**Subject Matter Expert Workshop for the Use
of Municipal and Commercial Equipment
for Radiological Response and Recovery:
National Urban Security Technology Laboratory
Workshop Summary Report**

Nuclear Engineering Division

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Subject Matter Expert Workshop for the Use of Municipal and Commercial Equipment for Radiological Response and Recovery: National Urban Security Technology Laboratory Workshop Summary Report

by

Michael D. Kaminski

Nuclear Engineering Division, Argonne National Laboratory

Katrina McConkey

Booz Allen Hamilton

Matthew Magnuson and Sang Don Lee

US Environmental Protection Agency

Office of Research and Development

National Homeland Security Research Center

Benjamin Stevenson and Orly Amir

National Urban Security Technology Laboratory

Department of Homeland Security

Science and Technology Directorate

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Abstract

This report documents equipment and methods to aid in a wide-area radiological or nuclear response and recovery effort in an urban environment. This report summarizes a workshop held in New York City. The objective of this workshop was to incorporate lessons learned from a prior workshop, close the gaps on some areas that were not discussed in the prior workshop, and include additional subject matter experts from critical infrastructure operations, such as tunnels and bridges, the Port Authority, and mass transit. Various missions were postulated in a hypothetical emergency scenario under five broad support goal categories. Based on the findings and input from a series of such workshops and meetings, we plan to develop “best practices” for use of equipment responding to and recovering from a wide-area radiological incident.

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1. Introduction

The National Urban Security Technology Laboratory (NUSTL) of the Department of Homeland Security's (DHS's) Science and Technology Directorate, in collaboration with the U.S. Environmental Protection Agency's (EPA's) National Homeland Security Research Center and Argonne National Laboratory, seeks to identify the equipment and databases that support methods that might be available for emergency operations which would mitigate the effects of a radiological or nuclear release that would compromise recovery in an urban environment or at a critical infrastructure. The purpose of this study is to understand what types of equipment might be available, and we wish to evaluate such equipment for its utility in mitigating a nuclear or radiological event. We understand that it will be impossible to initiate activities other than life-saving operations and secure a site for the safety of the people and the responders during the immediate, emergency phase of a response. Instead, we focused on the period of time between securing the site and a federally organized cleanup. This period might be significant, as we have learned from the Japanese and their response time frame for the disaster at Fukushima. Processes and procedures for a timely response and recovery to a wide-area contamination event are not currently established around the country. Instead, planning of this type is still in the very early stages, and this project is part of this early work.

We connected with relevant infrastructure and emergency management personnel; homeland security offices at the city, state, and regional level, especially major cities across the United States; and federal agencies. We compiled and evaluated recommended approaches to dealing with potential contamination scenarios and the types of equipment assets that would/could be invoked to assist in the response. We sought information on how various subject matter experts might approach the problem and possibly make recommendations on how current equipment reserves can be best used or modified to improve their utility in a radiological or nuclear mitigation response.

As part of initial steps toward gathering the expert opinions of a swath of subject matter experts across areas of emergency response and infrastructure operations, we held workshops that reflect regional variability, ranging from differences in local practices to extremes in weather. The first workshop was held at Argonne National Laboratory in Chicago, Illinois, on March 16-17, 2017. Workshop participants were presented with and discussed in detail five Support Goals associated with radiological response and recovery. These are: 1) Survey and Monitoring, 2) Mitigation of Received Dose to First Responders, 3) Decontamination (gross and final), 4) Waste Management, and 5) Containment of Water, Wastewater, and Other Wastes. A summary document was published entitled "Subject Matter Expert Workshop for the Use of Municipal and Commercial Equipment for Radiological Response and Recovery: Argonne National Laboratory Workshop Summary Report" (ANL/NE-17/35), which summarizes the discussion.

To continue to identify equipment and techniques for their use, we held a second workshop in New York City (NYC) at the NUSTL office on June 1, 2017. At this workshop, we hoped to incorporate lessons learned from the first workshop, close the gaps on some areas that were not discussed in the first workshop, and include additional subject matter experts (SMEs) from critical infrastructure operations such as tunnels and bridges, the Port Authority, and mass transit. This document (ANL/NE-17/36) summarizes the comments from the New York meeting.

2. Approach to Gathering Input

To facilitate workshop discussions on the development of ideas and methods for the use of municipal equipment, we generated several hypothetical missions or “scenarios” that were grouped under five “Support Goals,” as detailed in the workbook distributed to SMEs around the country and to participants of the workshop. The Support Goals cover, very broadly, potential needs during the response/recovery of a radiological contamination event. Within each Support Goal, we further pose more specific scenarios to help brainstorm ideas. The scenario poses a situation where a decision needs to be made to accomplish a task, such as covering the streets with different materials or containing contaminated waste water. Responses to the scenarios posed within the five Support Goals gathered at the New York workshop are summarized in the sections below.

These Support Goals and scenarios should not be considered exhaustive, but were intended to spark conversation and promote out-of-the-box thinking of potential uses of equipment. The equipment used to address these example scenarios was not intended to be applied in the field during life-saving operations. Instead, the intended timeline was as soon as possible in order to reduce dose to workers or the general public or to protect or restore critical infrastructure for its rapid return to service. The common initial state for all scenarios is that contamination has been spread over a wide area of the city, that first responders have identified the presence of radioactive contamination and have completed their response protocols to provide a preliminary assessment of the radioactive levels, and that life-saving operations have been completed. In this stage of operations, aside from unpredictable weather and precipitation, we expect the following activities in the impacted area:

- People, vehicles, and objects have moved/are moving in and out of the contaminated areas.
- Remediation for critical infrastructure is a matter of urgency (e.g., water utility, energy utility, transportation, medical, fire station, and government facilities).
- Regular activities (business, school, etc.) are continuing in the non-evacuated but contaminated area.
- Identification and remediation of hotspots are underway.
- Remediation strategies are in progress for the evacuated area.

Based on the post-workshop meeting and a review of the questionnaires after the workshop at Argonne, several suggestions were incorporated into the structure of the workshop in New York. First, there are many scenarios posed in the Support Goals workbook, sometimes with subtle differences, and discussion at Argonne circled through several scenarios. For instance, in the Survey and Monitoring Support Goal, Scenario 1 posed the problem of assessing radiation levels from contamination at the street level, while Scenario 2 was concerned with the radiation dose within residences and business. Because these are subtly different, the conversation centered on general radiation measurements with little distinction, at times, between the two scenarios. It was suggested that we limit the number of scenarios. Therefore, we focused on two to three scenarios that were not covered in the first workshop. Another suggestion from the first workshop was to help spur the discussion by providing the audience with examples of equipment and their uses. In response, we began the discussion of the Survey and Monitoring, Decontamination, Waste Management, and

Containment of Wastewater Support Goals with a short presentation on the equipment and methods being employed as part of the Fukushima remediation effort (Appendices A-D).

At the second workshop, a couple of brief presentations were given to introduce the project and provide a historical summary of our global experience in wide-area urban radiological decontamination techniques. The titles are given below, and copies of the presentations can be provided upon request (please email Michael Kaminski, kaminski@anl.gov).

- *Project Introduction and Objectives, Mike Kaminski, Argonne National Laboratory.*
- *Research for Radiological Remediation, Matthew Magnuson, Environmental Protection Agency, National Homeland Security Research Center*
- *Fukushima Remediation Observations, Sang Don Lee, Environmental Protection Agency, National Homeland Security Research Center*

The Workshop attendees are listed below. Note that we invited SMEs from the Metropolitan Transit Authority (MTA) Bridges and Tunnels, New York State Department of Health, New York City Department of Environmental Protection, and Fire Department of the City of New York, but they were unable to attend.

First Name	Last Name	Agency/Organization
Russell	Andreasi	MTA Police Department
John	Beldin-Quinones	U.S. Army Corps of Engineers (USACE)
Joe	Brandine	MTA Metro-North Railroad
Worth	Calfee	U.S. Environmental Protection Agency
Eliot	Calhoun	New York City Emergency Management
John	Chingas	New York Department of Sanitation (DSNY)
Mike	Debonis	U.S. Environmental Protection Agency
Christopher	Gallo	U.S. Environmental Protection Agency
Michael	Gemelli	MTA New York City Transit
Keyla	Hammam	MTA Police Department
Will	Jolin	Argonne National Laboratory
Michael	Kaminski	Argonne National Laboratory
Philip (Andrew)	Karam	New York City Police Department (NYPD)
Rabi	Kieber	U.S. Environmental Protection Agency
Sang Don	Lee	U.S. Environmental Protection Agency
Paul	Leggio	MTA Police Department/Bridges & Tunnels
Vincent	Mackey	New York City Emergency Management
Matthew	Magnuson	U.S. Environmental Protection Agency
Mark	Maiello	New York City Department of Health and Mental Hygiene
Andrew	Mark	New York City Emergency Management
Katrina	McConkey	U.S. Environmental Protection Agency
Anne	Mikelonis	U.S. Environmental Protection Agency

First Name	Last Name	Agency/Organization
James	Papagni	New York City Emergency Management
Nancy	Stanley	New Jersey Department of Environmental Protection
James	Stevenson	MTA- Long Island Railroad
Benjamin	Strong	New York City Emergency Management
Sarah	Taft	U.S. Environmental Protection Agency
Mark	Teitler	New York City Police Department
Ed	Truskowski	New Jersey Department of Environmental Protection
Stella	Wong	U.S. Environmental Protection Agency

3. Participant Responses to Scenarios for Support Goals

The participant responses to the scenarios for the Support Goals are provided in Appendix E and captured below.

3.1 Support Goal: Survey and Monitoring

Scenarios

We wish to monitor the contamination levels in affected areas for an extended period to understand the dose to workers and residents and the evolving change of contamination level over time. What types of municipal and commercial equipment can be used to enhance the survey and monitoring of contamination? (Note: we will not assess traditional survey monitoring equipment such as film badges, portable survey monitors, and gamma-ray spectrometers already in place with response vehicles or personnel since these are specialized pieces of equipment that are already accounted for in the first responder community's procedures.) Examples include using air filters from garbage trucks, delivery trucks, police vehicles, and firetrucks that have well-defined routes that can be tracked by GPS to understand the spatial distribution of airborne contaminations or attaching traditional survey equipment to vehicles that have well-defined routes to facilitate survey efforts. The scenarios under Survey and Monitoring are described in Table 1.

