users respond effectively and efficiently to drinking water and wastewater contamination events. These updates focus on adding new WCIT profiles on emerging contaminants of the greatest concern. For example, in response to blooms of dangerous cyanobacteria in recent years WCIT profiles were created for both microcystins and cylindrospermopsin to address their potential danger in water systems. WCIT contains over 800 priority contaminant profiles currently, but some profiles only contain analytical methods. To address this issue other priority contaminant lists, such as the Contaminant Candidate List (CCL), and input from water sector experts are being used to help identify contaminants of the greatest concern and to add more detailed information to profiles. Lastly, WCIT is undergoing a facelift to streamline the user interface and support compatibility with mobile devices. All of these updates are aimed at keeping the tool modern to address current and emerging contamination risks. Additionally, these updates will

provide a more dynamic and robust tool for water sector responders to use in the event of a water contamination incident.

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## Exposure and Pathways Analysis of Infectious Livestock Carcass Management Options During Emergency Situations

Sandip Chattopadhyay | U.S. Environmental Protection Agency

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### Abstract

Management of infectious livestock carcasses following large-scale mortalities is needed to protect humans, livestock, and wildlife from hazards; to maintain water, air, and soil resources; to protect ecological resources; and to enhance food and agricultural security. Previous environmental assessments of mass livestock mortality events relied primarily on qualitative evaluation of exposure or observations based on incident-specific circumstances, which limits their usefulness for general decision-making. To address the need for a comparative analysis, the U.S. Department of Homeland Security, U.S. Department of Agriculture, and U.S. Environmental Protection Agency are jointly conducting an exposure assessment and pathways analysis for potential releases of pathogens and chemicals using seven key carcass management options and associated carcass handling and transportation activities.

Exposure estimates are being used to rank the livestock carcass management options relative to one another for a hypothetical site and mortality scenario from a natural disaster and foreign animal disease outbreak. Two additional mortality scenarios will be assessed in future: chemical and radiological contamination emergencies. Pathogens and hazardous inorganic and organic chemicals that are released directly from decomposing carcasses or from carcass management and post-management processes were identified and evaluated for each management option based on the likely occurrence, survival, persistence, and mobility of concern.

A two-tiered approach was used to rank and assess the management options, potential exposures relative to one another for a hypothetical site under a set of standardized environmental conditions, scale of mortality, design and implementation of management options, fate and transport of contaminants in various media, and other toxicity benchmarks. This assessment provides a scientifically based understanding of the relative contribution of specific exposure pathways, identification of hazardous agents, and steps in carcass management processes to select best management practices by setting priority for mitigation in the event of emergency mass livestock mortalities.

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## Outdoor Biological Simulant Release in an Operationally Relevant Environment

Amanda Clark | Naval Surface Warfare Center - Dahlgren Division

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### Abstract

The Department of Homeland Security (DHS) requested Naval Surface Warfare Center - Dahlgren Division (NSWCDD), Chemical, Biological, and Radiological Concepts and Experimentation Branch (CODE B21) demonstrate that the currently fielded biosurveillance system can detect an aerosolized biological agent release in an operationally relevant environment. Aerosol collection systems were deployed to selected locations around Naval Support Facility-Dahlgren (NSF-Dahlgren). Biological simulant was released to demonstrate that the system could collect, detect, and identify the bio-aerosol in an outdoor environment. The systems, procedures, processes, and personnel used in this demonstration are representative of current biosurveillance operations. The term “operationally relevant” draws a distinction between the venue for this Operational Demonstration (NSF-Dahlgren) and other traditional biological detection test venues or laboratory test facilities. Located in Dahlgren, VA on the Potomac River, the NSF-Dahlgren location offers more relevant operational factors in terms of environment, topography, infrastructure and population. NSF-Dahlgren is also considered to be more representative of urban settings and moderate climatic conditions as compared to the typical test venues. Over a two month period, trials of record were executed by releasing the fluidized powder *Bacillus atrophaeus subs. globigii* (Bg) provided by Dugway Proving Ground (DPG) to demonstrate the system’s ability to detect the presence of aerosolized simulant. NSWCDD designed a three part referee system comprised of a filter based aerosol collection system, real-time particulate size and distribution analyzer, and a viable particle collector. Components of the referee system were specifically designed to maximize sensitivity in order to add defensibility to the design of the demonstration since it would serve as the ruler by which

the performance of the system being demonstrated was measured. A one hour background collection period was performed immediately prior to each simulant release and served as the baseline for trial samples and was followed by a Bg release and two hour collection period. The objective of demonstrating that the fielded systems could detect an intentional aerosol release of a biological simulant in an operationally relevant environment was met. Twenty of twenty-one accepted trials exhibited a least one positive detection and over 50% of the trials had more than one positive detection by both the referee and the currently fielded system. It was calculated that the collection systems were able to collect simulant and result in a positive detection up to 3.2 kilometers (2.0 miles) away from the point of dissemination. The data generated also provided valuable information regarding contamination control, re-aerosolization of powdered material, primary and secondary sampling as well as release characteristics of fluidized biological powders in an open air environment.

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## EPA's Dual Use Research of Concern Policy and Order

Brendan Doyle | *U.S. Environmental Protection Agency*

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### Abstract

This poster describes EPA Order 1000.19 Policy and Procedures for Managing Dual Use Research of Concern that implements two White House national security and research policies, the Dual Use Research of Concern Policy (March, 2012) and the Institutional Dual Use Research of Concern Policy (September 24, 2015). It outlines the roles and responsibilities of all EPA-funded intramural and extramural life sciences researchers and EPA's Institutional Contact for Dual Use Research to plan, conduct and communicate their research involving select agents and toxins responsibly. EPA Order 1000.19 was approved September 14, 2016; all EPA personnel are strongly encouraged to receive DURC Policy training and to comply with the Order's requirements.

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## Advanced Decontamination Concepts and National Security Product Development

Brian France | *TDA Research, Inc.*

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### Abstract

During a DHS-funded SBIR Phase I and Phase II project, TDA developed an advanced oxidant generation system to respond to an attack with biological agents. Specifically, this technology is capable of decontaminating anthrax spores on building exteriors and interiors, and is particularly suitable for decontamination over wide areas. This technology has also demonstrated efficacy against chemical warfare agent simulants and anthrax surrogates. This decontaminant formulation produces sustained, effective, low level oxidant concentrations that are effective for extended periods (hours to days). The decontaminant does not require special application equipment and has a long shelf life and the ability to be rapidly shipped on commercial air transport.

This dual-use technology is currently being developed by TDA and our partners for both commercial and national security applications, thus ensuring it will be available to meet the needs of the Federal on Scene Coordinators during a biological remediation event. TDA will present an update on this technology, including our efforts to develop national security and consumer applications.

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## Relative Susceptibility of Foot and Mouth Disease Virus (FMDV), Feline Calicivirus, and Bacteriophage MS2, to Five Disinfectants

Lindsay Gabbert | *U.S. Department of Homeland Security*

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### Abstract

Understanding and evaluating the effectiveness of decontamination methods against foreign animal diseases (FADs) is complicated by the biosafety requirements and need for high-containment facilities. Alternatively, surrogate organisms can be used to model the environmental fate and transport of FADs at lower biocontainment levels. In the United States, foot and mouth Disease virus (FMDV) can only be handled at the Plum Island Animal Disease Center, and few head-to-head validation studies are reported comparing the susceptibility of FMDV and potential surrogates to chemical disinfection. In this study, the OECD Quantitative Carrier Method for Evaluating Antimicrobials on Hard



Non-porous Surfaces was used to compare the susceptibility of FMDV and the viral surrogates Feline Calicivirus (FCV) and Bacteriophage MS2 (MS2) to disinfection with bleach, acetic acid, citric acid, Virkon S<sup>®</sup>, and Oxonia Active<sup>®</sup> using a 5-minute contact time.

Disinfectants used in the study were either EPA-registered or USDA-recommended for use in FMDV decontamination, and represented chemicals with different modes of action. Results indicate that FMDV was always inactivated within the USDA-recommended chemical use-dilution for each disinfectant. Compared to FMDV, both surrogate viruses were more resistant to inactivation with each disinfectant, except FCV was more sensitive to bleach.

MS2 was consistently the most resistant organism to disinfection under these conditions, and both surrogates were highly resistant to acetic and citric acids. This study provides valuable data directly comparing inactivation of FMDV to two surrogate viruses and may be used as a model for testing additional surrogates, or disinfection conditions, and may guide FMDV surrogate selection depending on future study goals.

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## Characterization of Anthrax Surrogates by Chromogenic Media

Douglas Hamilton | U.S. Environmental Protection Agency

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### Abstract

The safety threat posed by spores of virulent *Bacillus anthracis* precludes its use in many research activities and planning exercises. Avirulent surrogates belonging to the *B. cereus* group have been reported with properties similar to *B. anthracis*, with some organisms being useful surrogates for evaluation of decontamination processes, and other organisms being useful surrogates for reaerosolization studies. This study compared the growth characteristics of three members of the *B. cereus* group [*B. atrophaeus* subsp. *globigii* (BG), *B. anthracis* Sterne (BAS) and *B. thuringiensis* var. *kurstaki* (BTK)] when cultured on media containing chromogenic substrates.

