United States
Environmental Protection
Agency

EPA/600/R-15/317 | July 2016
www.epa.gov/homeland-security-research

Practical Considerations and Operational Recommendations for Waste Staging for Wide-Area Radiological Releases

Office of Research and Development
Homeland Security Research Center

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EPA/600/R-15/317
July 2016

U.S. Environmental Protection Agency

Practical Considerations and Operational Recommendations for Waste Staging for Wide-Area Radiological Releases

Revision Number: 005
Issue Date: May 18, 2016

U.S. Environmental Protection Agency
National Homeland Security Research Center
Decontamination and Consequence Management Division
Research Triangle Park, NC

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DISCLAIMER AND LIMITS ON SCOPE

The U.S. Environmental Protection Agency through its Office of Research and Development managed the research described here. This work was performed by Battelle under Contract No. EP-C-10-001 Work Assignment 5-34. It has been subjected to the Agency's review and has been approved for publication. Note that approval does not signify that the contents necessarily reflect the views of the Agency.

The cleanup process described in this practical recommendations document does not rely on and does not affect authority under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601 et seq., and the National Contingency Plan (NCP), 40 CFR Part 300. This document does not address or impact site cleanups occurring under other statutory authorities such as the United States Environmental Protection Agency's (EPA) Superfund program, the Nuclear Regulatory Commission's (NRC) decommissioning program, or other federal or state cleanup programs. This document expresses no view as to the availability of legal authority to implement this process in any particular situation. This document is intended to provide information and suggestions that may be helpful for implementation efforts and should be considered advisory. As indicated by the use of non-mandatory language such as "may," "should" and "can," this Manual only provides recommendations and does not confer any legal rights or impose any legally binding requirements upon any member of the public, states, or any other federal agency. The recommendations in this document are not required elements of any rule. Therefore, this document does not substitute for any statutory provisions or regulations, nor is it a regulation itself, so it does not impose legally-binding requirements on EPA, states, or the regulated community. The recommendations herein may not be applicable to each and every situation.

Questions concerning this document or its application should be addressed to:

Paul Lemieux
National Homeland Security Research Center
Office of Research and Development
U.S. Environmental Protection Agency
Mail Code E343-06
Research Triangle Park, NC 27711
919-541-0962

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LIST OF ACRONYMS AND ABBREVIATIONS

BOTE	Bio-response Operational Testing and Evaluation
137Cs	Cesium-137
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CI/KR	Critical Infrastructure/Key Resources
CMAT	Consequence Management Advisory Team
CRZ	Contamination Reduction Zone
DHS	U.S. Department of Homeland Security
DHS S&T	Department of Homeland Security Science and Technology Directorate
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EOC	Emergency Operations Center
EPA	U.S. Environmental Protection Agency
EZ	Exclusion Zone
FEMA	Federal Emergency Management Agency
FR	Federal Register
FRMAC	Federal Radiological Monitoring and Assessment Center
Hazus-MH	Hazards U.S. Multi-Hazard Model
HHS	Health and Human Services
HHW	Household Hazardous Waste
HW	Hazardous Waste
I-WASTE	Incident Waste Assessment and Tonnage Estimator
IAEA	International Atomic Energy Agency
ICS	Incident Command System
IND	Improvised Nuclear Device
LLMW	Low-Level Mixed Waste
LLRW	Low-Level Radioactive Waste
MDEQ	Michigan Department of Environmental Quality
NCP	National Contingency Plan
NHSRC	EPA National Homeland Security Research Center
NIMS	National Incident Management System
NRC	Nuclear Regulatory Commission
NRF	National Response Framework
NRIA	Nuclear/Radiological Incident Annex
NRT	National Response Team
NPP	Nuclear Power Plant
ORCR	Office of Resource Conservation and Recovery
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PAG	Protective Action Guide
PPE	Personal Protective Equipment
RCM	Radiological Contamination Mitigation
RCRA	Resource Conservation and Recovery Act
RDD	Radiological Dispersal Device
SME	Subject Matter Expert

SZ	Support Zone
UASI	Urban Area Security Initiative
UC	Unified Command
UK	United Kingdom
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
WAC	Waste Acceptance Criteria
WARRP	Wide Area Recovery and Resiliency Program
WEST	Waste Estimation Support Tool
WWTP	Wastewater Treatment Plant

GLOSSARY

Agency – A division of government with a specific function, or a non-governmental organization (e.g., private contractor, business, etc.) that offers a particular kind of assistance. In the incident command system (ICS), agencies are defined as jurisdictional (having a statutory role in incident mitigation) or assisting and/or cooperating (providing resources and/or assistance).