Table 1. Scenarios considered for Survey and Monitoring

Support Goal:	Survey and Monitoring
	Scenario Description
Scenario 1	We wish to measure on a regular basis the contamination levels in areas initially affected by contamination (that is, fallout deposits of radioactive material) in terms of external dose at the street level (that is, the radiation levels at the street from external gamma and beta radiations). What equipment can be used to provide such measurements, and what tools do we have to develop maps of contamination with this data?
Scenario 2	We wish to measure on a regular basis the contamination levels in areas initially affected by contamination (that is, fallout deposits of radioactive material) in terms of external dose within residences and businesses (that is, the radiation levels within the homes, apartments, or business offices from external gamma and beta radiation). What equipment can be used to provide such measurements, and what tools do we have to develop maps of contamination with this data?
Scenario 3	In the areas affected by contamination, we wish to measure on a regular basis the resuspended contamination levels at the street level (that is, the contamination attached to airborne particles that are suspended in the air as a result of vehicle travel, pedestrian travel, or wind). What equipment can be used to provide such measurements, and what tools do we have to develop maps of contamination with this data?
Scenario 4	We expect tracking of contamination from the initial deposit area to other areas via vehicle and personnel transport. What equipment and methods can be used to identify these contaminated egress routes? For instance, can vehicles originating from a contaminated zone be tracked by using existing highway cameras?
Scenario 5	How would the above equipment and methods differ if the contamination occurred at a critical infrastructure such as a hospital, wastewater reclamation facility or drinking water treatment plant, airport, or communications center (for example)?
Scenario 6	Other ideas related to monitoring and procedures include: <ul style="list-style-type: none"> i. Can we use traffic cams to evaluate the most used thoroughfares? ii. Can we use traffic cams/red light cams to track individual vehicles for follow-up survey for those most severely contaminated? iii. Can resulting dose maps be used to determine the best evacuation route to reduce the amount for exposure and facilitate the tracking of radioactive contamination.
Scenario 7	Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?

Summary of Scenario Discussion

We wished to focus our discussion on Scenarios 4-7 since we did not address these in the Chicago workshop. However, the discussion started with general surveying (Scenario 1 and 2).

General Surveying Observations

The protocol in NYC prescribes that when surveying an area, if the 100 $\mu\text{R/hr}$ threshold is reached, the responders stop action and must assess the dose rate maps very accurately for those areas. Firefighters would drive fire department vehicles up and down the streets to develop the maps since they have vehicles with the detectors. The fire department also has the training, but the health department has the SMEs, and the current protocol does not require an SME in the fire truck. This may change. New York has a significant amount of radiation detection equipment (Health, Fire,

HazMat, MTA, Police, and Securing the Cities partners and organizations), but what is not clear is how it would all be used. Is the purpose to characterize the surfaces for decontamination or to provide information to the public? Whatever the need is, the specific type of data needed must be explained. Most vehicle monitoring equipment is too sensitive and would be saturated at high contamination levels. Other less sensitive equipment is not connected by GPS to facilitate mapping.

Managing Survey Data

The question was raised that if the above organizations have so many pieces of equipment, how do they manage the data? For example, the fire department uses the RadResponder program.¹ The data filters to Incident Command (IC) centers and planning sessions. Other tools are available to assist (the NYPD and health department have their own systems), and all can reach back to RadResponder to retrieve data. Then, wherever the data end up—the command post, Office of Emergency Management, health department, or all the above—data can be aggregated into one location and displayed on a map or whatever form is needed. The NYPD has 4000 personal radiation detectors (PRDs) but most PRDs saturate at 25 mrem/hr. The fire department has 3500 PRDs (up to 100 R/hr), hundreds of Geiger-Mueller pancake probes, 12 or so vehicles and boats mounted with 2 x 4 x 16 in. NaI (e.g., FlexSpec Mobile by BTI), and a couple of high purity germanium (HPGe) detectors. The vast majority of meters are hand carried (Figures 1-5), and their data will not transmit directly to an IC center. The quality of data is not monitored strictly (NYPD has their meters calibrated annually), and since most require someone to record data, errors may occur. RadResponder does allow for a review of data by SME. It would be difficult to control data quality from non-experts.

Although not discussed at the workshop, it was brought to our attention that the Defense Advanced Research Projects Agency (DARPA) Sigma program is testing its network of DS3-NET detectors (from Kromek) in Washington, DC. The data (Figure 1) from these hand-held and mobile detectors can produce network-enabled mapping using ambulances in Washington.

Figure 1. D3S-NET integrated detectors from Kromek (<http://www.kromek.com/index.php/link-3/d3s>), shown in the left two panels. In the right panel, a map of the radiation levels that can be monitored in real-time to aid decision makers (permission granted by M. Wrobel, DARPA).

¹ From <https://www.radresponder.net/#about/index>; “The RadResponder Network is the national standard and Whole Community solution for the management of radiological data....RadResponder's flexible architecture enables organizations to rapidly and securely record, share and aggregate large quantities of data while managing their equipment, personnel, interagency partnerships, and multijurisdictional event space.”

Figure 2. Traditional Geiger-Müller instrument with pancake probe, which allows facile determination of gamma or beta radiations.

Figure 3. High resolution gamma-ray detectors used for many portable isotope identification applications. For example, the ORTEC portable high-purity germanium spectrometer (trans-SPEC-DX-100T) is battery powered and mechanically cooled rather than cooled by liquid nitrogen.

Monitoring Movement of Contamination

Scenario 2 dealt with suspended radioactive contamination, but we did not discuss monitoring of suspended contamination per se. Scenario 4 addressed the tracking of contamination because of movement in and out of the contaminated areas. Much, if not all, of the discussion from Scenario 1 applied here. The recent disaster preparedness drill called “Operation Gotham Shield” was noted by workshop participants. They identified a need for advanced planning, communication, trust, and a tool for monitoring and applying real time data. They also asked how the drill participants track the subways in that exercise but no one could provide an answer. However, it was noted that New York City monitors all buses by GPS and can probably install a radiation monitor on them and possibly trains without issue. Portal monitors might be an important tool at train stations since trains move ~50,000 people per hour. There are a couple of devices that work through the cell phones (manufactured by Kromek and Mirion), and could couple to GPS (see Figure 4, for example). More

information on detection systems can be found in other publications such as “Utilizing Preventive Radiological/Nuclear Detection Systems in a Consequence Management Response,” NNSA, July 2012.

Figure 4. Smart phone application available for gamma and X-ray detection. Such applications can display the radiation dose rates, radiation pulse count, and the measurement time.

The point was raised that there could be potential pushback from municipal employees to operate public transportation that could be used for monitoring with mobile devices. Therefore, instead of mobile devices, it might be better to make the detector fixed (i.e., stand-alone and immobile) at strategic locations. In bio-contamination experience, participants pulled filters from HVAC subway cars. In a radioactive contamination incident, the HVAC filters from subway cars could be pulled and scanned for radioactive particulates. Could the same be done for personal vehicles since they already go to the mechanic for a filter change? How about firetrucks or other municipal equipment? If this can be done, then how can the mechanics/maintenance workers be trained since these workers could experience higher exposures? Buses have cabin air filter (and various oil filters). However, in NYC, most people rely on trains and less on buses (2000-3000 buses), so perhaps monitoring of train cars will be more impactful. The city has regularly scheduled maintenance wash schedules for municipal vehicles (trains and buses), and the water is collected.

In washed cars in Japan, contamination was found accumulated on rubber seals around doors, etc., presumably due to Fukushima. Sanitation trucks currently pass through portal monitors before entering waste transfer station as does the garbage taken from the transit stations (NaI detectors). The Japanese have procedures for these types of monitors. Inside bus depots, they wash each bus, and have long barns for train cars. Questions remained. Do they recycle the collected water as in consumer car washes? What about surveying for alpha/beta emitting contamination, since these are much more difficult to detect than gamma rays or x-rays?

Figure 5. The WRM2 System (<https://www.mirion.com/products/wrm2-wireless-remote-monitoring-system>). This and other similar systems by various vendors can monitor and supervise a population of radiation monitors spread out over a large area. They wirelessly link devices equipped with transmitters and can display their status and measurements on a computer.

One participant provided a slide deck briefing on networked distributed personal dosimetry capabilities and needs (see Figure 5). This can be provided upon request (contact Michael Kaminski, kaminski@anl.gov).

In Japan, they obtain real-time dose rate measurements by using scintillating fiber rope. The NYC area has boats and helicopters that do surveys. Lower elevations can be surveyed by vehicle (but have limitations with higher floors) and roofs with helicopters. Drones are an unknown capability at this time, and may be flown in the urban canyon under certain circumstances. Monitoring trains (and understanding how trains may redistribute contamination) is a major concern because they are such an important part of New York/New Jersey area transportation. Use of buses is preferred for monitoring contamination since they follow the residential and business street routes; however, drivers may refuse to drive their buses or carry monitoring devices. Taxi drivers are non-union workers, so they may be a good option for putting monitors on taxis.

Could portal monitors be used to give a quick yes or no on vehicles exiting the contamination area (e.g., abandoned vehicles in highly contaminated zone)? Or could cars be diverted through wash units used for garbage trucks or buses and then passed through portal monitors to verify cleanliness for release? A massive distribution of Mirion-type hand-held devices around cities, neighborhoods, and subdivisions could be used, and real-time data output could be directed to stakeholders, e.g., homeowner association websites, to maintain awareness and transparency (public trust). Another technology is the Bubble Technologies RadBump, a portable speed bump that uses GM tube instruments for radiation detection (Figure 6).

Figure 6. Bubble Technologies' RADBUMP Geiger-Muller type radiation detector (<http://bubbletech.ca/product/radbump-2>), which looks like a portable speed bump but contains 1-4 Geiger-Muller tubes per lane (courtesy of Shutterstock).

Critical Infrastructure

Scenario 5 focused on methods appropriate for critical infrastructure. There was little discussion specific to this scenario, and much of the talk instead centered on earlier scenarios on radiation-level mapping and tracking. Related to critical infrastructure, representatives from NYC train and subway systems prepared radioactive decontamination guidance with Lawrence Livermore National Laboratory in 2003, which details the approach to radiological detection, containment, and recovery in the rail system, including recommended decontamination methods for specific rail cars and facilities (*New York City Transit Grand Central Station Pre-Incident Radiological Dispersal Response and Recovery Plan*, June 28, 2003, LLNL-TM-644423). See Appendix F for brief summary.

Use of Traffic Cameras and Light Systems

Scenario 6 raised other ideas such as use of traffic cameras and red-light cameras to track vehicles. Can portal monitors be placed at strategic intersection traffic lights? An electric supply is there already, and could be maintained as traffic lights are already on scheduled maintenance. Monitors could be placed beforehand, so the public becomes accustomed to seeing what is normal activity. An advantage to this idea of fixed monitors is that vehicles hosting monitors may be brought offline, but that would not be feasible for a monitor mounted on a street light, in Times Square for instance. Can traffic cams be used to determine which car is contaminated or not? We were not sure if that is possible. Are traffic lights on a communication network? Traffic cameras have wireless mesh networks all around the city. Can the network be rigged, so that survey monitors mounted on the street lights or traffic cams can link to a central command center? The answer is not clear, but the Department of Transportation owns the traffic camera system network. The Radiation Awareness and Interdiction Network system, being developed by the Domestic Nuclear Detection Office (DNDO) of DHS, would provide radioactive detection of vehicles and cargo and would identify vehicles for tracking purposes at

highway speed (contact person is Mark Wrobel at DND0). Within the Securing the Cities region, there are large quantities of PRDs, HPGe's, and others monitors and assets that could be brought in for an emergency.

Training

With regards to training within the Survey and Monitoring Support Goal, the point was raised that the assumption is made that contractors will be doing the bulk of the work, with the NYC providing oversight.