Culture-based analytical methods are the “gold standard” for determining the effectiveness of decontamination efforts and to inform response and recovery initiatives. Plate counting on chromogenic agar provides quantitative information about a sample, can determine if a pathogen is viable, and has the potential to improve laboratory surge response by evaluating samples based on biochemical characteristics. Chromogenic agars contain substrates that are enzymatically cleaved during cellular processes, resulting in the accumulation of the cleaved products within the vegetative cell and the ability to visually identify bacterial colonies (by morphology and color) based on substrate utilization. The chromogenic media investigated in this study produce visually striking blue colonies when organisms possessing specific biochemical processes are cultured.

Three media were selected for this study, including tryptic soy agar (TSA), R&F anthracis chromogenic agar (ACA) and Brilliance *Bacillus cereus* agar (BBCA). In replicate experiments, it was determined that no statistical difference exists between sample enumeration on TSA, ACA and BBCA for the selected surrogate spores. Incubation temperature and time were found to be critical to the positive identification of surrogate spores on chromogenic agars. This study identified methods useful in the characterization and quantification of surrogates routinely used for research and planning activities. The chromogenic agars are useful tools in the differentiation of certain types of spores based on biochemical characteristics, particularly in the presence of background flora that do not grow blue colonies. These media are readily adaptable to standard laboratory analytical methods.

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## Two Recent Examples of EPA's Response Capabilities for CWA Analysis

Lawrence Kaelin | U.S. Environmental Protection Agency

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### Abstract

The EPA's PHILIS mobile laboratory assets were used to determine the presence or absence of selected chemical warfare agents, and their breakdown products at two site in the US. The first was a site in Region 7, the City of Saint Louis and involved an abandoned "deterrent safe" where anecdotal information suggested the presence of toxic chemicals, possibly even sulfur mustard, in or around the safe. The second incident was in Region 5, during the Republican National Convention (RNC) in Cleveland and involved adhesive "stickers" that were placed on buildings and several people, including law officers, by a self-described anarchist demonstrator. Several law officers

complained of a "tingly feeling" upon removing the stickers. The PHILIS laboratories were stationed in nearby Westlake and analyzed the stickers samples as part of EPA's support of the RNC's inter-agency All Hazard Center.

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## Vapor Hydrogen Peroxide For Biological Decontamination – Process Optimization

Marek Kuzma | *Institute of Microbiology*

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### Abstract

Decontamination of large spaces (airports, government buildings, hospitals, etc.) represents up-to-date and not satisfactory solved problem. They can be a valuable target for terrorist attack, as well as places for a fast spread of infectious diseases, because they are places of high strategic importance and/or high concentration of people.

Particular decontamination methods were tested and approved for some applications and have their advantages and disadvantages. The use of vapor decontamination methods is quite easy and can be applied for wide areas.

Vapor hydrogen peroxide (VHP) is very progressive technology. This agent seems to be very active for decontamination and its elimination from decontaminated space is environmentally friendly, because it decomposes to water and oxygen.

The decontamination process comprises four steps, room preparation, generation of VHP in the room, exposure, and the final ventilation of the room. We were dealing with all the steps and found several parameters influencing their effectiveness.

There are several commercial devices for VHP generation. We have developed various devices for VHP generation, which can produce high concentration of hydrogen peroxide and can be easily deployed in a field.

The efficiency of decontamination is influenced by various parameters like hydrogen peroxide concentration, moisture level, the length of the decontamination process, morphology of decontaminated surface and its contamination. Our research was aimed to assess the influence of these parameters on the decontamination process. Decontamination effectiveness was evaluated using indicators. The efficiency of the decontamination process was correlated with various type of impurities in the decontaminated area.

Our results demonstrate that VHP decontamination is indeed very simple in terms of design, but the success is very closely related with the procedure setting, in particular moisture content in the decontaminated area and thus the degree of condensation on the surface, but also the pollution. The efficiency of the process in the presence of impurities can be affected to some extent by the moisture that influence the rate of rehydration of contaminated surface. The addition of adjuvants can also affect the rate and degree of decontamination.

Finally, the ventilation of the area can be a time-consuming process but application of special catalytic system can it substantially speed-up.

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## Broad-Spectrum Enzymatic Decontamination of CWAs

Anna Leech | *FLIR Detection, Inc.*

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### Abstract

FLIR is developing a broad-spectrum, materials-friendly enzymatic decontaminant that can rapidly hydrolyze chemical warfare agents (CWA). FLIR has demonstrated a reduced need for chemical agent-specific formulations; it is now possible to achieve hydrolysis of both G- and V-series nerve agents with organophosphorus hydrolase (OPH), and detoxify sulfur mustard (HD) through the addition of haloalkane dehalogenase.

FLIR has developed an enzyme-compatible solvent/surfactant package that is optimized for solubilization of persistent and hydrophobic CWA. The removal of contaminants from challenging materials is significantly enhanced,

while maintaining a high degree of material compatibility. Aqueous decontamination reactors have shown 99.9% hydrolysis of 2wt% Diethyl VX (DEVX, V-series), Diisopropylfluoro-phosphate (DFP, G-series) and 1,3-dibromopropane (DBP, HD) in under 15 minutes. Chemical agent resistant coating (CARC) panels were challenged with 10g/m<sup>2</sup> simulants. Extraction and GC-MS analysis reveal that 99.999% DEVX and DFP are hydrolyzed within 5 minutes and 99.9% hydrolysis of HD within 15 minutes.

FLIR's decontaminant has shown superior materials compatibility against other commercially available decontaminants in ASTM tests with metals, elastomers, and plastics, including improved performance for materials in side-by-side testing with sensitive materials.

FLIR's broad-spectrum decontaminant is versatile and can be adapted to various decontamination formulations such as: immediate decontamination due to the rapid hydrolysis of simulants, clearance decontamination through the addition of polymers to create a sprayable gel, personal decontamination as the components have been utilized in common household or beauty items, and sensitive equipment decontamination due to the high degree of materials compatibility. FLIR's enzymatic decontamination formulation is an adaptable and effective method for detoxifying CWA from a variety of surfaces.

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## Pre-Treatment Technologies to Facilitate Management of Animal Carcasses from Animal Health Emergencies

Paul Lemieux | *U.S. Environmental Protection Agency*

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### Abstract

The challenge associated with the disposal of animal carcasses following an animal health emergency includes protection of environmental, animal, and public health against potential microbiological threats. An animal carcass is composed of microbiologically active material that may contain viruses, bacteria, protozoa, parasites, prions, toxins, drug residues, and other chemicals. All of the biologically active materials need to be reduced to safe amounts, eliminated, or sequestered to minimize their potential hazard.

The treatment and disposal of animal carcasses is not federally regulated in the United States and varies between and within states. Pretreatment of infectious carcasses may be suggested by the carcass management decision makers to improve the operation of the mechanical components of the downstream process equipment and/or to minimize potential biological or physical effects of the disposal. The type of pretreatment will vary according to type and size of animal involved, the potential level and type of contamination, the disposal process to be used, and the desired characteristics of the end-product. In this study, eleven infectious carcass pretreatment technologies were identified and screened to assess how each technology might be used prior to, and in conjunction with, the six commonly used large-scale carcass disposal options. This poster details the results of that analysis.

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## Provisional Advisory Levels (PALs): A Tiered System of Exposure Evaluations

John Lipscomb | *U.S. Environmental Protection Agency*

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### Abstract

Following the 2001 terrorist attacks, the U.S. Environmental Protection Agency established the National Homeland Security Research Center to provide science that supports EPA's Homeland Security responsibilities including rapid response to accidental and intentional releases of toxic industrial chemicals and chemical warfare agents. Because of the lack of exposure guidelines between 24 hours and the subchronic duration (90 days), NHSRC began to develop Provisional Advisory Levels (PALs) values to provide important information to those managing emergency incidents and reuse activities involving exposures via air or drinking water. While they are quantified and presented as point values, they are neither promulgated nor regulatory.

Rather, PALs values are developed for inclusion in the suite of information used by incident managers to protect human health during evacuation, reentry and reuse activities. The PALs Standing Operating Procedure (SOP) borrows from the SOP for EPA's Acute Emergency Guideline Level (AEGL) program. PALs are established for inhalation as well as oral exposures, for durations of 24 hours, 30 days, 90 days and two years and for three tiers ranging from no adverse effect to a possibility of lethality. Above PAL 1 values, the likelihood of progressively adverse health effects

increases; above PAL2 values, the likelihood of severe, irreversible or escape-impairing effects increases; and above PAL3 values, the likelihood of lethality increases.

While PAL 1 values are intended to protect against (even reversible) adverse effects, and PAL3 values are intended to protect against lethality, the choice of effect and point of departure for PAL 2 value development to protect against serious, irreversible or escape-impairing effects may be complicated, especially when studies from multiple applicable durations indicate several potential candidate effects with differing dose response functions. This presentation will review the principle components of the PALs SOP in the context of values derived for acrylonitrile, hydrogen sulfide and phosgene.