Aqueous Waste – Waste that is water-soluble or water-based. Dealing with these wastes can require different approaches than other wastes that are in the liquid form of matter. Such wastes can be generated from **radiological contamination mitigation** activities. Compare to "**liquid waste**" and "**solid waste**."

Clearance – The process of determining that an item or facility is acceptable for reuse or reoccupancy. Generally occurs after decontamination and before reoccupancy. Clearance is not a term typically used when discussing waste management, although its usage is somewhat akin to the waste acceptance criteria (WAC) that deals with allowable levels of contaminants for waste to be allowed to proceed through a given disposal pathway.

Code of Federal Regulations (CFR) – The codification of the federal regulations published in the Federal Register by the executive departments and agencies of the federal government. Each volume of the CFR is updated once each calendar year and is issued on a quarterly basis. See http://www.gpoaccess.gov/cfr/index.html, Accessed February 25, 2015.

Contamination (radioactive) – Radionuclides on surface or in the environment as a result of a release of radiological material.

Contamination Reduction Zone (CRZ) – The transition area between the exclusion and support zones. This area is where responders enter and exit the exclusion zone and where decontamination activities take place. Also called the warm zone.

Critical Infrastructure (CI) – Systems and assets, whether physical or virtual, so vital that the incapacity or destruction of such may have a debilitating impact on the security, economy, public health or safety, environment, or any combination of these matters, across any federal, state, regional, tribal, territorial, or local jurisdiction.

Debris – The remains of something broken down or destroyed. Debris may also be considered to be waste depending upon what contaminants may be present.

Decontamination – The inactivation or reduction of contaminants from surfaces by physical, chemical or other methods to meet a cleanup goal. For the purposes of this document, decontamination does not include treatment of contaminated water or wastewater, or other wastes such as solid waste. Compare to definition of **Treatment**.

Early Phase – The beginning of a radiological incident when immediate decisions for effective use of protective actions are required and must therefore be based primarily on the status of the radiological incident and the prognosis for worsening conditions. When available, predictions of radiological conditions in the environment based on the condition of the source or actual environmental measurements may be used. Protective actions based on the

Protective Action Guides (PAGs) may be preceded by precautionary actions during the period. This phase may last from hours to days. For the purpose of these recommendations, early phase is defined as the first 72 hours. Although waste may be generated during the early phase of the response, it is likely that waste management activities will not take place until after the early-phase of the response. This document intends to highlight information to be included in pre-incident planning, and to provide decision makers information to identify incident-specific waste staging areas based on criteria established in the Pre-Incident Waste Management Plan (WMP); these decisions may very well be made during the first 72 hours of a response.

Emergency – Any incident, whether natural or man-made, that requires responsive action within hours to protect life or property. As defined in the Stafford Act, any occasion or instance for which, in the determination of the President, federal assistance is needed to supplement state and local efforts and capabilities to save lives and to protect property and public health and safety, or to lessen or avert the threat of a catastrophe in any part of the United States (Per 42 U.S.C. 5122).

Exclusion Zone (EZ) – The area with actual or potential contamination and the highest potential for exposure to hazardous substances. Also called the hot zone.

Federal On-Scene Coordinator (OSC) – The federal official responsible for coordinating and directing federal responses under subpart D, or the government official designated by the lead agency to coordinate and direct removal actions under subpart E, of the National Contingency Plan (NCP) (per 40 CFR 300.5). The specific duties of the OSC are provided in 40 CFR 300.120. The federal OSC is predesignated by the U.S. Environmental Protection Agency (EPA), U.S. Coast Guard, U.S. Department of Energy (DOE), or U.S. Department of Defense (DoD) depending on the location and/or source of the release and may be designated by other federal agencies under certain circumstances.

Federal Radiological Monitoring and Assessment Center (FRMAC) – An interagency response asset, supplemented by a DOE team and other DOE assets, to assist state, tribal, and local officials with monitoring, assessment, and health guidance for nuclear/radiological incidents. The mission of the FRMAC is to coordinate and manage all federal radiological environmental monitoring and assessment activities during a radiological incident, within the United States.