3.2 Support Goal: Mitigation of Received Dose to First Responders

Scenarios

We wish to reduce the radiation dose burden to response personnel. What types of municipal and commercial equipment can be used to carry out gross decontamination of contaminated surfaces, and what can be used to contain and prevent the resuspension and tracking of contamination either through the effects of wind or vehicle transport during the mitigation phase of the response to reduce the dose burden to first responder teams? Examples include using fireboats from the Port Authority to knock down radioactivity levels near the shore or dump trucks and bobcats to spread mulch and gravel across roadways to reduce the spread of contamination during vehicle transport. Note that “gross decontamination” is a type of decontamination that is conducted with the goal of reducing contamination levels. This reduction may not meet final cleanup levels, but may be useful to mitigate some public hazard or contain contamination. The scenarios under Mitigation of Received Dose to First Responders are described in Table 2.

Table 2. Scenarios considered for Mitigation of Received Dose to First Responders

Support Goal:	Mitigation of Received Dose to First Responders
	Scenario Description
Scenario 1	We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, and urban green spaces), reducing the potential for resuspension could be an important goal. Through prior research, we identified materials such as gravel, mulch, and sand as effective means of reducing resuspension if the material can be laid down over the contaminated surface. How would such material be distributed over an area of several linear blocks? How would such material be distributed over an area of several square miles?
Scenario 2	We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, and urban green spaces), reducing the potential for resuspension could be an important goal. Through prior research and experience, we identified that washing the surfaces with fresh water is effective in removing contaminated particles from surfaces, thereby reducing the dose in the immediate area. How would fresh water be distributed over an area of several linear blocks? How would fresh water be distributed over an area of several square miles? How do the methods change if the water must be distributed over vertical surfaces, such as the facades of buildings?

Table 2. (Cont.)

Support Goal:	Mitigation of Received Dose to First Responders
	Scenario Description
Scenario 3	We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, and urban green spaces), reducing the potential for resuspension could be an important goal. Through prior research and experience, we identified that washing the surfaces with water-containing salt (for example, seawater or salty water from water softener units) is effective in removing contaminated particles and fixed contamination from surfaces, thereby reducing the dose in the immediate area. How would the salt water be generated and distributed over an area of several linear blocks? How would the salt water be generated and distributed over an area of several square miles? How do the methods change if the salt water must be distributed over vertical surfaces such as the facades of buildings?
Scenario 4	How would our proposed method of addressing the Scenarios 1-3 change if the contaminated area is located sufficiently close to the ocean coast or other navigable waterway such that maritime equipment and methods can be used?
Scenario 5	We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, and urban green spaces), reducing the potential for resuspension could be an important goal. Through prior research and experience, we have identified that applying a layer of sprayable polymer coating with the consistency of wet paint (for example, outdoor paints and epoxies such as those designed for roadways or other paved surfaces) to the surfaces is effective in containing contaminated particles. How would this polymer coating material be distributed over an area of several linear blocks? How would it be distributed over an area of several square miles? How do the methods change if the sprayable coating needs to be distributed over vertical surfaces such as the facades of buildings?
Scenario 6	How would the equipment and methods in Scenario 1-3 and 5 differ if the contamination occurred at critical infrastructures such as a hospital, water reclamation facility or drinking water plant, airport, or communications centers (for example)?
Scenario 7	We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, and urban green spaces), reducing the potential for resuspension could be an important goal. An area of concern is contaminated debris and loose particles. In some areas, the debris is substantial and can be removed by bulldozer-type equipment. In other areas, the debris material is such that it can be swept and vacuumed. How should this problem be approached?
Scenario 8	Regardless of the scenario, how would the above equipment and methods differ if the contamination occurred along egress routes that are needed to transport people away from the affected area (for example, major highways)?
Scenario 9	Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?

Summary of Scenario Discussion

Scenarios 1-3 focused on the distribution of materials as an effective means of reducing resuspension and/or removing contaminated particles and fixed contamination from surfaces, while Scenario 4 addressed the same except near waterways. We focused our discussion on Scenarios 5, 6, and 8. Scenario 5 focused on covering the contaminated surfaces with a polymer coating, and the discussion also covered spraying of aqueous liquids. Figures 7-11 show various methods used to wash large surfaces.

Washing and Applying Polymer

Mobile wash unit trucks (approximately 120 of them in NYC) have pressure washers and water tanks for washing the transit stations. They have a few hundred feet of hoses. Can this be used for polymer paints without fouling the sprayers? New York has the same type of equipment at bus stops, and the work is performed through contractors. Vacuum trains (VakTrak) are used to prevent fires by pulling up the small debris along the tracks. New York has trains with a spray wand in the rear of the car and vacuum units.

Figure 7. Spray cars used to remove residue from the tracks

(<http://www.rtands.com/index.php/passenger/commuter-regional/mta-works-to-fight-slime-on-rail-lines.html>, permission granted © Metropolitan Transportation Authority).

Figure 8. Portable wash stations, which provide a means of washing contamination from vehicles in a buffer zone to prevent downstream contamination (truck image courtesy of Shutterstock; train image <http://www.mta.info/news/2012/10/03/lirr-opens-new-high-tech-train-wash>, permission granted © Metropolitan Transportation Authority).

Figure 9. Station being cleaned by MTA Mobile Wash Units (<https://www.youtube.com/watch?v=egYcBcpJRQM>; <https://untappedcities.com/2016/06/02/cities-101-how-do-nyc-subway-stations-get-cleaned-powerwashing/>; permission granted: <https://untappedcities.com/terms-of-use/>).

Figure 10. MTA jet trains for removing snow (<https://www.flickr.com/photos/mtaphotos/24656757057/>; <https://www.flickr.com/photos/mtaphotos/25636084648/>, permission granted Creative Commons).

The fire department has equipment that can spray foam onto surfaces, but was not sure if a polymer can be sprayed from them. Asphalt pot-hole patch trucks are from third-party contractors but are used for small surface applications. There are many types of agriculture spray vehicles available that spray horticultural oils to moisten soil and reduce resuspension. It was mentioned that similar technologies were investigated as part of a DHS-EPA collaboration to provide tools for radiological response, including early and clean-up phases.²

Figure 11. Wide-boom horticultural sprayer with source tank and adjustable nozzles (courtesy of Shutterstock).

Can paver trucks be used to lay down tar, paint, or salt onto roads after real time measurement of the dose rates?

² See U.S. EPA, *Wide Area Stabilization of Radiological Particulate Contamination*, EPA/600/R-16/067, https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=335602.

During the Cold War, Soviet Union responders shot water through jet engines mounted on the back of trucks to quickly blast contamination from vehicles. Can this approach be adopted, and with what engines? Jet engine blowers are used for removing snow on the rail lines in NYC, but these are not used as much anymore since they produce projectiles (e.g., rocks).

New York City used its own equipment to spray for West Nile and Zika virus and its own employees, it was believed. The sprayer systems were mounted on existing pick-up trucks to spray the aerosol. They also used helicopters to drop pesticides in uninhabited areas and did not fly in urban canyons. It is not known if the same sprayers could provide enough solution for radioactive decontamination applications, or could be adapted to spray polymer coatings. The city managers had months to plan their mitigation strategy because they knew Zika virus season was coming. If it was an emergency, they could have been prepared much quicker. They also may have rented helicopters to spray for Zika by using a map of Zika breeding sites. These all might be adopted for large-scale treatment of contamination, as could helicopters transporting bambi buckets that drop hundreds of gallons of water for firefighting.

Critical Infrastructure

Scenario 6 is concerned with contaminated dust/debris at critical infrastructure. Bridges and tunnels have their own vacuum trucks, and they use them to clean out clogged scuffers. There are user-operated cars that have special spray heads to deluge soap and water onto tunnel walls and use brushes on articulating arms to scrub the walls. Additionally, subway cars are outfitted with sprayers for tunnels between stations. During the Underground Transportation Restoration Operational Technology Demonstration held last fall by EPA and DHS, agricultural equipment was demonstrated for its use in bio-remediation of subway tunnels (see “Evaluation of Commercially-Available Equipment for the Decontamination of Bacillus Anthracis Spores in an Urban Subway System,” EPA/600/R-17/156, Washington, DC). For releases about a year ago (Maltodextrin), NYC informed the public ahead of time and received good feedback. Getting the word out through public education/communication beforehand was key.

Occupying Contaminated Land and Training

A point was made that in NYC, the planning assumption for an aggressive radiation emergency is limited to events involving an improvised nuclear device (IND) or radiological dispersal device (RDD). For a RDD, the assumption is that the public will not be working or living in contaminated areas due to the health risk. Also, the response and recovery plan will establish an environmental assessment area where the dose rates are mapped after the incident. This map would be developed by the health department. The fire department could probably also do the mapping since it is equipped with rad detectors. The fire and health departments would need to discuss and formulate training and a strategy for mapping (conversations toward this end have begun).

A point about training was raised. Finding people who were trained to spray for Zika virus was a logistical problem. Training was a concern.

3.3 Support Goal: Decontamination (Gross and Final)

Scenarios

We recognized that decontamination methods can be more effective if implemented within days of a release rather than months or years, when the contamination would evolve chemically and physically,

rendering it more difficult to remove. What types of municipal and commercial equipment can be used to carry out gross or final decontamination of contaminated surfaces? Examples include using asphalt-milling machines to remove the top layer of road surfaces, bobcats to remove the top layer of vegetation or soil, and tillers to turn over contaminated soil. Note that “gross decontamination” is a type of decontamination that is conducted with the goal of reducing contamination levels. This reduction may not meet final cleanup levels but may be useful to mitigate some public hazard or contain contamination. The scenarios under the Support Goal Decontamination (Gross and Final) are described in Table 3.

Table 3. Scenarios Considered for Decontamination (Gross and Final)

Support Goal:	Decontamination (Gross and Final)
	Scenario Description
Scenario 1	EPA studies identified that soil is a major source of contaminated material in decontamination efforts in an urban environment. Prior research and experience suggest that by removing less than 5 cm (2 in.) of soil, nearly all the contamination can be removed. What equipment would be useful in removing a very shallow depth of soil from large urban green spaces such as playgrounds and open grass fields?
Scenario 2	Same as Scenario 1, except that we wish to identify equipment that would be useful in removing a very shallow depth of soil from smaller, discontinuous plots of urban green spaces such as front and backyards and garden areas.
Scenario 3	Hard, horizontal surfaces such as roads, walkways, and parking lots can trap radioactive contamination. Prior studies and experience show that the contamination resides at or very near the surface of such hard materials (<1 cm or <0.5 in.). What equipment would be useful for removing contamination at the surface? What equipment would be useful in removing a very shallow depth of paving material? How does the choice of equipment and method change if many linear miles of surfaces need such treatment?
Scenario 4	As in Scenario 3, prior studies and experience show that the contamination on paved surfaces can be effectively reduced by washing these surfaces with water-based solutions. What type of equipment can be used to wash many linear miles of these paved surfaces and collect the washings?
Scenario 5	How would our proposed method of addressing the scenarios above change if the contaminated area was located sufficiently close to the ocean coast line or other navigable waterway or river system such that maritime equipment and methods can be used?
Scenario 6	Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?

Summary of Scenario Discussion

Scenarios 1-2 focused on identifying useful equipment for removing a very shallow depth of soil from large urban green spaces (such as playgrounds and open grass fields) and smaller discontinuous plots of urban green spaces (such as front and backyards and garden areas). Rather than open grass fields, the focus of our discussion was on forested areas such as Central Park (Figure 12). Current city resources include equipment to remove fallen trees. Defoliation of trees can likely be done by crop dusters (as is the practice on cotton farms). However, the issue of current resources and available workers that can be leveraged was questioned. It was suggested that workers who have similar hazards, such as asbestos and lead paint removal, be surveyed since they have experience with hazard protocols and operating equipment under such conditions.