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## Underground Transport Restoration Program. Lab to Field Studies by EPA Researchers

Lukas Oudejans | *U.S. Environmental Protection Agency*

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### Abstract

No abstract was provided for this poster.

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## Quantitative Method for the Detection of Sodium Fluoroacetate (Compound 1080) in Water by Direct Injection LC-MS/MS

Emily Parry | *U.S. Environmental Protection Agency*

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### Abstract

To support large scale environmental responses, the United States Environmental Protection Agency (EPA) established the Environmental Response Laboratory Network (ERLN) to serve as a national network of laboratories. The ERLN provides coordinated analytical capabilities and capacities, while ensuring quality data, during a large response effort. The EPA's Homeland Security Research Program developed and updates the Selected Analytical Methods for Environmental Remediation and Recovery (SAM) to provide the ERLN with recommended analysis methods for priority chemicals, radioisotopes, pathogens and biotoxins in different environmental matrices. Sodium fluoroacetate (FAA), is one such chemical. It is a mammalian pesticide that could contaminate water supplies and cause widespread harm. Historically, FAA was analyzed by gas chromatography requiring time consuming derivatization steps. Currently, measurement of FAA in water lacks an updated, verified analytical method. The objective of this research is to develop a direct injection liquid-chromatography tandem mass spectrometry (LC-MS/MS) method to address gaps associated with analytical methods in support of remediation efforts. A direct injection method eliminates sample preparation steps and results in swifter data reporting. The analytical target level is based on risk assessments developed from toxicity values. Several drinking water sources will be used to evaluate matrix effects, method interferences, and investigate compound stability in water. The developed method will utilize equipment that is widely available, and possess high throughput capabilities, to assist with lab capacity and capability issues that arise during large-scale remediation incidents.

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## Boron Doped Diamond Electrochemical Advanced Oxidative Process Treatment of Heavily Contaminated Water for Drain Disposal and PO

Rebecca Phillips | *ORISE Research Participant with U.S. EPA*

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### Abstract

Water contamination from intentional and unintentional incidents is of ever increasing concern. These incidents may include criminal/terrorist acts, natural disasters, and industrial spills, among others. The EPA HSRP is investigating boron doped diamond electrode (BDDE) advanced oxidation processes (AOP) in addition to the more established UV/H<sub>2</sub>O<sub>2</sub> and O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub> AOPs as potential strategies to treat contaminated water. Electrochemical AOPs are effective at producing active radical species including hydroxyl radicals, which are characteristic of AOPs and exhibit a higher oxidation potential than chlorine or ozone. The BDDE process exhibits several advantages over other electrodes and AOPs that make it an excellent candidate for AOP treatment. First, it may be operated without reagents, unlike many other AOPs, thereby reducing design and maintenance considerations. BDDEs are also able to attain a higher range

of working potentials and are more stable than other types of electrodes, resulting in higher performance compared to other electrode materials. This study examines the efficacy of BDDE treatment at varying current densities, reaction times, and electrolyte compositions and concentrations. Ideal working conditions are determined based on the microbial toxicity resulting from blank experiments as well as on AOP performance, as indicated by both contaminant destruction and resulting microbial toxicity. Microbial toxicity is rarely reported for BDDE processes and is indicated in this study by the Microtox and Nitrification Inhibition (NI) toxicity assays. These assays, selected based on advice from the wastewater industry, simulate toxicity to receiving waters as well as to wastewater treatment processes, thus giving utilities greater confidence in both accepting waters treated by this method, as well as utilizing it themselves. Several contaminants are assessed at concentrations (ppm) simulating those that may be found in contaminated water and wastewater which may arise from unintentional or intentional contamination incidents. Optimized conditions are used to evaluate the ability of the BDDE system to generate hydroxyl radicals compared to O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub> and UV/H<sub>2</sub>O<sub>2</sub> AOP technologies. Longer treatment times and TOC results will be presented to demonstrate the extent of mineralization observed. Results from treatment in several background matrixes will also be presented to demonstrate the system's effectiveness in clean waters, as well as simulated wash water components. The results of this study will demonstrate the applicability of this technology toward treatment of contaminated waters and wastewaters. This may provide decision makers with another tool to address water contamination issues and water utilities with another treatment strategy for refractory organic contaminants.

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## Disinfection Efficacy of COTS Against Ebola Virus and Possible Surrogate

Vipin Rastogi | *U.S. Army, Edgewood Chemical Biological Center*

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### Abstract

Emerging infectious diseases (EIDs) represent an ongoing threat to the health and livelihoods of people everywhere. Ebola virus (EBV) is one such EID posing a current threat, with the 2014 outbreak in West Africa responsible for >10,000 deaths and thousands more confirmed cases. EBV is an enveloped virus with a negative sense RNA genome belonging to the family Filoviridae.

Filovirus virions are unique filamentous particles approximately 80 nm in width and up to 14,000 nm in length. Due to the high mortality rate, EBV is classified as a select agent and handled under BSL-4 laboratory conditions.

Infection with EBV results in fever, vomiting, diarrhea and hemorrhage and is transmitted via contact with bodily fluids such as sweat, blood, secretions, saliva, tears, breast milk, stool, nasal drips, and semen. At present there are no products with a virucidal disinfectant label claim against EBV registered by the U.S. EPA. CDC and U.S. EPA recommend using a disinfectant approved for use on non-enveloped viruses (considered to be more resistant to disinfection) to disinfect surfaces and objects suspected of EBV contamination. As EBV is a risk group 4 pathogen, studies utilizing EBV are hazardous, difficult and can only be done at a limited number of labs with proper containment facilities. No good surrogate for studying EBV exists due to the unique morphology of the virus and the lack of any closely related viruses of a lower risk level.

Vaccinia virus (VACV), a close relative of the virus that causes smallpox, is an enveloped double-stranded DNA virus. VACV possesses a number of attractive characteristics for use as a surrogate for disinfection studies. VACV can be safely worked with under BSL-2 conditions, can be grown to high titers and can be easily quantified by plaque assay. Further, VACV (and other poxviruses) are one of the most persistent viruses on record with live virus recovered after years (at least 13) of storage at room temperature. The results show: 1) While VACV is very persistent on surfaces of military relevance, EBV persisted only for 24 hours; 2) Bioxy-S and vinegar were found to be very effective on all four tested surfaces ((anti-skid, nylon, TIS, and steel); 3) Of the five disinfectants tested (Bioxy-S, bleach, Calla, hydrogen peroxide, and vinegar), Calla was largely ineffective against both viruses. The efficacy results provide experimental support for suitability of VACV as a surrogate for EBV disinfection studies.

(Funding from Hazard Mitigation Team (J9-CB), DTRA, Fort Belvoir is greatly acknowledged.)

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## Preparing and Protecting Workers Through Training and Education in a Biohazard Environment

Jim Remington | *National Institute of Environmental Health Sciences*

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### Abstract

The NIEHS WTP and grantees consortia have maintained a passionate stake in infectious disease response over approximately two decades. While one aspect of biosafety may include aspects of compliance, controls, rigorous enforcement of standard rules, the WTP brings in real world experience and acknowledges the need for a more hybrid model; embracing an all-hazards risk stratification model.

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## Environmental Hazard Prediction Modeling of Low Volatility Agents for Mitigation of Contact Hazards and Vapor Hazards

Marc Roberts | *SRC, Inc.*

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### Abstract

Hazard prediction modeling requires a clear understanding of the physicochemical interactions and environmental processes governing the fate of chemical threats in the environment. The primary objective of agent fate modeling is to provide an operational tool to mitigate vapor and contact hazards of chemical threats. By implementing best practices of known estimation models, the prediction of the secondary evaporation and environmental fate of a multicomponent chemical threat droplet dispersed on operational substrates in an outdoor environment over time is attainable.

Chemical warfare agents that have low vapor pressures can persist in the environment for a substantial time and can penetrate into porous and permeable substrates causing potential exposures to personnel on the ground.

SRC, Inc. (formerly Syracuse Research Corporation) under contract with DTRA implemented the Droplet Reaction and Evaporation of Agents Model (DREAM) into the Joint Effects Model – Science & Technology Prototype (JEM-S&TP) and provide continual enhancement to its capabilities and environmental relevance. During this development phase, SRC restructured the core algorithm of DREAM to better reflect the chemical threat agent behavior that occurs in the environment on a variety of materials. The new algorithm is capable of simultaneously modeling the mass transport phenomena of a chemical on materials that are both porous and permeable. This capability expands DREAM's applicability to include materials of a variety of porosity and permeability where the chemical can exist as a sessile drop above the surface of the material, within the pores of the material, and absorbed into the material's solid matrix. Future efforts are aimed to leverage this new capability to expand the model to soils and urban materials. Such a tool can serve as a guide for both chemical decontamination and chemical sampling activities.