Federal Register (FR) – The official weekday publication for rules, proposed rules, and notices of federal agencies and organizations, as well as executive orders and other presidential documents. See http://www.gpo.gov/fdsys/browse/collection.action?collectionCode=FR, Accessed February 25, 2015.

Gross Decontamination – In the context of this document, “gross decontamination” is a part of the decontamination process, often representing a small fraction of the timeline of the entire decontamination process, during which the goal is to reduce contamination to levels that will be safe for at least a limited period of time. Such purposes support rapid restoration of critical infrastructure (CI) or key resources (KR) following a wide area incident.

Hazardous Waste – For the purposes of these recommendations, a solid or aqueous waste that may cause an increase in mortality or serious illness or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported,

disposed of, or otherwise managed. See **Solid Waste** and **Aqueous Waste** for the definitions of solid waste and aqueous waste, respectively, for the purposes of these recommendations.

Improvised Nuclear Device (IND) – An explosive nuclear device with energy measured in kilotons (a small fraction of Cold War-era nuclear weapons) that can be detonated with no warning.

Incident – An occurrence, caused by either human action or natural phenomena, that may cause harm and may require action. Incidents can include major disasters, emergencies, terrorist attacks, terrorist threats, wild and urban fires, floods, spills of hazardous materials, nuclear accidents, aircraft accidents, earthquakes, hurricanes, tornadoes, tropical storms, war-related disasters, public health and medical emergencies, and other occurrences requiring an emergency response.

Incident Command System (ICS) – A standardized on-scene emergency management construct specifically designed to provide for the adoption of an integrated organizational structure that reflects the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries. ICS is a management system designed to enable effective incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure, designed to aid in the management of resources during incidents. ICS is used for all kinds of emergencies and is applicable to small as well as large and complex incidents. ICS is used by various jurisdictions and functional agencies, both public and private, to organize field-level incident management operations.

Initial Response – Actions taken immediately following notification of a contamination incident or release. In addition to search and rescue, scene control, and law enforcement activities, initial response may include initial site containment, environmental sampling and analysis, and public health activities such as treatment of potentially exposed persons. These initial response activities are typically performed during the early phase of the response.

Intermediate Phase – The period beginning after the source and releases have been brought under control (has not necessarily stopped but is no longer growing) and reliable environmental measurements are available for use as a basis for decisions on protective actions and extending until these additional protective actions are no longer needed. This phase may overlap the early phase and late phase and may last from weeks to months.

Isolation Distance – Defined as the circular evacuation distance related to dangerous upwind and life-threatening downwind.

Key Resources (KR) – As defined in the Homeland Security Act, publicly or privately controlled resources essential to the minimal operations of the economy and government.

Late Phase – The period beginning when recovery actions designed to reduce radiation levels in the environment to acceptable levels are commenced and ending when all recovery actions have been completed. This phase may extend from months to years. A PAG level, or dose to avoid, is not appropriate for long-term cleanup.

Low-Level Radioactive Waste (LLRW) – Radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or by-product material as defined in

defined in Section 11e, (2), (3) or (4) of the definition of by-product material set forth in 10 CFR 20.1003 (per 10 CFR 61.2). LLRW may contain either high or low concentrations of radioactivity. In general practice, LLRW does not include naturally occurring radioactive material but does include man-made material.

Liquid Waste Liquid waste is any waste material that is determined to contain "free liquids" as defined by Method 9095 (Paint Filter Liquids Test), as described in Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods (SW-846). Compare to "**solid waste**."

Mitigation – Measures taken to reduce adverse impacts from radiological contamination to humans and the affected urban and environmental areas.

Mixed Waste – For the purposes of these recommendations, RCRA Section 1004 (41) defines mixed waste as waste that contains both hazardous waste and source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954.

National Contingency Plan (NCP) – Also called the National Oil and Hazardous Substances Pollution Contingency Plan, the plan (40 CFR Part 300) that generally provides a blueprint for carrying out response actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and section 311 of the Clean Water Act. The NCP is designed to provide for efficient, coordinated, and effective response to discharges of oil and releases of hazardous substances, pollutants, and contaminants. The NCP describes the organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants. The NCP is also the primary source from which Pre-Incident WMPs should be developed from, and coordinated with Area Contingency Plans by the regional response teams, including both state and local response agencies.