Figure 12. A view of Central Park in New York (courtesy of Shutterstock).

Scenario 2 addressed smaller discontinuous plots of urban green spaces such as front yards, backyards, and garden areas, and Scenario 3 addressed equipment that would be useful for removing contamination at the surface. Neither scenario was discussed, however.

For Scenario 4, many linear miles of pavement would be washed and the wash water collected. The equipment that was already discussed in Scenario 5 for the Mitigation of Dose Support Goal was reiterated as potentially useful. However, there were few ideas on how to capture the water. The MTA mentioned that they had pumper trucks that could remove water from flooded stations. However, the fate for all this water was the sewer system. New York City has 14 waste water treatment plants, and nearly all of Manhattan, Bronx, Brooklyn, and Queens have combined sewer systems.

Scenario 5 asked if there were additional resources that could be used if the contaminated surfaces were near a navigable waterway. When NYC had an asbestos release during a water break, the fire department hosed down the houses and the area, and brought in commercial crews. The point was raised that NYC assumes that they would use city resources in the short term, but would rely on contractors to do the job through its completion. Another point was that New York Port Authority Bridges and Tunnels can use fireboats to fight fires on bridges (Figure 13). Not only can they shoot water from the boats, they can also charge water lines running up to the bridge deck to clean off bridges with river and/or seawater – this capability could be used to decontaminate bridges and cars.

Figure 13. Fireboats, which can be used to pump water for supply or to decontaminate structures near the waterway. The New York Fire Department Firefighter II is capable of 50,000 gpm output (courtesy of Shutterstock).

Scenario 6 captured other thoughts brought up by the attendees, summarized as follows. If we needed to defoliate the leaves in Central Park to remove contamination (assumed to be found predominantly in the leaves), there would be public outcry. Also, the ability to access an area to perform immediate decontamination activities was questioned. For a crime scene investigation, the FBI will likely want up to two weeks before a crime scene is modified, but that is for the immediate release area and may not apply to the area affected by the downwind plume. Decontamination activities might be able to start at some areas if the location of the source is known. The public may want to return to their homes and neighborhoods. Police may want to make sure they do a thorough job to preserve evidence and secure prosecution. How will ordinary citizens be stopped from performing their normal activities? During the Liberty RadEx exercise, the stakeholders (including citizen groups) were asked what and where they would want decontamination activities initiated. Many options were discussed to preserve the vitality of the city, but also to allow neighborhoods to reopen. In Fukushima, the Japanese government had to go through the painstaking process of identifying the location of evacuees to obtain access agreements to begin the decontamination process.

Regarding training, decontamination activities need to be balanced with forensics needs. It might be best to have those trained in use of personal protective equipment, such as asbestos and lead paint removal personnel, involved to facilitate training for radiation work.

3.4 Support Goal: Waste Management

Scenarios

In the event of a large contamination incident, contaminated solid waste in varying sizes and container types will be generated over a wide area from businesses and residences. Solid radioactive waste should be collected for staging and disposal. What types of municipal and commercial equipment can be used to stabilize, contain, store, and transport the radioactive solid waste generated during mitigation and decontamination operations? An example would be to use municipal waste garbage trucks and current routes to pick up garbage associated with small-scale (local) operations, employing existing software and procedures developed for the transport of radioactive material to identify preferred routes. The scenarios under the Waste Management Goal are described in Table 4.

Table 4. Scenarios considered for Waste Management

Support Goal:	Waste Management
	Scenario Description
Scenario 1	We suspect that radioactively contaminated material will be generated in residences as a result of personnel and self-help decontamination practices. How would the individual waste receptacles generated by residences be collected to avoid an accumulation of radioactively contaminated materials within multi-family units or at the curbside? Does the equipment and method of collection differ for more sparsely distributed suburban areas as opposed to congested downtown residences?
Scenario 2	How would the answer to Scenario 1 differ if the radioactively contaminated material is being generated by local businesses as a result of self-help decontamination practices? How would the individual waste receptacles generated by local businesses be collected to avoid an accumulation of radioactively contaminated materials in multi-business units or at the curbside? Does the equipment and method of collection differ for more sparsely distributed suburban areas as opposed to congested downtown businesses?
Scenario 3	If the accumulated radioactively contaminated waste is being collected at staging locations (for example, parks and common grounds), what types of containers can be used to collect the waste receptacles and protect the public from transport of contaminated particles (for example, through resuspension of breached receptacles)?
Scenario 4	Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?

Summary of Scenario Discussion

Workshop discussions primarily covered Scenario 1, the collection of waste receptacles generated by residences to avoid an accumulation of radioactively contaminated materials at the curbside. Most of what was discussed could be applied to Scenario 2 (collection of waste from small businesses) as well.

Waste Disposal

In many ways similar to wastes generated after the Fukushima reactor accident, tremendous volumes of waste was collected after Hurricane Sandy (Figure 14). After Hurricane Sandy, NYC utilized a system of temporary debris storage facilities, such as parking lots, that the U.S. Army Corps of Engineers (USACE) set up. Most waste was similar to construction debris. After the waste was brought from the community to temporary storage facilities, it was handled through USACE or regular contractors and passed as a normal waste stream (by barge and then reloaded onto trucks for transport to Rochester landfill).³ Handling debris from Hurricane Sandy involved considerable manual work. For waste with radioactivity hazards, the manual work will increase tremendously. The question was asked whether contaminated waste can be hauled with a garbage truck. In NYC, there is already a significant problem with disposing of municipal waste, so there is a huge issue with finding a set of places to store and dispose garbage over many days/weeks. The NYC participants noted that city officials must look outside the city to help store and dispose the garbage, perhaps directly out of the city to some outside location. For 9-11, waste trucks brought a large portion of debris to a Staten Island landfill (Fresh Kills - closed now) by barge for sorting and disposal. Similar to this approach, could waste be disposed in container boxes located around neighborhoods and then placed directly onto barges? In theory, this can be done, but it is more complicated in practice. If a temporary storage location could be identified, then it could be moved there. However, it would be more difficult to identify such places in NYC than elsewhere.

Figure 14. Waste from Fukushima (<http://www.japantimes.co.jp/news/2013/10/19/national/fukushima-2020-will-japan-be-able-to-keep-the-nuclear-situation-under-control/>) and Hurricane Sandy (<https://media.defense.gov/2012/Dec/5/2000746913/-1/-1/0/121204-A-CE999-010.JPG>, permission granted U.S. Army Corp of Engineers).

³ *New York Times*, “Cost of Storm-Debris Removal in City is at Least Twice the U.S. Average,” <http://www.nytimes.com/2013/04/25/nyregion/debris-removal-from-hurricane-sandy-is-more-costly-than-average.html>, April 24, 2013.

Hauling Waste

How can such waste be transferred from the original area (streets) to temporary location? The city and contractors have numerous equipment types for hauling, such as garbage trucks, snow trucks, plow trucks, front loaders, and back loaders. Would NYC be better served by identifying a waste site outside of the city early and eliminating the temporary or interim storage locations? This strategy to relieve any temporary storage issues is to leave waste on city blocks where people are not living for a little longer until the waste can be moved out of the city. It would be a benefit to move the waste only once instead of multiple times (multiple moves of waste substantially increased the cost of handling in Hurricane Sandy). Plus, every time contaminated debris is moved, equipment must be decontaminated, and the hazardous waste tracked. For Hurricane Sandy, final disposal locations were established for biological waste, according to the New York Health Department. Identifying sites outside the state ahead of time is thus necessary.

Monitoring Waste

It was noted that landfills and transfer stations have radiation monitors to identify trucks containing contaminated garbage. The following questions were posed. What are their alarm thresholds? Do we know how much waste a truck can bring in and be approved for drop off? The role of insurance agencies was questioned. At what point do building owners say they do not want to have their building decontaminated, because they would rather collect on insurance? How much do the insurance companies have to insure, and when do they tap into their backup re-insurers?

Scenario 3 dealt with types of satellite receptacles that can be used to collect waste at temporary staging locations. Ground zero (where the release happens) may be used as a storage site since the area is already evacuated and contaminated. Sang Don Lee (EPA) briefly reviewed an option for collecting waste at temporary storage sites (tented structure with vents and measures to track the spread of contaminants). The procedure for measuring individual bags of contaminated garbage for radioactivity was asked. In Japan, they placed higher activity waste bags in the middle of the storage pile and lower activity bags on the outside and perimeter. It might be possible to leverage technologies developed by the Department of Energy over the past 30 years for minimizing waste (Figure 15), but many of these techniques are expensive and may not be very effective (e.g., soil washing and segmented gate sorting⁴).

⁴ U.S. Environmental Protection Agency, *Technology Reference Guide for Radioactively Contaminated Media*, EPA 402-R-07-004, October 2007.

Figure 15. Radiation Portal Monitor Test Area at the Nevada National Security Site (this image is available from the National Nuclear Security Administration Nevada Site Office Photo Library under number D05_2116).

3.5 Support Goal: Containment of Water, Wastewater, and Other Wastes

Scenarios

Water will likely be used by first responders to extinguish fires that may be generated during a radioactive release. Water may also be used to reduce radiation levels to early responders and subsequent response teams. Ideally, the water could be collected and treated at the point of use. However, we may need to collect, divert, and store radioactively contaminated water for proper treatment and disposal. What types of municipal and commercial equipment can be used to collect, contain, and transport liquid wastes and other wastes not identified in the Waste Management Support Goal? Examples include portable tanks and storage bladders, barges, tanker trucks, railroad tank car, fixed tank farms such as at refineries, storm sewers, and sewer water storage tunnels and reservoirs to facilitate collection of contaminated water. The scenarios under the Support Goal of Containment of Water, Wastewater, and Other Wastes are described in Table 5.

Table 5. Scenarios Considered for Containment of Water, Wastewater, and Other Wastes

Support Goal:	Containment of Water, Wastewater, and Other Wastes
	Scenario Description
Scenario 1	What types of barriers (for example, sandbags and berms) are available to collect water that is generated during its large-scale use (hundreds of thousands to millions of gallons) over a small urban footprint (for example, 1 square city block)?
Scenario 2	What types of barriers (for example, sandbags and berms) are available to collect water that is generated during its large-scale use (millions of gallons) over a large urban footprint (for example, 10 square city blocks)?
Scenario 3	Do the answers to Scenario 1 and 2 differ if the water is used to wash down vertical as opposed to horizontal surfaces?
Scenario 4	If the water is collected at the point of use, what containers/vessels/facilities are available to store the water generated in Scenarios 1-3 until it can be processed or transported?
Scenario 5	If the water penetrates the sewer system and can be diverted at a downstream collection site (for example, just prior to entering the water reclamation district or wastewater treatment plant), what containers/vessels/facilities are available to store the water until it can be processed or transported?
Scenario 6	If we wish to avoid the sewer system, what other methods of diverting water are available to collect water at a central location?
Scenario 7	Are there existing trench, dam, retention ponds, community reservoirs, etc., available to collect water, and are there paths for directing the wash water from its point of use to these existing collection systems?
Scenario 8	Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?