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## Full Spectrum CBRNE and Drug Sampling of Aerosols / Vapors to Support Safe Entry and Decontamination Assurance of Clandestine Laboratories

Marc Roberts | *SRC, Inc.*

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### Abstract

Clandestine laboratories used for the manufacture of narcotics, explosives, and chemical threats pose a substantial health threat to law enforcement, first responders, and the military. Their first question, "Is the air safe to breathe?" Recently, law enforcement observed a tremendous growth in the use of synthetic opioids such as fentanyl to cut street drugs like heroin resulting in serious concerns for potentially fatal exposures. In June of 2016, DEA issued a warning to the police to proceed with extreme caution when entering a suspected drug lab or handling unknown drug substances in the powder form. Careless synthesis and handling of these narcotics generate aerosols and vapors that can be inhaled upon entry. SRC, Inc. (formerly Syracuse Research Corporation) developed an air sampler designed to collect and concentrate aerosols and vapors commonly associated with narcotics, explosives, and CBRN threats. The patent pending Aether Scout™ Sampler integrates with in-the-field Thermo Scientific FirstDefender™ RMX Raman sensors to enable near-real-time detection and identification of chemical aerosols down to trace levels. Having a limit of detection (LoD) of solid chemical aerosols down to 0.5 µg/m<sup>3</sup> in 5 minutes (2.5 µg\*min/m<sup>3</sup>), the

Aether Scout™ Sampler combined with the FirstDefender™ RMX has potential to detect and identify chemical aerosol concentrations below the AEGL-1 concentration of VX (0.57 µg/m<sup>3</sup> in 10 minutes, or 5.7 µg\*min/m<sup>3</sup>).

The development, optimization, and testing of the Aether Scout™ sampler involved iterative computational fluid dynamic modeling, rapid prototyping using 3-D printing, dynamic aerosol chamber testing, and outdoor field testing. To ensure applicability to a large variety of chemical and biological aerosols, development efforts targeted respirable and inhalable aerosols 0.5-20µm in size. Prototype testing with live CWAs indicated that the Aether Scout™ sampler collects and retains GD vapor challenges at concentrations of 3 µg/m<sup>3</sup> with efficiencies ranging from 18-23% which is sufficient for desorption and detection with several handheld devices. The results of SRC's development efforts produced a novel device that can substantially aid in the protection of law enforcement, first responders, and the military.

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## Surface Sampling for Improved On-Site Detection with Raman Spectroscopy

Marc Roberts | SRC, Inc.

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### Abstract

Currently fielded surface detection instruments suffer from a substantial deficiency in achieving sufficiently sensitive results in a rapid manner with little or no sample preparation. Analyses requiring sample preparation are time consuming, can be error prone, and may effectively dilute your sample to a lower concentration that reduces the likelihood of achieving detection.

SRC, Inc. (formerly Syracuse Research Corporation) developed a novel surface sampler that substantially enhances and extends the capability of Raman spectroscopic sensors down to as little as 5 µg of chemical threats on surfaces. Its background-free collection substrate and mechanical interface enables signal enhancement not attainable by traditional handheld point-and-shoot techniques. It is designed to be sensor agnostic to work with numerous Raman and FTIR systems currently in the field. For the newly released Acu-Swab-R® product, SRC developed a patent pending swab sample vial holder known as the sidecar that allows it to interface seamlessly with the currently fielded Thermo Scientific FirstDefender® RMX (RMX) handheld Raman spectrometer. In addition, laboratory data shows the Acu-Swab-R® is compatible with the complementary fielded sensor, the Thermo Scientific TrueDefender FTX handheld FTIR.

During the design, development, and test of the Acu-Swab-R®, SRC optimized the physical form, material compatibility, collection substrate, through iterative testing and protocol development to maximize collection efficiency and detectability of all types of collection scenarios including liquid droplets, trace residues, diffuse powders, adhered solids, gels/pastes, and invisible samples. The resulting product improves Raman sensitivity by 3-5 orders of magnitude, while maintaining the integrity of the sample for safe encapsulated transport to supporting reachback laboratories for more elaborate analysis.

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## Employing Microbial Surrogates to Evaluate Chlorine Dioxide Fumigation & Heat Treatment of Poultry Barns Under Field Conditions

Julian Rosenberg | The Sabre Companies

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### Abstract

Commercial poultry production facilities affected by highly pathogenic avian influenza (HPAI) or other biological contaminants pose potential risks to public health. However, reliable processes for decontaminating complex facilities are limited. Under a cooperative research and development agreement (CRADA) with the EPA, the virucidal and sporicidal efficacies of chlorine dioxide (ClO<sub>2</sub>) fumigation were compared to heat treatment in a large-scale field test. A test matrix of microbiological surrogates and reference materials was devised to compare pathogen inactivation on diverse surfaces. The rationale for this surrogate approach addresses needs to determine disinfection efficacy on actual building materials and efficiently clear contaminated structures. Two microbial surrogates spanning the hierarchy of disinfection susceptibility were employed as biological indicators (BIs): MS2 bacteriophage (non-enveloped viral surrogate, more resistant than HPAI) and *Bacillus subtilis* spores (gram-positive bacterium).

Although the CRADA focused on remediation following an HPAI outbreak, the inclusion of a spore BI served as a valuable opportunity to generate data for elevated levels of preparedness. These surrogates are relevant to *B. anthracis* and Clostridial spores as well as other human and animal pathogens.

In the field trial, two dry cleaned layer barns (50×600ft) were staged with identical sets of BIs and treated with the respective decontamination technologies. Reference BI coupons (0.25in<sup>2</sup>) representing both porous and non-porous materials (wood, cotton belt, concrete, black iron, galvanized steel, and polyethylene) were inoculated with >1×10<sup>7</sup> viable microorganisms per coupon. These “sentinel” surrogates were prepared in triplicate, with and without organic soil loading of desiccated poultry manure, then individually sealed in Tyvek/Tyvek pouches to prevent cross-contamination, and distributed at five locations in each test barn. In total, over 1,000 BI coupons were deployed for this field test, including relevant controls. The test compared two specific treatment conditions: ClO<sub>2</sub> fumigation targeting a CT value of 25,000 ppmv-hrs at 75°F and 85% RH and heat treatment following USDA guidelines of 100-120°F for seven days with at least three consecutive days ≥100°F. Temperature, relative humidity, and ClO<sub>2</sub> concentration were measured in real-time at ten locations in the respective barns. Recovered BI populations were quantitatively analyzed by whole coupon extraction followed by enumeration of plaque or colony forming units. This endpoint bio-analysis revealed the differential sporicidal and virucidal efficacies of each decontamination method, showing significant dependence on coupon material. Collectively, this data set provides valuable insight into large-scale agricultural decontamination of various high-challenge surfaces with broader implications in developing a rapid, surrogate-based, facility clearance method.

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## Rapid Detection of Abrin by Fluorescent-Microsphere Array Multiplex Assay (FAMA): Development and Validation

Jawad Sarwar | *Omni Array Biotechnology*

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### Abstract

**Background:** Abrin is a lectin and one of the most potent plant toxins present in the seeds of the *Abrus precatorius* plant. Highly toxic product can be made from easily obtainable rosary bean seeds that can be used in biocrimes and for contaminating various materials. Quick detection of the toxins is critical in devising strategies to mitigate the harmful effects of the contamination source. There is no validated Abrin detection assay available at present in the Laboratory Response Network (LRN) laboratories. Hence we developed a Fluorescent-microsphere Array Multiplex Assay (FAMA) for rapid detection of abrin. This new assay is an essential requirement to enhance biodetection capabilities in strengthening our preparedness in combating Biothreat agents. FAMA can be performed using Luminex Corporation’s MAGPIX and BioPlex 100/200 versatile multiplexing platform. This assay is based on Luminex® xMAP® technology that employs fluorescent polystyrene microspheres, referred to here as beads, as an assay reaction surface. This technology allows the simultaneous detection and differentiation of multiple biomolecular interactions in a single reaction well. This assay was developed for the qualitative detection of abrin toxin in environmental samples, unknown white powders and impinged aerosol samples submitted to LRN laboratories. After the development of the assay, a detailed validation was performed in a multi-phase study.

**Methods:** Different panels and the individual members in the panel were selected by subject matter experts derived from many different government departments. Abrin FAMA validation was performed in multiple phases: 1) Linear dynamic range finding study for initial Limit of detection (LOD) finding, 2) Repeatability study for LOD determination, 3) Inclusivity panel consisting of extracts from 11 genetically diverse cultivars of *Abrus precatorius* seeds, 4) Near neighbor consisting of 35 samples, 5) Lectin with 65 different purified lectins, 6) Informational panel with 11 samples, 7) White powder panel comprising of 26 samples with and without spiking of Abrin toxin and 8) Biowatch filter extract with and without toxin spiking. Triplicate testing was performed by different operators and on different days.

**Results:** FAMA showed a limit of detection (LOD) of less than 100 pg per test and was to be reproducible in the repeatability study. Repeatability testing showed more than 100% sensitivity and 100% specificity. Detailed results and performance of the other will be presented at the meeting.