Pre-Incident Waste Management Plan – A plan that addresses the management of waste generated by all hazards, particularly from homeland security incidents ranging from natural disasters and animal disease outbreaks to chemical spills and nuclear incidents to terrorist attacks involving conventional, chemical, radiological, or biological agents. Given the amount and types of waste that can be generated during an incident, this plan is designed to assist emergency managers and planners in the public and private sectors in preparing for an incident's waste management needs, regardless of the hazard. For this document, being intended for a wide area radiological release, a Pre-Incident WMP needs to be developed with appropriate Federal, State and local response agencies, and incorporated into Area Contingency Plans to include "pre-established" waste staging areas. Without doing this ahead of time, first responders will not even know where waste would be considered to be staged within the initial 72 hours of an incident which could result in double handling of waste.

Protective Action Guide (PAG) – The projected dose to an individual, resulting from a radiological incident at which a specific protective action to reduce or avoid that dose is warranted.

Radiological Contamination Mitigation (RCM) – In the context of this document, radiological contamination mitigation means measures taken to reduce adverse impacts of radiological contamination on people and the environment. RCM is made possible through "containment"

and "gross decontamination" technologies. Note that RCM is a subset of mitigation activities undertaken by emergency responders which are measures taken to limit or control the consequences, extent, or severity of an incident that cannot be reasonably prevented. Note that although waste management is not specifically included in RCM, many of the activities that would be used for RCM may also be associated with waste minimization activities, and many of the "containment" and "gross decontamination" technologies generate waste.

Radiological Dispersal Device (RDD) – Any device that causes the purposeful dissemination of radioactive material, across an area with the intent to cause harm, without a nuclear detonation occurring. An RDD is commonly known as a "dirty bomb."

Recovery – Those capabilities necessary to assist communities affected by an incident to recover effectively, including, but not limited to, rebuilding infrastructure systems; providing adequate interim and long-term housing for survivors; restoring health, social, and community services; promoting economic development; and restoring natural and cultural resources. (From U.S. Department of Homeland Security, *National Disaster Recovery Framework*, FEMA publication, September 2011.)

Remediation – Any measures that may be carried out to reduce the radiation exposure from existing contamination of land areas (urban and environmental) through actions applied to the contamination itself (the source) or to the exposure pathways to humans.

Remediation Waste – For the purposes of these recommendations, when used in connection with hazardous waste, all solid and hazardous wastes, and all media (including ground water, surface water, soils, and sediments) and debris that are managed for implementing cleanup. The cleanup process presented in these recommendations do not rely on and does not affect any authority, including the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. 9601 et seq. and the National Contingency Plan (NCP), 40 CFR Part 300. This document expresses no view as to the availability of legal authority to implement this process in any particular situation.

Resource Conservation and Recovery Act (RCRA) – A 1976 federal law (42 U.S.C. §6901 et seq.) that gives the EPA the authority to control hazardous waste from the "cradle-to-grave," including the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of nonhazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. For more information, see http://www.epa.gov/lawsregs/laws/rcra.html.

Response – Immediate actions taken to save lives, protect property and the environment, and meet basic human needs (see also **Initial Response**). Response includes the execution of emergency plans and actions to support short-term recovery (see **Recovery**).

Resuspension – Settled matter that has returned to the atmosphere or has been dispersed in the environment due to physical disturbance.

Safety Zone – Safety or work zones are established primarily to reduce the accidental spread of radioactive substances by workers or equipment from contaminated areas to clean areas. Safety zones specify the type of operation that will occur in each zone, the degree of hazard at

different locations within the release site, and the areas at the site that should be avoided by unauthorized or unprotected employees. The three most frequently identified zones are the exclusion zone (hot zone), the support zone (cold zone), and contamination reduction zone (or warm zone). Safety zones for first responders to a radiological incident are identified as the Low-Radiation Zone (<10-100 mR/hr); Medium-Radiation Zone (100-1000 mR/hr); High-Radiation Zone (1000-<10,000 mR/hr); and Extreme Caution Zone (≥10,000 mR/hr).

