Overview of the EPA’s National Homeland Security Research Center’s Radiological Research Program

Emily Snyder – Acting Radiological Team Lead
NREP Conference Norfolk, Virginia
Radiological Dispersal Device (RDD)

- Usually refers to an explosive device constructed with radioactive materials ("dirty bomb") but also includes non-explosive dispersal means.
- The most likely radiological materials include cesium\textsuperscript{137}, strontium\textsuperscript{90}, iridium\textsuperscript{192}, americium\textsuperscript{241}, radium\textsuperscript{226}, cobalt\textsuperscript{60}, plutonium\textsuperscript{239} or plutonium\textsuperscript{238}, and are available from industrial, medical, agricultural, or military sources.
- RDDs are weapons of mass disruption due to their potential effect on the economy including recovery costs, business interruption, or possible abandonment of the site.

Schematic of a RDD
http://www.remm.nlm.gov/rd
d.htm#dirtybomb
EPA’s role in the RDD recovery process

• EPA is a coordinating and cooperating agency listed in the Nuclear/Radiological Annex of the National Response Framework (cooperating for IND/RDD)

• This plan builds upon the existing National Incident Management System

• During a response to an Incident of National Significance, coordinating agencies and cooperating agencies provide technical expertise, specialized equipment, and personnel in support of DHS, which is responsible for overall coordination of incident management activities
National Homeland Security Research Center

- Threat and Consequence Management Division
- Water Infrastructure Protection Division
- Decontamination and Consequence Management Division
- Response Capability Enhancement Team
Inputs...

<table>
<thead>
<tr>
<th>determine</th>
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<th>that result in</th>
<th>Science Products...</th>
<th>that yield</th>
<th>Outcomes...</th>
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<td>Impacts</td>
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Deterrence of attacks on water systems is improved; and when terrorist attacks occur, exposure of humans and the environment to contamination and the impact on water infrastructure are minimized, and water and water infrastructure, buildings and outdoor areas are effectively cleaned up and returned to use promptly.

The long-term impacts of terrorist attacks on human health, the environment and the economy are minimized.

EPA’s Homeland Security Research Program Logic
Remediation Timeline

**Containment/Mitigation**
- Characterization sampling to focus decontamination efforts

**Decontamination/Disposal**
- Final status surveys for reuse/reoccupancy
Infiltration of Rad Particles into Buildings

• Building design, ambient conditions, and building shell have effects on the penetration of particles from outdoors to indoors.

• Building features that most influence the entry of particles into indoor environment must be identified to determine the best means to mitigate penetration, thus minimizing exposure and decontamination requirements.
Infiltration of Rad Particles into Buildings

Two Compartment Chamber for Infiltration Studies

• Comprised of a single chamber with partition separating the outdoor compartment from the indoor compartment.

• Partition can be built as desired to simulate a building façade, cracks in a building surface, windows, doors, etc.
Infiltration of Rad Particles into Buildings

Exterior commercial walls to separate the compartments
• Building shell provides significant protection against particle entry:
  90% of 0.02 micron particles removed from infiltrating air
  50% of 0.5 micron
  60% of 1 micron
  90% of 5 micron

• Deposition rate constant has little influence on building protection factor for particles 0.1 to 2 microns aerodynamic diameter.

Mosley et al., American Filtration Society Meeting, 2002
Assessing the interactions of radiological agents with urban materials – driver and approach
PI: Sang Don Lee

• Goal: To develop effective decontamination technologies and strategies through understanding the interactions of radiological agents (such as cesium, strontium, and cobalt) with urban surfaces.
• Driver: Need seen by NHSRC researchers and international collaborators (Defense Research and Development Canada – Canada’s Department of Defense Counterpart)
• Approach: Study the physical and chemical interactions of chemical surrogates of radiological agents (Cs, Sr, Co) with common urban materials such as concrete, brick, limestone, marble, granite, and asphalt. These interactions are being studied as a function of environmental conditions (relative humidity, temperature, precipitation) and loading of radiological agent surrogate.
Assessing the interactions of radiological agents with urban materials part 1 - conventional outdoor explosion test

• Goals
  – To characterize the physicochemical properties of CsCl particles from outdoor explosion tests
  – To estimate the CsCl particle deposition and its subsequent penetration into limestone at various relative humidity conditions