**Conclusion:** A new assay (Abrin-FAMA) was developed and validated for swift detection abrin in the suspected samples. This detailed validation demonstrated clearly the usefulness of qualitative detection of abrin in the



laboratory. Abrin-FAMA was found out to be a reliable test with high sensitivity and specificity for the detection of abrin. This assay is amenable to automation and high throughput sample testing to meet surge capacity.

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## Fate and Transport of VX and Sulfur Mustard Across a Permeable Layer into Porous Subsurfaces

David See | *Battelle Memorial Institute*

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### Abstract

Depending on the location, a release of a chemical warfare agent (CWA) has the potential to contaminate painted and sealed surfaces. This study investigated the fate and transport of two CWAs, VX and sulfur mustard (HD), deposited on painted/sealed stainless steel and on freestanding paint/sealant films. A solid phase extraction (SPE) disk was placed under the test coupon to mimic a porous material and to collect agent which permeated through the paint/sealant films. Three types of paints and two types of sealants were evaluated. Samples were challenged with 2 microliters of VX or HD and then held at ambient laboratory conditions for durations ranging from 3 hours to 48 hours (HD) or 72 hours (VX). Following weathering, residual CWA was measured via wipe-sampling of the coupon surface, solvent extraction of the steel or freestanding film, and solvent extraction of the underlying SPE. Extracts were then analyzed for VX or HD using gas chromatography/mass spectrometry. CWA recoveries from the film wipe, film extraction, and SPE extraction were measured and reported, as well as the total CWA recovery based on the summation of the individual recoveries.

Generally, total VX recoveries and film wipe recoveries decreased with increasing weathering ( $\leq 62\%$  after 72 hours and  $\leq 19\%$  after 72 hours, respectively). VX was generally detected from the film extractions (4.4% to 47% after 72 hours) and SPE extractions ( $< 2.5\%$  to 19% after 72 hours), but consistently increasing or decreasing trends were not apparent across all the paints/sealants. HD recoveries from surface wiping rapidly decreased ( $\leq 2.0\%$  after 48 hours), but HD remained recoverable from film and SPE extractions. On painted surfaces, total HD recoveries remained high ( $\geq 72\%$ ) after 48 hours, except in the case of oil gloss painted stainless steel (25%). Total HD recoveries obtained during sealant testing tended to be lower (generally  $\leq 48\%$  after 48 hours), with the exception of polyurethane sealant film placed over SPE disk, which yielded a total recovery of 86% after 48 hours (73% of which came from the underlying SPE disk).

This research clearly demonstrates that VX and HD can penetrate through paints/sealants and are quite capable of migrating into underlying porous materials. Surface sampling may capture only a fraction of the VX and HD retained in paint/sealant layers and/or underlying porous materials, thus sampling and remediation strategies must address the potential for CWA to be retained within porous materials beneath painted/sealed surfaces.

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## Potential Environmental Impacts While Processing Contaminated Personnel

Markham Smith | *Defense Threat Reduction Agency*

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### Abstract

Over the past year the Defense Threat Reduction Agency (DTRA) J9 conducted three Table Top Exercises (TTXs) titled Elysium I, II and III to examine doctrine, procedures and science and technology (S&T) related to contamination mitigation of personnel, casualties, and human remains. The Elysium TTXs mapped processes associated with casualty care and mortuary affairs operations in OCONUS chemical, biological and radiological (CBR) contaminated environments. The majority of discussions and observations cited during the TTXs indicated that additional doctrine and policy is necessary to ensure the effective and efficient processing of both contaminated casualties and human remains. These observations highlighted the potential for environmental contamination while recovering and managing personnel, casualties and human remains both at the incident site and during transport from contaminated to non-contaminated areas such as medical treatment facilities. A similar documented concern is the potential environmental impacts associated with the temporary burial of decedents exposed to a CBR hazard. A final Elysium table top exercise will be conducted to discuss a Homeland based scenario. The results of the Elysium series will inform the development of an Integrated CBRN Concept for personnel contamination mitigation and identify technology and operational needs to inform S&T development. The intent of the Integrated CBRN Concept is to better coordinate and synchronize preparation and response activities following a CBRN incident.

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## Gelled Formulations for Subway Decontamination

Mark Tucker | Sandia National Laboratories

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### Abstract

Decontamination of subway systems following the release of a biological warfare agent such as *Bacillus anthracis* spores will be very challenging due to several factors including:

- Subway systems contain very large surface areas in the tunnels and stations most of which consist of hard-to-decontaminate materials such as unsealed concrete.
- Large portions of the surface areas in subway systems are oriented in the vertical or the horizontal downward-facing direction making it difficult to achieve desired contact times with liquid decontaminants.
- Material surfaces in subway systems typically contain large amounts of grime which may place an organic burden on a decontaminant and lower its efficacy.
- Most areas of a subway system have relatively cool surface temperatures (~55°F) which may lower the efficacy of common decontaminants.

The presence of organic loads such as grime and the low surface temperature of materials in a subway system may require decontaminants to remain on a surface for longer than normal contact times (i.e., 30 minutes or greater) to achieve high efficacy. However, many decontaminants (e.g., pH adjusted bleach) will run-off and not remain on vertical and downward-facing surfaces for the required contact time which may make it difficult to achieve desired efficacy levels. Therefore, methods to allow common decontaminants to cling to a surface (including vertical and downward-facing surfaces) for longer periods of time are needed. In addition, by minimizing the run-off of liquid decontaminants, the volume of liquid waste generated during decontamination operations may also be reduced. We have investigated the use of gelling materials that can be added to common decontaminants to allow them to achieve longer contact times on vertical and downward-facing surfaces and to minimize run-off. We have added these gelling materials to formulations containing pH adjusted bleach, activated peroxide, or dichloroisocyanuric acid and evaluated their efficacy in laboratory studies on test coupons of various materials under low temperature (55°F) conditions. We have also evaluated the efficacy of these gelled decontaminants in the presence of grime on the surface of test coupons. Finally, we conducted a larger scale study using these gelled decontaminants during the Operational Technology Demonstration which was conducted as a part of the US Department of Homeland Security, Science & Technology Directorate's Underground Transport Restoration Project.

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## Assessment of the Use of Sodium Hydroxide for the Destruction of Ricin

Nicola Walker | Defence Science and Technology Laboratory

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### Abstract

Ricin is a protein toxin found in the seeds of the castor oil plant *Ricinus communis*. It can be extracted from the seeds by a number of different methods producing an extract with high protein content, with ricin typically being 10 % of the total protein concentration in an aqueous extract. We are interested in methodologies for simple and rapid destruction of ricin.

Chlorine based decontaminants e.g. sodium or calcium hypochlorite, can be used to decontaminate protein toxins by denaturing and hydrolysing the toxin. A disadvantage of the addition of these chlorine based decontaminants to stocks of highly proteinaceous solutions is that they can cause frothing and the release of free chlorine resulting in a respiratory hazard to the operator.

We have therefore investigated the use of sodium hydroxide as a potential low technology, environmentally friendly and relatively safe method for the destruction of large quantities of aqueous ricin extract. Being a protein, NaOH will hydrolyse the amide bond between the amino acids of the ricin resulting in the toxin being broken down into small peptides and amino acids, thereby destroying the toxin. The efficiency of 10 %, 5 %, 2.5 % or 1 % w/v NaOH to hydrolyse ricin both in 500mM NaCl and in 500mM NaCl pH4 was assessed by an antibody based Hand Held Assay and SDS-PAGE.

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## Enzyme-Based Disclosure Sprays for Nerve and Blister Chemical Warfare Agents

Jeremy Walker | *FLIR Detection, Inc.*

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### Abstract

FLIR has developed several enzyme-based sprayable products for use in the detection of chemical warfare agent deployment. Agentase Disclosure Spray development for both nerve (G and V) and blister agents was initially funded by the Defense Threat Reduction Agency (DTRA). The sprays have reached the required technological maturity to transition (Nerve ADS, 2015; Blister ADS, expected 2017) into the Contamination Indicator/Decontamination Assurance Systems Program of Record (CIDAS-POR) under the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD).

When applied to a surface, ADS colorimetrically responds to the presence of trace levels of chemical warfare agents within five minutes. The sprays are compatible with a variety of surface materials and environmental conditions. Optimization of product shelf life has been a main focus of development efforts, with excellent stability demonstrated after extended storage at elevated temperatures. A fluorescent dye Nerve ADS chemistry has also been developed for use in low-light or covert operations.

By accurately locating precise areas of contamination, decontamination efforts can be more focused and performed with more confidence. This significantly reduces the amount of expensive decontaminant required to complete decontamination operations.