Solid Waste – Any discarded material that is abandoned, recycled, inherently waste-like, or a military munition, subject to certain exclusions. See 40 CFR 261.2 for the complete definition. Compare to "**liquid waste**" and "**aqueous waste**" which refer to composition and state of matter of the waste, which leads to necessarily special approaches to dealing with radiological waste. RCRA defines the term solid waste as: Garbage (e.g., milk cartons and coffee grounds); Refuse (e.g., metal scrap, wall board, and empty containers); Sludges from waste treatment plants, water supply treatment plants, or pollution control facilities (e.g., scrubber slags); Industrial wastes (e.g., manufacturing process wastewaters and non-wastewater sludges and solids); Other discarded materials, including solid, semisolid, liquid, or contained gaseous materials resulting from industrial, commercial, mining, agricultural, and community activities (e.g., boiler slags). The definition of solid waste is not limited to wastes that are physically solid. Many solid wastes are liquid, while others are semisolid or gaseous. The term solid waste, as defined by the Statute, is very broad, including not only the traditional nonhazardous solid wastes, such as municipal garbage and industrial wastes, but also hazardous wastes. Hazardous waste, a subset of solid waste, is regulated under RCRA Subtitle C.

Staging Area – A temporary location at or near an incident site that is designated as a support or cold zone used to stage personnel and equipment for immediate dispatch to the incident site to support operations. There can be more than one staging area per incident. For the purposes of this document, there would be two types of staging areas that would be set up: 1) "Response and/or Equipment/Emergency Personnel Staging Area"; and 2) "Waste Staging/Temporary Storage Area".

Support Zone (SZ) – The area of the site that is free from contamination and that may be used safely as a planning and staging area. Also called the cold zone.

Treatment – For the purposes of these recommendations, when used in connection with hazardous waste, any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste to neutralize such waste or to recover energy or material resources from the waste, or to render such waste nonhazardous, or less hazardous and therefore safer to transport, store, or dispose of; or amenable to recovery, amenable to storage, or reduced in volume. Treatment is not the same as "decontamination." (See **Decontamination.**)

Treatment technology – For the purposes of these recommendations, any unit operation or series of unit operations that alters the composition of a hazardous substance or pollutant or contaminant through chemical, biological, or physical means so as to reduce toxicity, mobility, or volume of the contaminated materials being treated. Treatment technologies are an alternative to land disposal of hazardous wastes without treatment.

WARRP – The Wide Area Restoration and Recovery Program, a DHS-led effort done in collaboration with other government agencies and the Denver Urban Areas Security Initiative (UASI) to develop planning documents for chemical, biological, and radiological incidents in the city of Denver that could be used as starting templates for other communities to use for planning purposes.

Waste – Material in gaseous, liquid or solid form for which no further use is foreseen.

Waste Acceptance Criteria

Waste Management – For the purposes of these recommendations, the administration of activities that include, but are not limited to, source reduction, waste minimization, waste segregation, decontamination, recycling, transport, staging, storage, treatment, and disposal.

Waste Staging – Temporarily storing waste for the purpose of accumulation and sorting to facilitate transportation, transfer, treatment and/or disposal, and to keep radiological waste from contaminating non-hazardous waste streams or from causing impacts to public health and the environment.

Waste Staging Area – A location at an incident site designated for the temporary accumulation and sorting of radioactive waste and debris until that waste is manifested and shipped to an offsite disposal facility. In the context of this document (i.e., first 72 hours), the Waste Staging Area(s), or at least selection criteria for the Waste Staging Area(s) should be “Pre-Designated” as part of the Pre-Incident Waste Management Plan.

ACKNOWLEDGMENTS

We would like to thank the following EPA staff members, outside organizations, and contractors for their ongoing participation in this effort:

Cardarelli, John	EPA Consequence Management Advisory Team
Hall, John	EPA National Homeland Security Research Center
Ierardi, Mario	EPA Office of Resource Conservation and Recovery
Jablonowski, Eugene	EPA Region 5
Lee, Sang Don	EPA NHSRC
Lemieux, Paul	EPA NHSRC
Lynch, Marissa	EPA Office of Water
Magnuson, Matthew	EPA NHSRC
Parrish, Cayce	EPA Office of Homeland Security
Pickrel, Jan	EPA Office of Water
Rhame, Ken	EPA Region 4
Schultheisz, Dan	EPA Office of Radiation and Indoor Air
Snyder, Emily	EPA NHSRC
Steuteville, Bill	EPA Region 3
Stilman, Terry	EPA Region 4
Walker, Stuart	EPA Office of Superfund Remediation and Technology Innovation

Outside Organizations

Nisbet, Ann	United Kingdom (UK) – Public Health England
Stevenson, Ben	Department of Homeland Security