• Experimental - Two open field RDD tests collaborating with LLNL
  – Different positions: one hanging in the air and the other partially buried in the soil
  – Filter samplers, particulate matter samplers, particle deposition on limestone coupons
Description of conventional outdoor explosion test

RDD was set off 1 m high from the ground (CsCl: 2 kg, C4: 2 kg)

Near Field: Limestone coupons
Far Field: Polycarbonate Filters and Sidepaks

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<td>RH (%)</td>
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CsCl particle characterization
Assessing the penetration of cesium into building materials - limestone

Limestone coupon
10 feet from detonation

Dry pre-conditioning
Limestone coupon 10 feet from detonation - wet pre-conditioning
Assessing the interactions of radiological agents with urban materials - Conventional outdoor explosion test – Conclusions and next steps

• Decontamination of cesium chloride on porous urban surfaces (such as concrete and limestone) presents significant challenges.

• Elapsed time may increase difficulty of decontamination.

• Relative humidity and precipitation affect surface and sub-surface radionuclide interactions and therefore may affect the ability to decontaminate these porous urban surfaces.

• Currently decontamination technologies that are both efficacious enough to meet the required levels and non-destructive for porous surfaces are not available.

• Next steps include study of strontium and cobalt interactions with urban materials
Remediation Timeline

**Containment/Mitigation**

- Characterization sampling to focus decontamination efforts

**Decontamination/Disposal**

- Final status surveys for reuse/reoccupancy
Evaluation of on-line radiation sensors for alpha, beta, and gamma radiation (Technical Associates Model SSS-33-5FT) PI: John Hall

Will be challenged with radioisotopes in finished drinking water at EPA's National Air and Radiation Environmental Laboratory in Montgomery AL
Radiological sampling and analysis - ERLN support projects and driver
PIs: Kathy Hall and John Griggs (ORIA)

• Projects:
  – RAD Fast Methods for Water and Air Filters
  – Swipe Efficiency Validation
  – Rapid methods for select radionuclides in SAM for soil and water

• Completed:

• Driver: There is a need for rapid methods for sampling/analysis. Without these methods the overall remediation timeline will be greatly extended.
Rapid radiochemical methods approach

- Five radionuclides from SAM have been selected as the starting point for the process of developing rapid methods for incident response samples
  - $^{241}$Am
  - $^{238}$, $^{239+240}$Pu
  - $^{238}$U
  - $^{90}$Sr
  - $^{226}$Ra
- Five aspects of the methods that will be validated
  - Can the method achieve the required method uncertainty at the selected action level and below?
  - Can acceptable method blank analyses be performed?
  - Is the minimum detectable concentration selected achievable?
  - Is there a bias to the measurement at any level or on the blanks?
  - Are the chemical yields of the method acceptable?
Completed aspects of validation studies

• Five rapid radiochemical methods have been written for water- they reduce analysis time by at least 50%.
  – Rapid methods employ more rapid separation chemistry based on ion selective columns for the target radionuclide.
  – Many of the older, established radiochemical methods employ more time consuming and often multiple separation steps and techniques.
• The methods have undergone validation testing at a laboratory using the MARLAP approach for method validation.
• A Method Validation data assessment report has been completed for the five methods.
• Air particulate filter rapid dissolution methods have been written to support development of rapid methods for filters.
Remediation Timeline

Containment/Mitigation

Characterization sampling to focus decontamination efforts

Decontamination/Disposal

Final status surveys for reuse/reoccupancy
Persistence and decontamination of radionuclide contaminants in drinking water systems-driver and approach – PI Jeff Szabo

- **Driver:** The persistence of radionuclides in water systems and the efficacy of traditional water system decontaminants are unknown
- Non-radioactive cesium and cobalt acted as surrogates for Cesium-137 and Cobalt-60
- Biofilm annular reactors (BAR) containing iron coupons that were corroded in Cincinnati tap water simulated pipes in drinking water systems
- Cesium and cobalt persistence on the corroded iron surface was monitored for 6 weeks.
- Efficacy of the following decontamination methods was determined:
  - Flushing
  - Superchlorination
  - Ethanol
  - Ammonia
  - Sulfuric acid
- Oxidation state of adhered species on iron coupons was studied using X-ray absorption near-edge spectroscopy (XANES) and X-ray absorption fine structure (XAFS).
Persistence of cesium in water system - injection in bio-film annular reactor containing iron test coupons