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## Lewisite and VX Degradation By-Product Analysis for Environmental Remediation by Liquid Chromatography/Tandem Mass Spectrometry

Stuart Willison | *U.S. Environmental Protection Agency*

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### Abstract

Analytical detection methods for conventional chemical warfare agents (CWA) were mostly derived for military purposes (i.e., developed by the military for protecting military personnel) and did not focus on the environmental aspect nor intended for use when dealing with contaminated civilian areas. However, if civilian areas are affected by these chemicals (e.g., Tokyo, Japan in 1995 and Syria in 2013), then it is necessary to ensure that the method is appropriate for a particular analyte in a particular matrix. This study investigated CWA degradation by-products, which are considered extremely hazardous to humans and the environment, with similar toxicity values as the parent CWA agent. The new methods address sampling and analysis for Lewisite degradation products (chlorovinyl arsonous acid (CVAA) and chlorovinyl arsonic acid (CVAOA)) in soil, wipe extracts, and water by LC-MS/MS. Because Lewisite 1 degradation products are unique, and neither the parent or degradates exist in the environment, they are unambiguous indicators for Lewisite 1. CVAOA was derived by oxidizing CVAA and Lewisite 1 using a 30 % hydrogen peroxide solution, followed by analysis. LC approaches directly allow for the detection of Lewisite 1 hydrolysis and oxidation products in the presence of environmental interferents. Water samples fortified with VX degradation product (EA2192) were analyzed by LC-MS/MS. The compound was evaluated using EPA Method 538 conditions, including accuracy, precision, reproducibility, linearity, stability, detection limit, and quantitation limit. The Method Detection Limit for CVAOA was calculated as 0.041 mg/L in water, 0.44 µg/wipe, and 0.073 µg/g, 0.032 µg/g, 0.028 µg/g and 0.055 µg/g in sand, Nebraska, Virginia, and Georgia soils, respectively. Average extraction efficiencies were 80-112 % for sand, Nebraska, and Georgia soils. Virginia soil extraction efficiencies were more challenging (~ 40 %). The Method Detection Limit for EA2192, determined from seven sample replicates at the calibration 1 level prepared over three batches, was calculated to be 0.013 µg/L. The Method Reporting Limit of 0.125 µg/L was determined from seven sample replicates at the calibration 2 level (0.12 µg/L).

### Abstract

Chemical decontamination efficacy tests against persistent nerve agent (VX) and distilled mustard agent (HD) were performed at the Battelle Hazardous Materials Research Center (HMRC) to assess the hazard mitigation performance of Dahlgren Decontaminant prepared by First Line Technology, LLC (FLT) and by the Naval Surface Warfare Center Dahlgren Division (NSWCDD). Contact transfer and remaining contamination tests were performed on coupon samples of five materials: chemical agent resistant coating, water dispersible (CARCW), polycarbonate (Lexan), ship deck coating (Nonskid), silicone rubber, and stainless steel (17-4PH) that are typically representative of military vehicles and equipment.

Test procedures, calculations, and analyses were performed following U.S. Army Test Operations Procedure (TOP) 8-2-061A "Chemical Decontaminant Testing" [1], using detailed practices described in ECBC-TR-980 "The Chemical Contaminant and Decontaminant Test Methodology Source Document, Second Edition" [2]. Contact transfer results were compared to chemical exposure hazard levels published in USACHPPM 47-EM-5863-04 "Acute Toxicity Estimation and Operational Risk Management of Chemical Warfare Agent Exposures" [3], using hand surface area estimates from Yu, et.al., Burns. 2008 Dec; 34(8):1183-9 [4] and Sheridan, et.al., J Burn Care Rehabil. 1995 Nov-Dec; 16(6):605-6 [5].

Dahlgren Decontaminant formulations from FLT and NSWCDD exhibited similar chemical hazard mitigation performance against each chemical warfare agent on each test material. In general, contamination levels were reduced by at least two orders of magnitude on coatings and hard materials. Differences in decontamination performance were observed on polycarbonate (Lexan) with HD and on Navy Nonskid with VX. Differences were caused by variations in the materials, themselves, not the decontaminant. Tests with the FLT formulation used SABIC Margard MR-10 polycarbonate and Navy Nonskid Compound-G (Type-I), while tests with the NSWCDD formulation used SABIC GE Lexan XL-10 and a sprayable Nonskid coating (Type-IV).

The chemical agent contact exposure hazard was reduced to negligible risk levels (i.e., no noticeable effect) on most materials for both chemical agents, even with repeated direct contact (i.e., ten hand touches). Reduction of contamination levels on silicone rubber was less than one order of magnitude for both HD and VX. Repeated direct contact with HD on silicone would be sufficient to produce noticeable but not disabling health effects.

Repeated direct contact with VX on silicone or Compound G Nonskid would be sufficient to produce deaths and severe disabling or incapacitating injuries.

Incidental contact (i.e., one hand touch) with VX on silicone would still be sufficient to produce disabling or incapacitating injuries.

# Appendix A. Agenda

## DAY 1: TUESDAY, NOVEMBER 1, 2016

7:00 AM	<b>Registration</b>
General Session 1 - Program Overviews, Responses, and Field Studies Auditorium, C-111. Presentations and Q&A moderated by Lukas Oudejans and Timothy Boe   <i>U.S. EPA</i>	
8:00 AM	<b>Opening Remarks</b> Lukas Oudejans and Shawn Ryan   <i>U.S. Environmental Protection Agency</i>
8:15 AM	<b>EPA's Homeland Security Research: From CBRNE to "All-Hazards"</b> Gregory Sayles   <i>U.S. Environmental Protection Agency</i> Jonathan Herrmann   <i>(Retired) U.S. Environmental Protection Agency</i>
8:50 AM	<b>An Overview of the UK Government Decontamination Service's Science and Technology Program</b> Dudley Hewlett   <i>Department for Environment, Food and Rural Affairs, United Kingdom</i>
9:30 AM	<b>BREAK</b>
General Session 1 (cont.) - Program Overviews, Responses, and Field Studies Auditorium, C-111. Presentations and Q&A moderated by Hiba Ernst and Mario Ierardi   <i>U.S. EPA</i>	
10:00 AM	<b>Current Status in Fukushima and Study on Volume Reduction and Recycling</b> Kiyohiko Eino   <i>Japanese Ministry of the Environment</i>
10:45 AM	<b>Research Supporting the Development of Capabilities for Environmental Remediation for Chemical, Biological, and Radiological Contamination</b> Shawn Ryan   <i>U.S. Environmental Protection Agency</i>
11:15 AM	<b>Jack Rabbit II Chlorine Release Field Experiments</b> Shannon Fox   <i>Department of Homeland Security</i>
11:45 AM	<b>LUNCH</b>
12:45 PM	<b>Keynote Speaker: Perspectives from EPA's Leadership on Homeland Security Research</b> Stan Meiburg, Acting Deputy Administrator   <i>U.S. Environmental Protection Agency</i>
General Session 1 (cont.) - Program Overviews, Responses, and Field Studies Auditorium, C-111. Presentations and Q&A moderated by Matthew Magnuson and Christopher Gallo   <i>U.S. EPA</i>	
1:00 PM	<b>Demonstration of Radiological Decontamination and Mitigation Technologies for Building Structures and Vehicles</b> Sang Don Lee   <i>U.S. Environmental Protection Agency</i>
1:25 PM	<b>Water, Water Everywhere: Managing Contaminated Water from Chem-, Bio-, and Rad- Decontamination</b> Hiba Ernst   <i>U.S. Environmental Protection Agency</i>
1:50 PM	<b>Toward Cleanup and Recovery of Underground Transit Systems from a Biological Agent Event</b> Don Bansleben   <i>Department of Homeland Security</i>
2:15 PM	<b>Fumigation of a Subway Railcar Using Methyl Bromide to inactivate <i>Bacillus anthracis Sterne</i></b> Jasper (Joe) Hardesty   <i>Sandia National Laboratories</i>
2:40 PM	<b>BREAK</b>

Concurrent Sessions 1

Underground Transport Restoration Auditorium, C-111 Moderated by Shawn Ryan and Charlie Fitzsimmons   <i>U.S. EPA</i>		Water Infrastructure Protection and Decontamination C-113 Moderated by Jim Goodrich   <i>U.S. EPA</i>	
3:15 PM	<b>Investigation of Sampling and Analysis Protocols for Underground Transport Restoration</b> Staci Kane   <i>Lawrence Livermore National Laboratory</i>	3:15 PM	<b>Water Utility Decontamination Preparedness Tools</b> Veronica Aponte-Morales   <i>U.S. Environmental Protection Agency</i>
3:40 PM	<b>Advances in Sampling and Situational Awareness Using Augmented and Virtual Reality Devices</b> Robert Knowlton   <i>Sandia National Laboratories</i>	3:40 PM	<b>Assessing the Effectiveness of Coliform Decontamination in Aircraft Drinking Water Systems</b> Jeffrey Szabo   <i>U.S. Environmental Protection Agency</i>
4:05 PM	<b>Spray Knockdown System for Rapid Containment and Neutralization of Airborne CBW</b> Mark Tucker   <i>Sandia National Laboratories</i>	4:05 PM	<b>Field-Scale Water Infrastructure Decontamination and Wash Water Treatment</b> Jim Goodrich   <i>U.S. Environmental Protection Agency</i>
4:30 PM	<b>Decontamination Options in a Subway Environment Following a Biological Release</b> Lukas Oudejans and Shannon Serre   <i>U.S. Environmental Protection Agency</i>	4:30 PM	<b>Installation of Routine and Heightened Biosecurity Equipment and Protocols at Beef Cattle Feed Yard in the High Plains</b> Robert DeOtte   <i>West Texas A&amp;M University</i>
4:55 PM	<b>Developing Guidance for the Rapid Return to Service of Underground Transportation Systems Following a Biological Agent Attack</b> Robert Fischer   <i>Lawrence Livermore National Laboratory</i>	4:55 PM	<b>Biocontaminants in Wastewater: Interactions Between <i>Bacillus Globigii</i> Spores and Mixed Cultures of Activated Sludge</b> Willie Harper   <i>Air Force Institute of Technology</i>
5:20 PM	DAY 1 ADJOURNS		