Contractors

Battelle Memorial Institute
Booz-Allen Hamilton
CSS-Dynamac

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1. BACKGROUND

The U.S. Environmental Protection Agency (EPA) is working with the U.S. Department of Homeland Security Science and Technology Directorate (DHS S&T) to strengthen the Homeland Security Enterprise by performing a project to support first responders for radiological incidents.[1] This project focuses on four tasks: (1) methods for radiological contamination mitigation (RCM) via "containment" which prevents the resuspension and subsequent dispersion of radiological particle contamination, (2) methods for radiological contamination mitigation via "gross decontamination" which physically removes radiological contaminants from impacted areas of interest, (3) methods of early phase (first 72 hours) staging and storage of radiological waste, and (4) development of a software application to help facilitate early decision-making regarding containment, decontamination and waste storage/disposal during a wide-area radiological incident.

A recurring theme in this document concerns the whole concept of waste management activities that would occur during the early phase (first 72 hours) of an incident. During the early phase of an incident, the first responders will not be performing waste management activities to any great extent. There are, however, two main aspects of waste management that will apply during the early phase of an incident:

- From a planning perspective, a Pre-Incident Waste Management Plan (WMP) should be developed to address all aspects of waste management in the context of a system-of-systems where inter-related decisions cascade throughout the response; this WMP will contain elements that may impact or be impacted by activities the first responders take during the early phase of the response; and
- From an operational perspective, decision making regarding waste management will begin during the early phase of the response, as the Pre-Incident WMP is implemented. Implementing waste staging operations will not likely occur during the first 72 hours of a response, however, using criteria developed in the Pre-Incident WMP to identify incident-specific areas for waste staging operations may indeed occur during the first 72 hours of a response. For radiological incidents, conducting waste staging without conducting Pre-Incident Waste Management Planning and coordinating that plan with the overall response plan may result in health impacts to first responders, as well as longer term impacts to public health and the environment.

Containment (task 1 listed above) and gross decontamination (task 2) approaches for radiological containment mitigation after wide-area radiological contamination incidents are under study. They are briefly described in Appendix A and will be presented separately with the software application "app" (task 4) housing the waste management information summarized in this document. It should be noted that since the first-responders would probably not be actually performing waste staging operations during the early-phase of a response, this documents inclusion in the app will be as a linked reference, since the target audience for this

[1] DHS website: http://www.dhs.gov/homeland-security-enterprise, accessed February 28, 2015.

document is not the first responders themselves, but the waste management decision makers who will be making decisions in parallel with the first-responders. This document focuses on methods to incorporate waste staging into Pre-Incident planning, as well as to support waste management decision makers for staging and temporary storage of radiological waste (task 3), with the intent to provide decision-makers with recommendations and best practices for initial waste handling and staging that could be implemented in the early phases of a response to a wide-area radiological incident (in parallel to the first-responders' early-phase activities). Waste staging can be defined as the process by which space is allocated for sorting waste into different waste streams, isolating radioactive waste in order to keep it from contaminating non-hazardous waste streams, and storing waste until disposal capacity becomes available. These incidents could include nuclear power plant (NPP) accidents as well as detonation of radiological dispersal devices (RDDs), otherwise known as "dirty bombs," or Improvised Nuclear Devices (INDs). Note that NPPs have their own response plans which may or may not include considerations of waste staging and temporary storage. It is hoped that waste management would be included in the NPP response planning.

Clean up of cesium-137 is the primary focus of this document, due to its ability to move easily throughout the environment; however, other radionuclides could contribute to a contamination incident and these recommendations can be applied to those radionuclides.

These operational recommendations provide multi-level (federal, state, territorial, tribal and local) response/recovery information for wide-area radiological releases, are intended to be general in nature, and could be used in a multitude of settings (i.e., applied nationwide, including urban environments).

Although waste management is typically viewed as a function associated with later phases of the response and recovery, waste will start being generated almost immediately after the initial contaminating incident and as a result, "pre-incident" waste management planning to include early phase staging of waste is needed. Waste management decisions made by first responders during the early phase of the response may impact waste management options available later in the response/recovery process as well as impact the overall cost, timeline, and difficulty of the recovery to come.