Summary of Scenario Discussion

It was emphasized throughout the conversations that in emergency incidents such as an improvised nuclear device or nuclear power plant response, the fire department must do what they need to do to save lives and control fires. Firefighters will try to isolate and divert the wastewater, but the reality is most of the water will initially go into the sewer system. For the cleanup, it will be necessary to work with the sewer authority to determine the best ways to control the movement of water.

Wash Down of Buildings

Scenarios 1 and 2 focused on identifying the types of barriers that are available to collect water generated during large-scale use over a small or large urban footprint. We did not address these items per se. Instead, we discussed Scenario 3, the wash down of vertical surfaces like building facades and collection of water. An apron system that acts like a skirt could be created, where wash water generated from washing is collected one story at a time, e.g., the 20th floor facade and then the 19th floor facade, rather than allowing the water to flow down to the street level. We know from experiments by Argonne and others that this can work well, since the decontamination factor can be 10 or greater for steel and glass. The skirt system at the street level is something that can be put in place by, for example, HESCO units. New York City has a berm system in place for flooding, but the specific details were not known. Automated window and facade washing units might also be used (Figure 16).

Figure 16. Window washing machines, which can be used to decontaminate windows and walls. An example is the IPC Eagle system (<http://www.ipceagle.com/products/highrise%E2%84%A2-professional-window-cleaning-system#.WrqexYj49hE>) for self-climbing high rise window cleaning (6.8-16 foot cleaning path, 1-2 gallons per minute, 1 or 3 Phase, 230 volt). The facade cleaning system created by Thomann-Hanry® in Paris cleans masonry by projecting fine powders with compressed air to gently remove surface dirt and deposits (courtesy of Shutterstock).

Sewers and Subways

Scenarios 4 and 5 focused on the containers/vessels that are available to store the water before and after ingress into the sewer system. The New York Health Department's understanding from their conversation with New York Department of Transportation was that they have an understanding of the material that flows into storm drains and passes through the sewers to the treatment plants, and they are prepared to remove and replace the contaminated components of the operation (such as settling beds and bio reactors). Approximately 60% of NYC sewers are combined sewers, while the remainder of storm runoff is taken to the rivers, bays, and streams.⁵ It was mentioned that previous conversations between Argonne, the EPA, and water treatment plants (through the Water Environmental Research Foundation and Chicago's Metropolitan Water Reclamation District) resulted in the understanding that removal of bacterial beds would involve essentially a shutdown of plants and should be avoided.

Certain NYC train stations would be under water if subway workers turned off pumps during normal operations. When it rains, certain stations do flood even when the pumps are running (Figures 17 and 18). If water is accumulating at the street, grate covers can limit water infiltration into the subway system and encourage its flow into storm water drains, where it can be processed at the treatment plant for combined sewer systems (Figure 19). If capacity is reached, the overflow is diverted directly to outflows such as rivers. The question was asked if there are simple ways of developing filtration systems ad hoc, then recycling the water from wash down. It is possible. Vermiculite clay and other natural materials have been shown to absorb radioactive cesium, but a method would be needed to collect water and divert it into a water treatment system. For flooding, NYC deployed berms to divert coastal influx. They also tested water bladders to hold water from flooded subways, which might be

⁵ NYC Environmental Protection, "Types of Sewer Drainage Areas in New York City," http://www.nyc.gov/html/dep/html/stormwater/sewer_system_types.shtml (accessed 2018).

used to prevent waters from contaminating downstream tunnels. For Sandy, they were able to deploy gates to hold flood waters at certain vulnerable rail yards. ILC Dover (Frederica, DE) did some tests with MTA to demonstrate the deployment of a new bladder system (partially supported by DHS).

Figure 17. Flood prevention. In much the same way that homeowners and small businesses board their windows and doorways to protect their structures from flood and wind damage, New York MTA workers covered subway tunnels (shown above) and ventilation grates with plywood to help prevent flooding in the wake of Hurricane Sandy (<https://www.flickr.com/photos/mtaphotos/6089113566/in/album-72157627541713890/>, permission granted Creative Commons).

Figure 18. New York City subway system after Hurricane Sandy (<https://imgur.com/f5n6R>). After Sandy, working pump systems, extra pump trains and portable pumps such as the one shown above right were used to remove water from the subway system (<https://www.flickr.com/photos/mtaphotos/albums/72157627541713890/with/6085662147>; permission granted Creative Commons).

Figure 19. Map showing combined sewer overflow (CSO) and wastewater treatment plants in NYC region. Water exceeding the capacity of the sewers (combined sewer overflows) is released through several outflows directly into the rivers and sea. New York City has 446 CSOs and Chicago and its suburbs have approximately 400. (Source: Rosenzweig et al., “Developing Coastal Adaptation to Climate Change in the New York City Infrastructure-Shed: Process, Approach, Tools, and Strategies,” *Climatic Change*, May 2011, permission granted Springer Publishing.)

Scenario 5 suggested that water can be diverted from reaching a reclamation plant and asked what containers/vessels/facilities are available to store the water until it can be processed or transported. Hydraulic fracturing water storage tanks and water vacuum trucks are used to make up chemicals for injection into wells and then used to recover the produced water (telephone conversation with J. Schwalbach of Separmatic Systems after the NYC Workshop).

Scenario 6 focused on methods to divert water to a central location other than the water treatment plants and Scenario 7 on existing reservoirs to collect contaminated water. Scenario 8 asked for other thoughts and questions. These topics were not addressed.

Training

Regarding training, the New York Department of Environmental Protection and others had to develop procedures for people to enter sites contaminated by thorium. These procedures could be referenced for training activities.

4. Feedback Form Summary

The organizers distributed Participant Feedback Forms at the conclusion of the workshop. Two responses were gathered from participants. One was from U.S. EPA Environmental Response Team, and the other from someone with responsibilities in Emergency Support Function (ESF) #3 in support of ESF #10, a federal response to actual or potential oil and hazardous materials incidents. The Environmental Response Team has the responsibility to respond, aid in characterization, and aid with cleanup activities. Their capabilities lie with detection/characterization equipment, air sampling/monitoring, and ability to aid in cleanup. They also have GPS-based telemetry and robotic sampling/monitoring capabilities.

The ESF#3 officer has no in-house capabilities but instead contracts out work. The officer recommended that ESF#10 be involved to discuss further and noted that the Center of Expertise within USACE in Kansas City (<http://www.nwd.usace.army.mil/About/Centers-of-Expertise>) or Omaha or others might be useful in future meetings.

5. Wrap Up

Consistent with the first workshop, the purpose of this second workshop was to introduce a broad swath of experts from within New York and New Jersey along with federal response personnel to gain a first-order understanding of the approaches and concerns within each of the Support Goals. From this, we expected to close the gaps identified after the first workshop and gain experience in upcoming information gathering activities to arrive at a consensus on technologies that might be suitable for a timely recovery effort. Based on the findings and input from the workshops and additional information gathering activities, we plan to develop “best practices” for use of equipment responding to a wide area radiological incident. This development may include modifications of equipment and revision of operational/maintenance procedures to fill gaps revealed in the summary report. As there are many gaps, using the summary report as a guide, we will seek stakeholder input on the highest priority gaps. The plan is to combine information from this workshop with those of the previous and include responses from other state and local SMEs through the written Support Goals Workbook or telephone and smaller meetings. This document serves the purpose of providing a summary of input from the workshop held at NUSTL from which to build and focus future effort. We will also seek input on the format of the “best practices” documents to make them as practical as possible to the stakeholders.

Appendix A: Slides presented by Dr. Sang Don Lee to initiate conversation for Survey and Monitoring Support Goal ⁶

Mobile Monitoring

TEPCO

○ Development of monitoring devices based on cars, automobiles, and walking and deploying them on the site according to the usage.

Extensive investigation on radiation distribution (Travel survey by a monitoring car)

21st round (16th March 2015-20th April) results
(Map source: METI HP)

Monitoring car

Spherical camera image

Radiation level survey for additional decontamination (Government controlled decontaminated areas)

Condition of DR monitoring by walking

Example showing measurement results

Radiation level survey for the resumption of infrastructure (JR Joban Line)

Condition of railway track monitoring by walking

Radiation level measurement by drone

Airborne Survey Systems

Increasing:
cost, altitude, fuel, range, maintenance, pilot qualifications, ground support

Toshiba's Simplified Method for Measuring Radioactivity Concentration per Container

Plastic Scintillation Fiber (PSF)

KURAMA (Kyoto University RAdiation MApping) System

⁶ All photos in Appendices A-D are by permission from the U.S. EPA.

Airborne Survey Systems

Increasing:
cost, altitude, fuel, range, maintenance, pilot qualifications, ground support

Toshiba's Simplified Method for Measuring
Radioactivity Concentration per Container

KURAMA (Kyoto University Radiation Mapping) System

Plastic Scintillation Fiber (PSF)

Personal radiation dose map

(Examples showing 3 typical routes from Fukushima Revitalization Headquarters to the interior of Fukushima City)

“Staying place situation”

Automatically determines “Staying place situation” from GPS location information (location, time, moving speed). Automatically calculates the personal dose at staying area from dosimeter data and displays it on the map.

<Displayed information>

- individual external doses for one hour while staying there
- latitude
- longitude
- duration of staying

“Traveling route situation”

Dosimeter data is linked up with GPS location information (location, time) and integrated personal dose. The personal dose per one hour is calculated by fixed time and displayed on the traveling route with different colors according to color tables.

<Displayed information>

- measurement interval: 5minutes
- total individual external doses from “Start” to “Goal”
- length of traveling time

Appendix B: Slides presented by Dr. Sang Don Lee to initiate conversation for Decontamination Support Goal

Fukushima Decontamination Guidelines

Road Decontamination

	Technique
A	Street sweeping
B	Ride-on sweeping
C	Water-jet vehicle
D	Manual high-pressure water washing
E	Hydro-blast ultra-high pressure water washing
F	Dry-ice blasting
G	Sand-blasting
H	Medium-scale shot-blasting (Iron balls)
I	Large-scale shot-blasting (Iron balls)
J	Asphalt planing/shaving
K	Mechanical digger asphalt removal
L	Top-soil removal from unpaved road or soft-shoulder

EPA report: Current and Emerging Post-Fukushima Technologies...

Residential Decontamination

Techniques Used for Decontamination ①

- Houses, buildings
 - Removing deposits from the roof, deck, and gutters
 - Wiping off roofs and walls, high-pressure washing etc.
- Gardens and trees
 - Mowing, removing fallen leaves, topsoil stripping etc.
- Roads
 - Removing deposits in ditches, high-pressure washing etc.

Decontaminating roofing tiles (by wiping)

Decontaminating paved surfaces (by a collective type high-pressure water cleaner)

Decontaminating gardens (by removing soils etc.)