## DAY 2: WEDNESDAY, NOVEMBER 2, 2016

7:00 AM Registration

General Session 2 - Chemical, Biological, and Radiological Research Efforts  
Auditorium C-111. Presentations and Q&A moderated by Timothy Boe and Lawrence Kaelin | *U.S. EPA*

8:15 AM **EPA's Selected Analytical Methods for Environmental Remediation and Recovery**  
Romy Campisano | *U.S. Environmental Protection Agency*

8:40 AM **Basic Research for Next-Generation Decontamination Technologies**  
Stephen Lee | *U.S. Army Research Office*

9:05 AM **Hazard Mitigation Science and Technology Program for the DoD Chemical and Biological Defense Program**  
Charles Bass | *Defense Threat Reduction Agency*

9:30 AM BREAK

### Concurrent Sessions 2

Biological Agent Detection  
Auditorium, C-111  
Moderated by Brendan Doyle | *U.S. EPA*

Chemical Agent Research  
C-113  
Moderated by David Bright | *U.S. EPA*

9:50 AM **Bioluminescent Reporter Phage System for *Bacillus Anthracis* Detection and Clearance Monitoring Following Environmental Release**  
David Schofield | *Guild BioSciences*

9:50 AM **The Chemical Terrorism Risk Assessment**  
David Bradley | *Department of Homeland Security / Leidos Contract Support*

10:15 AM **Rapid, Quantitative Biological Indicator System with *Bacillus Thuringiensis* AI Hakam Spores**  
Yoojeong Kim | *Triton Systems, Inc.*

10:15 AM **The Chemical Agent Reactions Database (CARD)**  
David Morton | *Department of Homeland Security / Battelle Contract Support*

10:40 AM **Detection and Identification of Environmental Microbes Contamination Using Novel LC-ESI-MS/MS Method**  
Rabih Jabbour | *U.S. Army, Edgewood Chemical Biological Center*

10:40 AM **Chemical Hot Air Decontamination of CWA-Contaminated Materials**  
Joseph Myers | *U.S. Army, Edgewood Chemical Biological Center*

11:05 AM **Development of Standards and Testing of Portable Biodetection Equipment for the Screening of Biothreat Agents**  
Rachel Bartholomew | *Pacific Northwest National Laboratory*

11:05 AM **Natural Attenuation of VX following Application onto Nonporous and Porous Materials**  
David See | *Battelle Memorial Institute*

11:30 AM LUNCH

### Concurrent Sessions 3

Environmental Resilience / Biological Agent Sampling & Methods  
Auditorium, C-111  
Moderated by Sarah Taft and Leroy Mickelsen | *U.S. EPA*

Radiological Agent Research  
C-113  
Moderated by Sang Don Lee | *U.S. EPA*

12:30 PM **Environmental Resilience: Exploring Scientific Concepts for Strengthening Community Resilience to Disasters**  
Brendan Doyle | *U.S. Environmental Protection Agency*

12:30 PM **Modeling Decontamination Strategies in the Aftermath of a Nuclear Detonation**  
Matthew Clay | *U.S. Department of Health and Human Services / Leidos Contract Support*



12:55 PM	<b>The Application of Biological Agent Sampling Methods to a Wide-Area Incident</b> Colin Hayes   <i>ERG</i>	12:55 PM	<b>In Half a Half-Life of Cesium-137: NHSRC Research for Radiological Remediation</b> Matthew Magnuson   <i>U.S. Environmental Protection Agency</i>
1:20 PM	<b>Novel Methods for the Characterization of Viable <i>Bacillus</i> Spores from Wastewater and Landfill Leachate</b> Douglas Hamilton   <i>ORISE Research Participant with U.S. EPA</i>	1:20 PM	<b>RN Decontamination of Military Sensitive Equipment</b> Marc Desrosiers   <i>Defence Research and Development Canada</i>
1:45 PM	<b>Comparative Efficacy of Decontamination Technologies for <i>Bacillus anthracis</i> and <i>Bacillus Atrophaeus</i></b> Vipin Rastogi   <i>U.S. Army, Edgewood Chemical Biological Center</i>	1:45 PM	<b>A Novel Approach for Evaluating Cost Effective Decontamination Options for Remediating a Radiologically Contaminated Site</b> Jim Mitchell   <i>U.S. Environmental Protection Agency</i>

Poster Session  
Building B Atrium

2:10–3:40  
PM

**Poster Session of the Decontamination R&D Conference**

Join us in the Building B Atrium to view posters and interact with poster presenters.

1	<b>Impact of Fumigation Using Methyl Bromide with Chloropicrin on Electronic Equipment</b> Alden Adrion   <i>U.S. Environmental Protection Agency</i>
2	<b>Updates and Developments to EPA's Water Contaminant Information Tool (WCIT)</b> John Bain   <i>U.S. Environmental Protection Agency</i>
3	<b>Exposure and Pathways Analysis of Infectious Livestock Carcass Management Options During Emergency Situations</b> Sandip Chattopadhyay   <i>U.S. Environmental Protection Agency</i>
4	<b>Outdoor Biological Simulant Release in an Operationally Relevant Environment</b> Amanda Clark   <i>Naval Surface Warfare Center - Dahlgren Division</i>
5	<b>Response Guidance Development</b> Tod Companion   <i>U.S. Department of Homeland Security</i>
6	<b>EPA's Dual Use Research of Concern Policy and Order</b> Brendan Doyle   <i>U.S. Environmental Protection Agency</i>
7	<b>Advanced Decontamination Concepts and National Security Product Development</b> Brian France   <i>TDA Research, Inc.</i>
8	<b>A Surfactant Blend Designed Specifically for Decontamination with Multiple Uses</b> Brian France   <i>TDA Research, Inc.</i>
9	<b>Relative Susceptibility of Foot and Mouth Disease Virus (FMDV), Feline Calicivirus, and Bacteriophage MS2, to Five Disinfectants</b> Lindsay Gabbert   <i>U.S. Department of Homeland Security</i>
10	<b>Characterization of Anthrax Surrogates by Chromogenic Media</b> Douglas Hamilton   <i>U.S. Environmental Protection Agency</i>
11	<b>Radiological Contaminant Persistence and Decontamination in Drinking Water Pipes</b> Ryan James   <i>Battelle Memorial Institute</i>
12	<b>Two Recent Examples of EPA's Response Capabilities for CWA Analysis</b> Lawrence Kaelin   <i>U.S. Environmental Protection Agency</i>

13	<b>Vapor Hydrogen Peroxide For Biological Decontamination – Process Optimization</b> Marek Kuzma   <i>Institute of Microbiology</i>
14	<b>Broad-Spectrum Enzymatic Decontamination of CWAs</b> Anna Leech   <i>FLIR Detection, Inc.</i>
15	<b>Pre-Treatment Technologies to Facilitate Management of Animal Carcasses from Animal Health Emergencies</b> Paul Lemieux   <i>U.S. Environmental Protection Agency</i>
16	<b>Provisional Advisory Levels (PALs): A Tiered System of Exposure Evaluations</b> John Lipscomb   <i>U.S. Environmental Protection Agency</i>
17	<b>A Responsible Solution for Animal Disease Events</b> Tony Nazal   <i>InVivo Reclamation Bioservice</i>
18	<b>Improving Temperatures for Subway Surface Decontamination</b> Malik Oliver   <i>MIT Lincoln Laboratory</i>
19	<b>Underground Transport Restoration Program. Lab to Field Studies by EPA Researchers</b> Lukas Oudejans   <i>U.S. Environmental Protection Agency</i>
20	<b>Quantitative Method for the Detection of Sodium Fluoroacetate (Compound 1080) in Water by Direct Injection LC-MS/MS</b> Emily Parry   <i>U.S. Environmental Protection Agency</i>
21	<b>Boron Doped Diamond Electrochemical Advanced Oxidative Process Treatment of Heavily Contaminated Water for Drain Disposal and PO</b> Rebecca Phillips   <i>ORISE Research Participant with U.S. EPA</i>
22	<b>Disinfection Efficacy of COTS Against Ebola Virus and Possible Surrogate</b> Vipin Rastogi   <i>U.S. Army, Edgewood Chemical Biological Center</i>
23	<b>Preparing and Protecting Workers Through Training and Education in a Biohazard Environment</b> Jim Remington   <i>National Institute of Environmental Health Sciences</i>
24	<b>Environmental Hazard Prediction Modeling of Low Volatility Agents for Mitigation of Contact Hazards and Vapor Hazards</b> Marc Roberts   <i>SRC, Inc.</i>
25	<b>Full Spectrum CBRNE and Drug Sampling of Aerosols / Vapors to Support Safe Entry and Decontamination Assurance of Clandestine Laboratories</b> Marc Roberts   <i>SRC, Inc.</i>
26	<b>Surface Sampling for Improved On-Site Detection with Raman Spectroscopy</b> Marc Roberts   <i>SRC, Inc.</i>
27	<b>Employing Microbial Surrogates to Evaluate Chlorine Dioxide Fumigation &amp; Heat Treatment of Poultry Barns Under Field Conditions</b> Julian Rosenberg   <i>The Sabre Companies</i>
28	<b>Rapid Detection of Abrin by Fluorescent-Microsphere Array Multiplex Assay (FAMA): Development and Validation</b> Jawad Sarwar   <i>Omni Array Biotechnology</i>
29	<b>Fate and Transport of VX and Sulfur Mustard Across a Permeable Layer into Porous Subsurfaces</b> David See   <i>Battelle Memorial Institute</i>