To support this project, an extensive literature review of waste management topics related to other types of wide area disasters, such as natural disasters, including exercises and incidents related to wide area radiological contamination, such as NPPs, RDDs, or INDs was performed. The review also included the identification of waste staging procedures (task 3) directed at radiologically contaminated waste. In addition, the Radiological Mitigation and Waste Management Stakeholders Workshop was held on April 1-2, 2014, in Arlington, Virginia. The meeting goals were: (1) to develop a shared understanding of existing knowledge in the area of early phase mitigation and waste management activities, (2) to obtain stakeholder input on what specific containment and mitigation technologies should be tested and how to test them in a realistic manner, and (3) to obtain stakeholder input on needs for waste management guidance and the Radiological Gross Decontamination and Waste Management First Responder

Application (Radiation Decon Application). Following the April 2014 meeting, five representative cities were initially chosen for visits/meetings in an effort to engage stakeholders further. The cities were chosen after considering criteria such as city size, climate, emergency response experience, radiological experience, and other resources available. One small city, one medium city, and three large cities were chosen based on these criteria and discussions among a group of EPA regional contacts and members of the proposed software development team. Of five cities initially considered, the three cities visited were Burlington, Vermont; Charlotte, North Carolina; and Los Angeles/Long Beach, California. The three city visits took place in mid- to late-June 2014. Collectively, more than 60 stakeholders attended the meetings ranging from firefighters, health care officials, health and safety officials, health physicists, civil support personnel, bomb squad personnel, nuclear power plant emergency planners, and HAZMAT specialists to interested scientists and responders. In each of the cities, stakeholders agreed that an electronic software application ("app") that could be used to assist with decision-making regarding radiation decontamination and waste management in the early phases of an incident would be useful. The information from this document is intended to be included in the app, once completed, however, it is likely that the information will be provided as a link because the first-responders may not be making waste management decisions during the early phase of a response (they may, however, require background information to place waste management into perspective with the wider response). Many stakeholders did note that the application would likely be more useful for response personnel that staff Emergency Operations Centers (EOCs) rather than for firefighters or other first responders whose principal initial role during a large-scale radiation incident response would be safeguarding lives. Rather, the state and local waste management and radiation control authorities will be making waste management decisions to implement Pre-Incident Waste Management Planning documents in parallel with the emergency response operations that the first responders will be performing.

> A Radiological Mitigation and Waste Management Stakeholders Workshop was held on April 1-2, 2014. Thirty-five meeting attendees representing a wide range of federal, state, and local government, international organizations, health care professionals, emergency response personnel, and academia participated in the two-day meeting. Participants of the meeting shared knowledge, explored differing opinions, and expanded understanding of the current state and future research and technology needs for the areas related to early phase radiological responses. The overwhelming consensus at the workshop was "the need" for waste management operational guidelines following an incident of this nature.

1.1 Purpose of the Operational Recommendations

The purpose of this document is to provide general information directed at pre-planning waste management, primarily early phase (first 72 hours after onset of the incident) staging and storage of radiological waste for a user audience that may include first responders, emergency management planning organizations, qualified radiological cleanup contractors, or recovery personnel involved in response/recovery operations. Based on input from the stakeholder workshop and the three-city meetings, the operational recommendations developed for this project will be formatted suitably for inclusion in the application software that is also being

developed, and will become an important consideration in local, state, and federal decision-making. Information in this document may be helpful as Pre-Incident WMPs are produced as well as while the plans described in the Pre-Incident WMP are carried out.

This document leverages previously published information by EPA and other federal agencies, as well as institutional knowledge gained from existing programs such as EPA's Superfund program and from recent large-scale incidents (Hurricane Katrina, Deepwater Horizon, Fukushima, etc.). In addition, the audience (see Section 2.1) intended to use this document also has access to online guidance and handbooks that may be considered when responding to a radiological incident. See the reference section for complete citations for relevant guidance and handbooks.

1.2 Why These Recommendations are Necessary

DHS National Planning Scenario 11 describes a hypothetical radiological attack with an RDD in a moderate-to-large U.S. city (DHS, 2006). After the initial lifesaving activities occur in response to a radiological incident, first responders may be responsible for initial efforts to contain the contamination, perform gross decontamination of vehicles and equipment, and temporarily stage waste (e.g., used personal protective equipment [PPE], decontamination wash water). All waste and debris removal activities (e.g., waste staging area management and coordination) will be coordinated by the Incident Command/Unified Command (IC/UC) (state and local agencies, as well as other federal agencies) and will be consistent with or coordinated with pre-incident WMPs and address state or local requirements developed as part of the RDD incident preparation. Given the differences between debris and waste, FEMA guidelines for debris (FEMA, 2014) may not be applicable to waste management. Therefore, the recommendations in this document for initial waste staging are adapted from FEMA guidelines for debris management, with the understanding that a radiological incident may require more space. The incident may involve different types of wastes (liquid versus solid), mixed versus hazardous or non-hazardous. If these nuances are not accounted for in the Pre-Incident WMP, there is a chance that the waste may not be handled properly causing additional delays, costs, and potentially exposures to the public or first responders.