Photos provided by: Date City

High-pressure water washing

Brushing

Decontamination adsorbent

Wiping gutters

High-pressure water jet washing

Manual brushing of walls

MOEJ Decontamination Guidelines

JAEA Decontamination Pilot Project report vol 1

Figure 2-20: Examples of decontamination techniques for houses

Public Facility Decontamination

Intensive decontamination in Tominari Primary School

Surface: 2-3 $\mu\text{Sv/h}$ $\Rightarrow$ 0.7-1 $\mu\text{Sv/h}$

Decontamination of paved area by shot blasting

Surface: 3-5 $\mu\text{Sv/h}$ $\Rightarrow$ 1-1.5 $\mu\text{Sv/h}$

Decontamination by volunteers from around the country

Shot blasting machine

Vacuum suction machine

July 2011

3rd MOE-IAEA meeting, Date City 4/19/2017

Figure 2-25: Decontamination methods for play equipment

Figure 2-26: Decontamination of swimming pools

JAEA Decontamination Pilot Project report vol 1

Vegetation, Forest, Lawn Decontamination

Techniques Used for Decontamination ②

Vacuum vehicles

High-pressure water washing with a tower wagon

Photo provided by: Japanese Society of Turf grass Science

Photo provided by: JAEA

Removal of litter (vacuum)

Removal of litter and humus

Pruning (vehicle mounted platform lift)

Pruning (ladder & chainsaw)

Bamboo thinning (chainsaw)

Felling (mechanical harvester)

Figure 2-16: Illustration of forest decontamination techniques

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Farmland Decontamination

Hammer knife mower

Cultivator and mower

Stripping topsoil

Stripping subsoil

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Topsoil stripping (mechanical digger)

Manual topsoil stripping

Thin layer topsoil stripper

Reversal tillage with plough

Fixation agent application

Solidified soil separation and recovery machine

Figure 2-18: Various soil treatment methods applied to agricultural land

Other Decontamination Activities

Removal of litter and moss

High pressure water washing of pebbles

Removal of debris from drains

Appendix C: Slides presented by Dr. Sang Don Lee to initiate conversation for Waste Management Support Goal

Fukushima Remediation Trivia Questions: Waste Management

- How much of waste from decontamination?

~20 Million tons

- How many waste storage sites?

~1100 Temporary Storage Sites

~150,000 On-place Storage Sites

Waste Management: Temporary Storage Sites

Naraha Town Rice Field – On-Site Storage

Okuma Town Baseball Field – Temporary Storage Facility

Tomioka Town Sports Complex – On-Site Storage

Tomioka Town Park – Temporary Storage Facility

Fukushima City Private Residence – On-Site Storage
Above ground, not buried on-site

US Embassy Science Fellow Report

Waste Management: Volume Reduction

Figure 2-28: Illustration of some volume reduction methods for solid organic waste

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Waste Management: Tracking

Figure 2-30: Flexible container and labelling system for packages and transport vehicles

JAEA Decontamination Pilot Project report vol 1

3rd MOE-IAEA meeting 4/19/2017

Overview of the Construction of Interim Storage Facility in FY2016

Image of the soil flow

Removed soil will be transported from temporary storage site to the soil storage facility after breaking the container bags and classifying in the reception/classification facility

2nd IAEA-MOE meeting, MOEJ

Imaginary Picture of Reception / Classification / Soil Storage Facility

Reception / Classification Facility

Soil Storage Facility

2nd IAEA-MOE meeting, MOEJ

Appendix D: Slides presented by Dr. Sang Don Lee to initiate conversation for Waste Water Support Goal

Containment of Wastewater: treatment

Figure 2-27: Decontamination of liquid waste: flow chart and equipment

JAEA Decontamination Pilot Project report vol 1

Containment of Wastewater

Removal of sediment in side ditches, etc.

Transfer of water from vacuum tanker to treatment tank

Sludge remaining after treatment

Appendix E: Raw notes of responses to the scenarios

Scenario Description: Survey and Monitoring	Scenario Response (Please provide specific ways in which you would respond to the scenario and what types of equipment you would require. Please use National Incident Management System (NIMS) typing if it is available and you are familiar with the Federal Emergency Management Agency (FEMA) NIMS system.) Note: Below includes returned responses and responses captured during the workshop.
<p>Scenario 1: We wish to measure on a regular basis the contamination levels in areas initially affected by contamination (that is, fallout deposits of radioactive material) in terms of external dose at the street level (that is, the radiation levels at the street from external gamma and beta radiations). What equipment can be used to provide such measurement and what tools do we have to develop maps of contamination with this data?</p>	<p>When surveying, 100 micoR/hr is the stop-action threshold, so they must assess dose rates maps very accurately in those areas. Their protocol is to drive vehicles up and down the streets to develop maps. The fire department would probably be put into service to do the mapping since they are equipped with rad detectors. The fire department and health department need to get together and formulate training and a strategy for mapping (conversations to do this have begun). Fire department and health department discussed a partnership where fire department would have health department SMEs on truck or available when needed. The fire department has some vehicles that have GPS and monitor tied in for mapping, but is it easy to use? Can such things be integrated with RadResponder? The point was raised that they assume contractors are doing the bulk of the work and the city is overseeing. City has a lot of rad detection equip (Health, Fire, Haz Mat, MTA, Police, Securing the Cities partners and organizations), but what is not clear is how it would all be used. For the purposes of characterization for decontamination, what is the data you want? A lot of vehicle monitoring equipment is too sensitive and would be saturated at contamination levels. And other less sensitive equipment are not connected by GPS. E.g., Bubble tech detector saturate at 1mrem/hr (500,000 cts/ sec is threshold). If they have so many pieces of equipment, how do they manage data? The fire department uses RadResponder program. Data filters to incident command center and planning session. Other tools are available to assist (New York City Police Department (NYPD) and Health Department have their own systems), and all can reach back to RadResponder to get data. Then, wherever it ends up, the command post, office of emergency management, health department, or all the above, data can be aggregated into one location and displayed on a map or whatever form is needed. NYPD has 4000 detectors (most personal radiation detectors [PRD] saturate at 25 mrem/hr). Fire has 3500 PRD (up to 100R/hr), hundreds of Geiger-Mueller (GM) pancake probes, 12 or so vehicles 2x4x16 NaI on vehicles and boats, and a couple of High Purity Germanium (HPGe) radiation detectors. The vast majority of meters are hand carried and data does not transmit directly. Do they monitor quality of data? No, NYPD has meters calibrated. But most require someone to record data so errors may occur. It was recently learned of DS3-NET from Kromek that can produce network-enabled mapping, and the system is being tested in Washington, DC using ambulances. Kromek is good when looking for something that integrates into cell phone. However, it is not readily available when an event occurs.</p>

<p>Scenario 2: We wish to measure on a regular basis the contamination levels in areas initially affected by contamination (that is, fallout deposits of radioactive material) in terms of external dose within residences and businesses (that is, the radiation levels within the homes, apartments, or business offices from external gamma and beta radiations). What equipment can be used to provide such measurement and what tools do we have to develop maps of contamination with this data?</p>	
<p>Scenario 3: In the areas affected by contamination, we wish to measure on a regular basis the re-suspended contamination levels at the street level (that is, the contamination attached to airborne particles that are suspended in the air as a result of vehicle travel, pedestrian travel, or wind.). What equipment can be used to provide such measurement and what tools do we have to develop maps of contamination with this data?</p>	

<p>Scenario 4: We expect tracking of contamination from the initial deposit area to other areas via vehicle and personnel transport. What equipment and methods can be used to identify these contaminated egress routes? For instance, can vehicles originating from a contaminated zone be tracked using existing highway cameras?</p>	<p>The recent disaster preparedness drill called “Operation Gotham Shield” was brought up and how we tracked contamination in the subways in that exercise. Big finding from Gotham Shield was the need for advanced planning. How do we work together to get this information out to the right people? How we talk about risk is real important. Conversation needs to happen now. Trust needs to happen from beginning. Need a way of monitoring and applying it real time, so data can be seen and reported daily. New York monitors all buses by GPS and can probably install a radiation monitor on them without issue and possibly on trains. Some train stations service 50,000 people per hour, so portal monitors might be important. At some point we are not giving up on the city. Couple devices that work through the cell phone and couple to GPS (one available now and one coming up). These are a few hundred dollars each and manufactured by Kromek, and Mirion. With the regard to potential pushback from municipal employees, why not make these static monitors and incorporate into existing bus stops or subway stations? Instead of mobile, it might be better to make the detector fixed (i.e., stand alone, immobile) at strategic locations. Any strategic location will have stationary. Stationary is good indicator, but does not mean individual is receiving the dose measured by these units, with their lifestyles and paths, so we will need individual dosimeters. In their bio-contamination experience [pulled filters from HVAC subway cars (several filters per car replaced every set of miles ~70,000)], HVAC filters in subway cars could be scanned for rad (easy to get, about 10 different car models). Cars already go to mechanic for a filter change? How about firetrucks or public worker equipment? How do you guide mechanic workers/maintenance of vehicles, etc? Certain public groups might be exposed. How are we going to deal with it? Do buses have cabin air filter- think so. The city moves less people on buses (2000-3000 buses). City has regularly scheduled maintenance and washing schedules for municipal vehicles (trains, buses), and the water is collected. In Japan, they washed cars but found contamination accumulated on rubber seals around doors, etc. Sanitation trucks currently pass through portal monitors before entering waste transfer station, as well as garbage taken from the transit stations (NaI detectors). They have procedures for these types of monitors. Inside bus depots, they each have bus wash, and long barns for train cars. Do they recycle waters like in commercial washes? What of alpha / beta emitters? Can we use paver trucks to lay down tar, paint, salt onto roads after doing real time measuring of the dose rates (Japanese scintillating fibers)? They have boats helicopters that do surveys. For tall building canyons, we do not have a way of surveying middle heights. Can survey the roof of the building from helicopter. We can do lower elevations by vehicle (but have limitations with higher floors). Drones are an unknown at this time. Trains are major concern - needed for transportation. Bus - (drivers may say no). Taxis drivers are non-union workers, so may be good option for putting monitors on taxis. Buses over trains because of routes.</p>
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<p>Scenario 5: How would the above equipment and methods differ if the contamination occurred at a critical infrastructure such as a hospital, wastewater reclamation facility or drinking water treatment plant, airport, or communications centers (for example)?</p>	<p>Use of portal monitors to give gross yay or nay on vehicles exiting the contamination area (e.g., abandoned vehicles in highly contaminated zone), or divert cars through wash units used for garbage trucks or buses and then pass vehicles through portal monitor. Massive distribution of Mirion type devices around cities, neighborhoods subdivisions and have output directed toward homeowner association web sites, e.g., Bubble Tech Rad Bump has speed bump containing GM tube instruments. New York Train and Subway systems completed a radioactive decontamination guidance with Lawrence Livermore National Laboratory (LLNL) (New York City Transit Grand Central Station Pre-Incident Radiological Dispersal Response and Recovery Plan, June 28, 2003, LLNL-TM-644423).</p>
<p>Scenario 6: Other ideas related to monitoring and procedures:</p> <ul style="list-style-type: none"> i. Can we use traffic cams to evaluate the most used thoroughfares? ii. Can we use traffic cams/red light cams to track individual vehicles for follow up survey for those most severely contaminated? iii. Can resulting dose maps be used to determine the best evacuation route to reduce the amount for exposure and facilitate the tracking of radioactive contamination? 	<p>Can we place portal monitors at strategic intersection traffic lights? Electricity is there already and could be maintained as already scheduled. Is there any other reason to have them there beforehand? Advantage to this idea of fixed monitors is that vehicles may be brought off line but a monitor at a street light in Times Square would be strategic. Can we use traffic cameras and see which car is hot or not? Not sure if that's possible. Are traffic lights on a communication network? Traffic cameras have wireless mesh network all around city. Can we ride the network to insert survey monitors into it? Not sure, but the Department of Transportation owns it. Radiation Awareness and Interdiction Network (RAIN) system that DHS Domestic Nuclear Detection Office (DNDO) is trying to develop works at highway speed (contact person is Mark Wrobel). Within the Securing the Cities region, they have tens of thousands of PRDs, HPGe's and others monitors and assets that could be brought in.</p>
<p>Scenario 7: Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?</p>	