Environmental Scanning Electron Microscopy coupled with X-ray analysis of pipe coupon surfaces after system contaminated with CsCl

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<0.5 % below MDL
Persistence of cobalt in water system - injection in bio-film annular reactor containing iron test coupons

Environmental Scanning Electron Microscopy coupled with X-ray analysis of pipe coupon surfaces after system contaminated with cobalt

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<0.5 % below MDL
Persistence of cobalt - cobalt injection in bio-film annular reactor containing iron test coupons - time series

Change in the amount of cobalt present on corroded iron coupons following flushing and superchlorination

Persistence and decontamination of radionuclide contaminants in drinking water systems – conclusions and next steps

- Cobalt is persistent on pipe coupons from simulated water system at both initial solution concentrations of 10 and 100 mg l⁻¹ solutions

- Absorbed cobalt on pipe coupons was resistant to both physical and chemical decontamination methods

- Next steps - Cross center workgroup currently gathering information to determine which radionuclide contaminants to research next and what decontaminants to include in these studies
Determining the Efficacy of Gross Decontamination Technologies – Assessment Of The Impact Of Water Wash Down For Mitigation Of Radiological Dispersal Device (RDD) Contamination – Session 6

Emily Snyder, Sang Don Lee, Lukas Oudejans, Julia Barzyk, John McGee

National Homeland Security Research Center
Ongoing Research
Gross decontamination - drivers and focus

• During an event low tech methods may be used to decontaminate urban areas after the release of an RDD. These methods include: firehoses, pressure washers, and dry and wet vacuums.

• Driver – The efficacy of these technologies as well as the waste streams are unknown.

• Focus - Water wash down of urban surfaces using fire hoses or pressure washers is an all hazards approach to decontamination

• Effects of water wash down for decontamination of urban surfaces covered with Radiological Dispersal Device (RDD) contamination are unknown

• Water wash down may reduce the RDD contamination levels on the surface being decontaminated but it may also create a large secondary waste stream, spread contamination to uncontaminated areas, and compromise later decontamination efforts.

• In addition, fire hoses and/or pressure washers could re-aerosolize the radioactive particles, creating an additional health hazard.

• All of these impacts must be assessed in controlled studies to determine if water wash down is an appropriate approach for RDD decontamination.
Objectives and approach:

• Objectives:
  – Evaluate the decontamination efficacy of a fire hose
  – Assess the fate of RDD contaminants in the environment after water wash down

• Approach:
  – Construct a benchtop system that mimics use of a firehose
  – Determine the amount of cesium (Cs\(^{133}\)) removed from the surface through analysis of the waste water;
  – Examine the subsurface penetration of cesium into the concrete;
  – Characterize the aerosol cesium particles created during the water wash down
Gross decontamination - next steps

• Complete similar evaluation for pressure washers
• This will be completed in room size chamber due to splash back
• During these evaluations will continue to:
  – Determine the amount of cesium (Cs133) removed from the surface through analysis of the waste water;
  – Examine the subsurface penetration of cesium into the concrete;
  – Characterize the aerosol cesium particles created during the water wash down

Room size chamber in EPA NHSRC’s facility in Research Triangle Park, NC
RDD Decontamination Technology Testing – Session 11

John Drake

National Homeland Security Research Center
Ongoing Research
Technology testing - drivers and approach

- Driver: States and locals upon consult with the Stakeholder Group (populated by EPA responders such as the National Decontamination Team and the Radiation Emergency Response Team) need information on the effectiveness of the available decontamination technologies.

- Methods and technologies will be selected based on:
  - Availability (*can be deployed quickly, sufficient to decon many city blocks*)
  - Effectiveness (*decon factor for particular urban substrate*)
  - Speed
  - Cost (*material/equipment, waste disposal, labor hours, etc*)
Technology Testing – Completed Work

- Work completed at Battelle/INL facility
- Decon Factors for strippable coatings were determined for concrete contaminated with cesium chloride (Cs\textsuperscript{137})
- Material and surface finish of concrete representative of a typical urban environment.
- Coupons orientated in both the horizontal and vertical direction to mimic an actual urban environment.
- Two commercial coatings were selected
  - Mechanical: traps removable contamination (particulates)
  - Chemical: also includes a chelating agent to chemically draw contamination from the substrate