30	<b>Potential Environmental Impacts While Processing Contaminated Personnel</b> Markham Smith   <i>Defense Threat Reduction Agency</i>
31	<b>Gelled Formulations for Subway Decontamination</b> Mark Tucker   <i>Sandia National Laboratories</i>
32	<b>Assessment of the Use of Sodium Hydroxide for the Destruction of Ricin</b> Nicola Walker   <i>Defence Science and Technology Laboratory</i>
33	<b>Enzyme-Based Disclosure Sprays for Nerve and Blister Chemical Warfare Agents</b> Jeremy Walker   <i>FLIR Detection, Inc.</i>
34	<b>Lewisite and VX Degradation By-Product Analysis for Environmental Remediation by Liquid Chromatography/Tandem Mass Spectrometry</b> Stuart Willison   <i>U.S. Environmental Protection Agency</i>
35	<b>Chemical Hazard Mitigation Efficacy of Dahlgren Decontaminant</b> George Wrenn   <i>Battelle Memorial Institute</i>

**Concurrent Sessions 4**

<b>Biological Agent Research</b> Auditorium, C-111 Moderated by Worth Calfee and Shannon Serre   <i>U.S. EPA</i>		<b>Radiological Agent Research</b> C-113 Moderated by Terry Stilman   <i>U.S. EPA</i>	
<b>3:40 PM</b>	<b>Fate and Transport of Spores in Urban Environments: Understanding the Impact of Precipitation on Decontamination</b> Anne Mikelonis   <i>U.S. Environmental Protection Agency</i>	<b>3:40 PM</b>	<b>A Water-Based Formulation for Rapid Response after a Radiological Incident</b> Wenxing Kuang   <i>Environment and Climate Change Canada</i>
<b>4:05 PM</b>	<b>Composite Sampling Efficiency for Clean and Grime Coated Surfaces</b> Brett Amidan   <i>Pacific Northwest National Laboratory</i>	<b>4:05 PM</b>	<b>Irreversible Wash-Aid, Treatment, and Emergency Reuse System (IWATERS) for Strontium Contaminations</b> Michael Kaminski   <i>Argonne National Laboratory</i>
<b>4:30 PM</b>	<b>Streamlining Documentation of Sampling and Analysis Plans and Data Quality Objectives for Biological Contamination Events</b> Erin Silvestri   <i>U.S. Environmental Protection Agency</i>	<b>4:30 PM</b>	<b>Current and Emerging Post-Fukushima Technologies and Techniques for Wide Area Radiological Survey and Remediation</b> Mark Sutton   <i>Lawrence Livermore National Laboratory</i>
<b>4:55 PM</b>	<b>Environmental Impact of Synthetic Biology</b> Chris Warner   <i>U.S. Army Corps of Engineers</i>	<b>4:55 PM</b>	<b>Evaluation of Low-Tech Remediation Methods Following Wide Area Rad/Nuc Incidents</b> Ryan James   <i>Battelle Memorial Institute</i>
<b>5:20 PM</b>	<b>DAY 2 ADJOURNS</b>		

**DAY 3: THURSDAY, November 3, 2016**

**7:00 AM** | **Registration**

**Concurrent Sessions 5**

<b>Biological Agent Decontamination</b> Auditorium, C-111 Moderated by Sanjiv Shah and Benjamin Franco   <i>U.S. EPA</i>		<b>Livestock Remediation Options</b> C-113 Moderated by Joseph Wood   <i>U.S. EPA</i>	
<b>8:00 AM</b>	<b>Hot, Humid Air Decontamination of a C-130 Aircraft Contaminated with Spores</b> Tony Buhr   <i>Naval Surface Warfare Center - Dahlgren Division</i>	<b>8:00 AM</b>	<b>Field Demonstration of Aboveground Burial as a Tool for Managing Animal Carcasses Following a Disease Outbreak</b> Gary Flory   <i>Virginia Department of Environmental Quality</i>
<b>8:25 AM</b>	<b>Domestic Self-Help Clean-up of Biological Material in the Indoor Environment</b> Howard Walls   <i>RTI International</i>	<b>8:25 AM</b>	<b>Viral Bio-Threat Agent Persistence in U.S. Landfill Leachate</b> Megan W. Howard   <i>Battelle Memorial Institute</i>
<b>8:50 AM</b>	<b>Effects of High Intensity Blue Light on <i>Bacillus</i> Spores</b> Joanne Thwaite   <i>Defence Science &amp; Technology Laboratory, United Kingdom</i>	<b>8:50 AM</b>	<b>Current Operational and Economic Considerations Comparing Chlorine Dioxide Fumigation to Heat Treatment for Poultry Barns</b> John Mason   <i>The Sabre Companies</i>
<b>9:15 AM</b>	<b>Use of the OECD Quantitative Method to Demonstrate the Susceptibility of Bacteria and Bacterial Spores to Sodium Hypochlorite</b> Jordan Zambrana   <i>ASPPH Research Participant with U.S. EPA</i>	<b>9:15 AM</b>	<b>Validation of Mobile Autoclave Using Temperature and Pressure Variables for Potential Use for Domestic Agricultural Emergencies</b> Craig Ramsey   <i>U.S. Department of Agriculture</i>

**9:40 AM** | **BREAK**

**Concurrent Sessions 6**

<b>Biological [Ricin] Agent Research</b> Auditorium, C-111 Moderated by Eric Rhodes and Elise Jakabhazy   <i>U.S. EPA</i>		<b>Waste Management Practices</b> C-113 Moderated by Paul Lemieux   <i>U.S. EPA</i>	
<b>10:00 AM</b>	<b>Developing an EPA-Registered Anthrax Decontamination Product</b> Brian France   <i>TDA Research, Inc.</i>	<b>10:00 AM</b>	<b>The Future of the Waste Estimation Support Tool</b> Timothy Boe   <i>U.S. Environmental Protection Agency</i>
<b>10:25 AM</b>	<b>Development of a Sample Processing Approach for Ricin Detection in Environmental Samples</b> Sanjiv Shah   <i>U.S. Environmental Protection Agency</i> and Staci Kane   <i>Lawrence Livermore National Laboratories</i>	<b>10:25 AM</b>	<b>Evaluation of Porous Materials for Testing Antimicrobial Products Using the OECD Quantitative Method</b> Stephen Tomasino   <i>U.S. Environmental Protection Agency</i>
<b>10:50 AM</b>	<b>Detailed Validation of a Laboratory Biosensor Test for Rapid Detection of Ricin Toxin</b> Kodumudi Venkateswaran   <i>Omni Array Biotechnology, LLC</i>	<b>10:50 AM</b>	<b>Treatment of CBRN Decontamination Effluent – A Research Project Exploring Feasibility</b> Victor Medina   <i>U.S. Army Engineer Research and Development Center</i>

11:15 AM	<b>Attenuation of Ricin Toxin Under Ambient Conditions and Elevated Temperature and Humidity</b> Joseph Wood   <i>U.S. Environmental Protection Agency</i>	11:15 AM	<b>Carcass Management and Pathogen Transport During HPAI 2015</b> Lori Miller   <i>U.S. Department of Agriculture</i>
<b>General Session 3 - Closing</b> Auditorium, C-111			
11:40 PM	<b>Closing Remarks</b> <i>NHSRC</i>		
12:00 PM	<b>CONFERENCE ADJOURNS</b>		

# Appendix B. Participants

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# Appendix C. Presentation Slides

SEE SEPARATE DOCUMENTS ENTITLED:

Appendix C 2016 EPA Decontamination Conference Presentation Slides Vol. I  
(presentation slides)

Appendix C 2016 EPA Decontamination Conference Presentation Slides Vol. II  
(poster presentations)



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