<p>Support Goal Training: Wide-area radiological contamination incidents are rare, and a response to such an incident will require tremendous human assets. We learned from the cleanup efforts in Japan that many thousands of individuals each day are engaged in clean-up activities. What are your thoughts and recommendations on availability of trained human assets and training of additional assets that will likely be needed in order to accomplish the scenarios under this Goal? (Note: We realize that training will be a significant effort and an additional limiting factor in any response scenario. Further, it may need to be addressed more thoroughly in the future, but we would like input to help guide how we should continue toward developing training guidance.)</p>	
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Scenario Description: Mitigation of Received Dose to First Responders	Scenario Response (Please provide specific ways in which you would respond to the scenario and what types of equipment you would require. Please use NIMS typing if it is available and you are familiar with the FEMA NIMS system.) Note: Below includes returned responses and responses captured during the workshop.
<p>Scenario 1: We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, urban green spaces), reducing the potential for resuspension is a potentially important goal. Through prior research, we have identified materials such as gravel, mulch, sand as effective means of reducing resuspension if the material can be laid down over the contaminated surface. How would such material be distributed over an area of several linear blocks? How would such material be distributed over an area of several square miles?</p>	
<p>Scenario 2: We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, urban green spaces), reducing the potential for resuspension is a potentially important goal. Through prior research and experience, we have identified that washing the surfaces with fresh water is effective in removing contaminated particles from surfaces, thereby reducing the dose in the immediate area. How would fresh water be distributed over an area of several linear blocks? How would fresh water be distributed over an area of several square miles? How do the methods change if we need to distribute the water over vertical surfaces such as the facades of buildings?</p>	

<p>Scenario 3: We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, urban green spaces), reducing the potential for resuspension is a potentially important goal. Through prior research and experience, we have identified that washing the surfaces with water containing salt (for example, seawater or salty water from water softener units) is effective in removing contaminated particles and fixed contamination from surfaces, thereby reducing the dose in the immediate area. How would we generate the salt water and distribute it over an area of several linear blocks? How would we generate the salt water and distribute it over an area of several square miles? How do the methods change if we need to distribute the salt water over vertical surfaces such as the facades of buildings?</p>	
<p>Scenario 4: How would our proposed method of addressing the Scenarios 1-3 change if the contaminated area was located sufficiently close to the ocean coast line or other navigable waterway such that maritime equipment and methods can be used?</p>	

<p>Scenario 5: We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, urban green spaces), reducing the potential for resuspension is a potentially important goal. Through prior research and experience, we have identified that applying a layer of sprayable polymer coating (with a consistency of wet paint) [for example, outdoor paints and epoxies such as those designed for roadways or other paved surfaces] to the surfaces is effective in tying down contaminated particles. How would we distribute this polymer coating material over an area of several linear blocks? How would we distribute it over an area of several square miles? How do the methods change if we need to distribute the sprayable coating over vertical surfaces such as the facades of buildings?</p>	<p>Mobile wash unit trucks (approximately 120 of them in NYC) have pressure washers and water tanks for washing stations. They have a few hundred feet of hoses. Can this be used for polymer paints without fouling the sprayers? [Vehicles would have to spray from the rear, to avoid driving over fresh paint lines]. Vac trains are used to prevent fires by pulling up the debris along tracks. Wand is from the rear of the train and vac unit. They have same equipment at bus stops and it is through contractors. Fire department has equipment that can spray foam onto surfaces, but not sure if polymer will work in them. Asphalt pot hole patch trucks (does everything itself – patches and pours tar) are from third-party contractors, but done in small surface applications. Lots of agriculture sprays available that spray (LLNL) horticultural oils to reduce resuspension. During the Cold War, Soviet Union responders shot water through jet engines mounted on the back of trucks to quickly blast contamination from vehicles. Can we do this, and with what engines? Jet engine blowers are used for removing snow on the rail lines in New York, but these are not used as much anymore since they produce projectiles (e.g., rocks). Tunnel repair is contractor based. New York City used their own equipment to spray for West Nile and Zika viruses and their own employees, it was believed. They used sprayers systems mounted on existing pick-up trucks to spray the aerosol. Not known if same sprayers could provide enough decontamination solution for rad or could be adapted for spray of polymer coatings. They had months to plan their mitigation strategy because they knew Zika virus season was coming. If it was an emergency situation, it could be prepared a lot quicker. Municipal employees - finding people who are trained was a logistical task - training was a concern. Aviation has bambi buckets that drop hundreds of gallons. They also may have rented helicopters to spray for Zika by using map of Zika breeding sites. The helicopters dropped pesticides in uninhabited area. Helicopters will not fly in urban canyons. A point was made that in New York, the planning assumption for an aggressive radiation emergency is limited to improvised nuclear device (IND) and radiological dispersal device (RDD) events. On the RDD side, the assumption is that public will not be working or living in contaminated areas due to the health risk. Also, the response and recovery plan will establish an environmental assessment area where the dose rates are mapped after the incident. This would be developed by the health department. The fire department would probably be put into service to do the mapping since they are equipped with rad detectors. The fire department and health department need to get together and formulate training and a strategy for mapping (conversations to do this have begun). Can we use paver trucks to lay down tar, paint, salt onto roads after doing real time measuring of the dose rates?</p>
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<p>Scenario 6: How would the above equipment and methods in Scenario 1-3 and 5 above differ if the contamination occurred at critical infrastructures such as a hospital, water reclamation facility, or drinking water plant, airport, or communications centers (for example)?</p>	<p>Bridges and tunnels have their own vac trucks, and they use them to clean out clogged scuffers. They have special cleaning equipment for cleaning tunnel walls. A user-operated car has special spray heads to deluge water and soap onto walls and brushes that are on articulating arms. Also have subway cars outfitted with sprayers for tunnels between stations. The fire department has equipment to spray foam, but not sure it can handle other decontaminants. During the Underground Transportation Restoration Operational Technology Demonstration held last fall by EPA and DHS, agricultural equipment was demonstrated for its use in bio-remediation of subway tunnels (report will be out soon). For releases about a year ago (Maltodextrin), New York City informed the public ahead of time and received good feedback. Getting the word out through public education/communication beforehand is key.</p>
<p>Scenario 7: We have identified that airborne contamination is a significant source of radiation dose to unprotected people. Given that the contamination after settling is primarily found on horizontal surfaces (e.g., streets, walkways, parking lots, urban green spaces), reducing the potential for resuspension is a potentially important goal. An area of concern is covered in contaminated debris and loose particles. In some areas, the debris is substantial and can be removed by bulldozer-type equipment. In other areas, the debris material is such that it can be swept and vacuumed. How would you approach the problem?</p>	
<p>Scenario 8: Regardless of scenario, how would the above equipment and methods differ if the contamination occurred along egress routes that are needed to transport people away from the affected area (for example, major highways)?</p>	
<p>Scenario 9: Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?</p>	

<p>Support Goal Training: Wide-area radiological contamination incidents are rare, and a response to such an incident will require tremendous human assets. We learned from the cleanup efforts in Japan that many thousands of individuals each day are engaged in clean-up activities. What are your thoughts and recommendations on availability of trained human assets and training of additional assets that will likely be needed in order to accomplish the scenarios under this Goal? (Note: We realize that training will be a significant effort and an additional limiting factor in any response scenario. Further, it may need to be addressed more thoroughly in the future, but we would like input to help guide how we should continue toward developing training guidance.)</p>	
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Scenario Description: Decontamination (Gross and Final)	Scenario Response (Please provide specific ways in which you would respond to the scenario and what types of equipment you would require. Please use NIMS typing if it is available and you are familiar with the FEMA NIMS system.) Note: Below includes returned responses and responses captured during the workshop.
<p>Scenario 1: EPA studies identified that soil was a major source of contaminated material in decontamination effort in an urban environment. Prior research and experience suggests that by removing less than 5 cm (2 inches) of soil, nearly all the contamination can be removed. What equipment would be useful in removing a very shallow depth of soil from large urban green spaces such as playgrounds and open grass fields?</p>	<p>Current city resources, city has equipment to remove fallen trees. Defoliation of trees can be done likely by crop dusters (such as done on cotton farms). Will need to look at current resources and workers that can be leveraged. Have we looked at workers who have similar hazards such as asbestos removal who have the procedures and equipment and better level of understanding of risk?</p>
<p>Scenario 2: Same as Scenario 1 above, except that we wish to identify equipment that would be useful in removing a very shallow depth of soil from smaller, discontinuous plots of urban green spaces such as front and backyards and garden areas.</p>	
<p>Scenario 3: Hard, horizontal surfaces such as roads, walkways, and parking lots can trap radioactive contamination. Prior studies and experience shows that the contamination resides at or very near the surface of such hard materials (<1 cm or <0.5 inches). What equipment would be useful for removing contamination at the surface? What equipment would be useful in removing a very shallow depth of paving material? How does the choice of equipment and method change if many linear miles of surfaces need such treatment?</p>	

<p>Scenario 4: As in Scenario 3 above, prior studies and experience shows that the contamination on paved surfaces can be effectively reduced by washing these surfaces with water-based solutions. What type of equipment can be used to wash many linear miles of these paved surfaces and collect the washings?</p>	<p>Equipment that was already discussed for tunnels is appropriate, but no equipment is available to capture the water.</p>
<p>Scenario 5: How would our proposed method of addressing the Scenarios above change if the contaminated area was located sufficiently close to the ocean coast line or other navigable waterway or river system such that maritime equipment and methods can be used?</p>	<p>In asbestos release in water break, the fire department hosed down the houses and such and brought in commercial crews. The city assumes that they would use city resources in short term, but rely on contractors to do the job. Bridges and tunnels can use fireboats to fight fires on bridges. They charge water lines to clean off bridges with river and/or seawater. We can use this feature for decontamination of bridges and maybe cars passing through.</p>
<p>Scenario 6: Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?</p>	<p>What is the effect of public outcry for defoliating Central Park? For a crime scene investigation, the Federal Bureau of Investigation (FBI) wants up to two weeks or so before the crime scene is modified. But, that is for immediate release and so much of what we discuss here is for the plume. It was mentioned that the size of the crime scene could be the entire scene. The public may want to come back, but the police department wants to make sure they do a proper job. Are you going to stop ordinary citizens from doing their own thing? Liberty Rad Ex exercise asked the stakeholders what and where do they want decontaminated. Where do you start decontamination? It was mentioned to maybe start at both ends, in order to not lose the vitality of the city. Identifying evacuees takes a lot of time. Japan has 150 people to trace evacuees. How can we track evacuees and get access agreement?</p>