Reports available: www.epa.gov/nhsrc/tte_radionuclides.html
Technology testing - next steps

• Larger scale technologies will be evaluated for removal of cesium chloride ($\text{Cs}^{137}$) from concrete

• Technologies that will be tested include:
  – Vacuum assisted power brushing
  – Media blasting
  – Water blasting

• Effluent will be captured and quantified during the evaluation of the technologies as would be done when they are deployed
Evaluation of commercial cleaners for removal of radionuclides from indoor surfaces PI: John Drake

- Commercial cleaners, such as Simple Green and Spray Nine, will be evaluated for removal of radionuclides from indoor surfaces
  - FY09 work will focus on removal of cesium chloride (Cs $^{137}$) from four indoor surface types [2 porous (hydrophilic, hydrophobic), and 2 non-porous (hydrophilic, hydrophobic)]
  - Work will also be completed at Battelle/INL
  - Surfaces will be those commonly found in bathrooms and kitchens (help general public reduce their exposure due to dermal and ingestion routes)
- Driver – Direct research need from the Office of Emergency Management (OEM)
- Project approach determined by project team comprised of OEM and NHSRC personnel
Evaluation of commercial cleaners for removal of radionuclides from indoor surfaces – cleaners

- Literature search was completed
- The following cleaners were considered based upon literature search results and industry experience
  - Simple Green
  - Spray Nine
  - Cleaners containing ~ 1\text{w/w}\% citric acid
  - Easy Off Heat One Step Stove Top Cleaner, Shout Advanced Action Gel, and Lime Away Tub and Tile Cleaner
  - Cleaners containing mix of EDTA and surfactant
  - Tilex Soap Scum Remover and Disinfectant
  - Dishwashing detergent
  - Tide
  - Dry methods (lint roller, etc.)
Evaluation of RDD sequestration coatings – driver and approach PI: John Drake

- RDD sequestration coatings could be used during an event to contain the RDD particles and mitigate exposure to the contaminants
- Driver – A team of NHSRC researchers (DCMD and RCE) and members of the National Decontamination Team (a part of OEM) decided that the effectiveness of these coatings should be determined
- Approach
  - Do a project survey to determine what coatings are available
  - Do a literature search to determine if any of these coatings have been evaluated
  - Work on an interagency committee to determine performance specifications (ASTM) for the sequestration coatings
  - Planned not funded: Develop test methods for the performance specifications
  - Planned not funded: Use these test methods to evaluate the coatings
Remaining projects related to decontamination
PIs: John Drake and Kathy Hall

• RDD Decontamination for Response Assets
  – Guidance document for decontamination of response assets (firetrucks, ambulances etc.) based upon information available in the literature
  – Driver: A team of NHSRC researchers (DCMD and RCE) and members of the National Decontamination Team determined this information was needed

• RDD Tabletop Workshop
  – The locale has been selected (Cincinnati), local response personnel have been invited and scenario for the tabletop have been selected.
  – Summary of workshop with recommendations for filling both research and response gaps will be generated
  – Driver: A team of NHSRC researchers (DCMD and RCE) and members of the National Decontamination Team determined this information was needed
Addition of radionuclide contaminants to the Disposal Decision Support Tool PI: Paul Lemieux

- Decision Support Tool provides information on:
  - Amount of waste generated (does not currently have a blast estimation tool)
  - Possible disposal sites
  - Possible transportation routes
  - Ways to package waste for disposal and transport
Access to the Disposal Decision Support Tool

http://www2.ergweb.com/bdrtool/login.asp

First-time users will need to request a user ID and password – the link above has directions for making the on-line request. Your request will be approved and your login ID and initial password will be emailed to you.
Canadian collaborative projects

- Canadian Research Technology Initiative (CRTI) out of Defense Research and Development Canada funded two projects
  - CRTI 0169 Development of a Universal Surface Decontamination Formulation
    - Role in project: Selection of chelators and testing of surface decontamination foam under technology testing program
  - CRTI 1556 Radiological Dispersal Device Contamination Interactions With Urban Surfaces
    - Role in project: Study the interactions of cesium and strontium with urban materials (concrete, brick, limestone, granite) see slides 10 - 18