<p>Support Goal Training: Wide-area radiological contamination incidents are rare, and a response to such an incident will require tremendous human assets. We learned from the cleanup efforts in Japan that many thousands of individuals each day are engaged in clean-up activities. What are your thoughts and recommendations on availability of trained human assets and training of additional assets that will likely be needed in order to accomplish the scenarios under this Goal? (Note: We realize that training will be a significant effort and an additional limiting factor in any response scenario. Further, it may need to be addressed more thoroughly in the future, but we would like input to help guide how we should continue toward developing training guidance.)</p>	<p>Balance decontamination with forensics. Asbestos and lead paint removal services are trained in use of PPE, so it may be easier to train those types of professions, for example, to perform radiation work and quickly understand the hazards and hazard mitigation.</p>
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Scenario Description: Waste Management	Scenario Response (Please provide specific ways in which you would respond to the scenario and what types of equipment you would require. Please use NIMS typing if it is available and you are familiar with the FEMA NIMS system.) Note: Below includes returned responses and responses captured during the workshop.
<p>Scenario 1: We suspect that radioactively-contaminated material will be generated in residences as a result of personnel and self-help decontamination practices. How would the individual waste receptacles generated by residences be collected to avoid an accumulation of radioactively-contaminated materials within multi-family units or at the curbside? Does the equipment and method of collection differ for more sparsely distributed suburban areas as opposed to congested downtown residences?</p>	<p>For Hurricane Sandy waste, the city set up a system of temporary debris storage facilities that USACE set up, such as parking lots. Most waste was similar to construction debris. After waste was brought from community to temporary storage facilities, it was handled through USACE or regular contractors and passed as a normal waste stream. Sandy was a lot of manual work, but if you add radioactive contamination, manual work will increase tremendously. Can we dump contaminated waste into a garbage truck? In New York, there is already a problem with disposing of municipal waste. They are a day away from the waste system busting, so there is a huge issue finding a set of places to place garbage over many days/weeks! We must look outside the city to help us place the garbage. We need to consider moving the garbage directly out of the city and to some outside location. For 9-11, waste trucks went to Staten Island by barge to landfill (which is closed now). Can we place waste in container boxes and then place it on barges directly? They have plenty of equipment types for hauling, such as garbage trucks, snow trucks, plow trucks, front loaders, and back loaders. Would we be better served by identifying a waste site outside of the city early and eliminating the temporary or interim storage locations? This strategy to relieve any temporary storage issues is to leave waste on city blocks where people are not living for a little longer until we can get it out of the city. Every time debris moves, we need to decontaminate a piece of equipment and track the hazardous waste, so can we from a planning perspective find a final resting place. That was done for biological waste, as the health department has identified spots to place bio waste. Could we do same approach as from 9-11 in that container boxes are packed and carried directly onto barges for transport and disposal? Yes, conceptually, but it's more complicated. So if we can classify a temporary storage location, then yes it can be moved. But it might be difficult to identify such a place in New York than elsewhere. Identifying sites outside ahead of time the state is necessary. It was noted that there are many commercial companies that do sanitation. Department of Sanitation has snow plows, front end loaders and backhoes.</p>

<p>Scenario 2: How would the answer to Scenario 1 above differ if the radioactively-contaminated material is being generated by local businesses as a result of self-help decontamination practices? How would the individual waste receptacles generated by local businesses be collected to avoid an accumulation of radioactively-contaminated materials in multi-business units or at the curbside? Does the equipment and method of collection differ for more sparsely distributed suburban areas as opposed to congested downtown businesses?</p>	<p>Can we find out what is the alarm points for the landfill and sanitation for waste coming into the site? How do we know how much waste a truck can bring in and be approved for drop off? Idea of insurance costs for a building - at what point does a building owner say he does not want to have his building decontaminated because they would rather collect on insurance? How much do the insurance companies have to insure, and when do they tap into their backup re-insurers?</p>
<p>Scenario 3: If the accumulated radioactively-contaminated waste is being collected at staging locations (for example, parks and common grounds), what types of containers can be used to collect the waste receptacles and protect the public from transport of contaminated particles (for example, through resuspension of breached receptacles)?</p>	<p>Ground zero (where the release happened) may be a good option as a storage site since the area is already evacuated. Sang Don briefly reviewed an option for disposing waste at temporary storage sites (tented structure with vents and measures to track spread of contaminants). Discussed measuring individual bags for radioactivity. High waste bags in middle and low on outside. Might want to leverage Department of Defense (DoD) waste minimizing techniques, but that can be expensive.</p>
<p>Scenario 4: Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?</p>	
<p>Support Goal Training: Wide-area radiological contamination incidents are rare, and a response to such an incident will require tremendous human assets. We learned from the cleanup efforts in Japan that many thousands of individuals each day are engaged in clean-up activities. What are your thoughts and recommendations on availability of trained human assets and training of additional assets that will likely be needed in order to accomplish the scenarios under this Goal? (Note: We realize that training will be a significant effort and an additional limiting factor in any response scenario. Further, it may need to be addressed more thoroughly in the future, but we would like input to help guide how we should continue toward developing training guidance.)</p>	

Scenario Description: Containment of Water, Wastewater, and Other Wastes	Scenario Response (Please provide specific ways in which you would respond to the scenario and what types of equipment you would require. Please use NIMS typing if it is available and you are familiar with the FEMA NIMS system.) Note: Below includes returned responses and responses captured during the workshop.
Scenario 1: What types of barriers (for example, sandbags and berms) are available to collect water that is generated during its large-scale use (hundreds of thousands to millions of gallons) over a small urban footprint (for example, 1 square city block)?	
Scenario 2: What types of barriers (for example, sandbags and berms) are available to collect water that is generated during its large-scale use (millions of gallons) over a large urban footprint (for example, 10 square city blocks)?	
Scenario 3: Do the answers to Scenario 1 and 2 above differ if the water is used to wash down vertical as opposed to horizontal surfaces?	
Scenario 4: If the water is collected at the point of use, what containers/vessels/facilities are available to store the water generated in Scenarios 1-3 until it can be processed or transported?	New York City Department of Environmental Protection (DEP) met with the health department, and might say that they understand material gets into storm drains, then a portion of water goes to sewer system. The water plants are prepared to remove the contaminated components of the operation (such as settling beds and bio reactors), then replace. A book entitled The Works by Kate Ascher explores the systems that manage water, traffic, sewage and garbage, subways, electricity, mail, etc. Approximately 60% of New York sewers are combined sewers while the remainder of storm runoff is taken to the rivers, bays, and streams. It was mentioned that previous conversations between Argonne-EPA and water treatment plants resulted in understanding that removal of bacterial beds was essentially a shutdown of plants, which is not good. When it rains, what happens to the tunnels? In New York, certain stations would be under water if they turned off pumps during normal operations, and when it rains, it does flood even with the pumps running. If they have water accumulating at the street, they have grate covers that cover the intake so water does not infiltrate much into the subway system and stays at street level or goes into conventional sewer. The combined sewer takes water to reclamation plant. If there is too much water, then the water diverts it directly to river. If there are simple ways of developing filtration systems ad hoc, then it is possible to recycle the water from wash down. Vermiculite can be used for soaking up material (absorb radioactive Cs). Would need a way to collect water and divert into a system like this. Could we create an apron system where you are collecting one story at a time? For example, can we wash down tall buildings and skirt the building at the e.g., 20th floor and collect water one floor at a

	time? And move down with each floor? Does that work? We know from our testing that this can work well, since for steel and glass the decontamination factor (DF) can be 10 or greater. The skirt system at the floor level is something we can put in place via e.g., HESCO. May have such a HESCO berm system (like HESCO or is it HESCO?) in their inventory. For flooding, they deployed these types of berms to divert coastal influx. Tested water bladders to hold water from flooded subways. Might be used to prevent waters from contaminated downstream tunnels. For Sandy, they were able to deploy gates to hold floodwaters at certain vulnerable rail yards. The Immigration Removal Centre in Dover, England, Dover bladder did some tests with MTA to show deployment of the bladder, and upcoming demo by the same company was just announced by DHS.
Scenario 5: If the water penetrates the sewer system and can be diverted at a downstream collection site (for example, just prior to entering the water reclamation district or wastewater treatment plant), what containers/vessels/facilities are available to store the water until it can be processed or transported?	Frack water storage tanks and frack water vacuum trucks. These are used to make up chemicals for injection into wells and then used to recover the produced water. (Telephone conversation with Jack Schwalbach of Separmatic Systems after NYC Workshop).
Scenario 6: If we wish to avoid the sewer system, what other methods of diverting water are available to collect water at a central location?	
Scenario 7: Are there existing trench, dam, retention ponds, community reservoirs, etc. available to collect water and are there paths for directing the wash water from its point of use to these existing collection systems?	
Scenario 8: Do you have other thoughts or specific questions based on your experiences in your geographical area related to this topic?	

<p>Support Goal Training: Wide-area radiological contamination incidents are rare, and a response to such an incident will require tremendous human assets. We learned from the cleanup efforts in Japan that many thousands of individuals each day are engaged in clean-up activities. What are your thoughts and recommendations on availability of trained human assets and training of additional assets that will likely be needed in order to accomplish the scenarios under this Goal? (Note: We realize that training will be a significant effort and an additional limiting factor in any response scenario. Further, it may need to be addressed more thoroughly in the future, but we would like input to help guide how we should continue toward developing training guidance.)</p>	<p>The contaminated site and contaminated sewer line. Worked with DEP to come up with procedures for people to enter those contaminated areas.</p>
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Appendix F: Summary of the “New York City Transit Grand Central Station Pre-Incident Radiological Dispersal Response and Recovery Plan” (June 28, 2003, LLNL-TM-644423)

“This document is a pre-Incident response and recovery plan for the New York City Transit managed Grand Central Station (GCS). It was prepared following extensive on-site interviews and data collection. The plan included herein was designed to be an operationally focused, hands-on guide to help direct immediate actions to minimize the consequences of a radiological dispersal incident and to facilitate the preparation of a post-incident response and recovery plan. This document includes explanatory text, charts, tables and “pull sheets.” Pull sheets are designed as stand-alone 1-2page documents that can be easily printed and distributed post-incident to provide location specific information to radiological incident responders.

This response and recovery plan contains eight interrelated sections providing comprehensive post-incident technical information and facility-specific strategies to support restoration of GCS service after a radiological dispersal incident:

- ☐ Section 1: Contamination Incident Information
- ☐ Section 2: Facility Information
- ☐ Section 3: Incident Management Plan
- ☐ Section 4: Return to Service Plan
- ☐ Section 5: Initial Post-Incident Monitoring Plan
- ☐ Section 6: Facility Decontamination Plan
- ☐ Section 7: Rolling Stock Decontamination Plan
- ☐ Section 8: Waste Management Plan
- ☐ Section 9: Local Station Recovery Strategies

The collective NYCT/GCS pre-incident response and recovery plan focuses on prompt operational and longer-term consequence management actions and recovery strategies. This plan does not address the crisis management phase of the initial incident response, e.g., incident notifications, emergency response, or criminal/forensic investigations.”

Nuclear Engineering Division

Argonne National Laboratory

9700 South Cass Avenue, Bldg. 208

Argonne, IL 60439-4854

www.anl.gov

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