> Regulations and permitting procedures for these activities may need to take advantage of state authorities that allow for emergency approvals. Most state regulations allow for such emergency approvals. It is important that this be planned ahead of time so that the appropriate coordination and approvals take place among all the stakeholders who will be involved in the waste management activities.

These "operational recommendations" have been developed as part of an overall "Pre-Incident Waste Management Planning Process", to facilitate identification of specific sites for waste staging that may have been not specifically defined in Pre-Incident WMPs, and to aid as those sites are prepared. Proper identification of waste staging sites is important, otherwise, waste might be subjected to multiple handling, which increases the potential impact on the health of the first responders, the public, and the environment.

Plans developed before the incident may need to be modified to meet the needs of the specific incident. In all cases, RDD waste management will involve creating nearby temporary waste staging and storage locations. For example, as part of the Liberty RadEx exercise, a comprehensive WMP was developed for RDD wastes, including options for waste staging and disposal for all waste streams. It should be noted that in the Liberty RadEx exercise, these activities did not take place during the first 72 hours after the incident. In addition, successful waste management activities required the appropriate State and local (city public works) people working on the Pre-Incident WMP who knew about the city. This again substantiates that a Pre-Incident WMP, developed by the right people ahead of time and coordinated with Federal, State and local agencies as part of the Area Contingency Plan in accordance with the National Contingency Planning process is what is needed.

Most immediate injuries from a radiological incident, such as an RDD incident, are likely to occur from the explosion of the bomb (heat, debris, and force); such attacks immediately affect individuals close to the site of the explosion and contaminate nearby areas with large amounts of radioactive particles. Health risks include the trauma associated with being caught in the explosion itself and the potential for increased risk of cancers attributable to (1) long-term exposure to increased amounts of residual radiation and (2) acute inhalation and ingestion of high concentrations of contaminated particles. Following a radiological release, re-suspension and tracking of contamination may complicate containment of the contaminated area and create additional exposure to the first responders. As a result of this and what the State and local individuals at the workshop identified as their priorities in the first 72 hours, it will be important that Pre-Incident WMPs address wastes being generated from medicals facilities and personal/mass decontamination operations as an early phase activity. An example of an RDD scenario is described in Section 7. As part of the Wide Area Recovery and Resiliency Program (WARRP), guidance was developed to reduce the time and resources required to recover a wide urban area (specifically, Denver) following a chemical, biological, or radiological incident, including meeting public health requirements and restoring critical infrastructure (CI), and key resources (KR) (both civilian and military) and high-traffic areas.

Zones of contamination are identified based on the degree of actual or potential contamination and the radiation levels in the area.[2] Defining zones in this manner can be a useful approach to planning and executing a response, including predicting casualties and medical needs, determining where to locate waste staging areas, and understanding where to expect damage to select the appropriate staging area(s) where federal assets can be optimally located. Containment and gross decontamination actions that may help to mitigate impacts of these issues (See Appendix A) include, for example, (1) securing the area within identified isolation distances, (2) setting up a single egress and ingress route, and (3) minimizing the amount of contaminated equipment and vehicles leaving the contamination reduction zone (CRZ) or "warm zone." This zone is also where first responders enter and exit the hot zone and where decontamination activities take place.

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[2] U.S. Department of Health and Human Services (HHS), Radiation Control Zones and Perimeters Recommended by Various Agencies for Responding to Radiological Emergencies http://www.remm.nlm.gov/zones_radincident.htm, accessed March 24, 2015.

2. SCOPE OF THE OPERATIONAL RECOMMENDATIONS

Lessons learned during natural disasters emphasize the need for pre-incident waste management planning to address the complexities of radiological incidents, otherwise one risks handling waste several times, increasing the cost and risk of exposure to workers and the public, or treatment/ storage/ disposal facilities may not be available when needed. These operational recommendations focus on early phase waste staging activities (staging refers to temporarily storing waste so that separation, pre-treatment, packaging, and other waste management activities can be performed at a designated location away from the primary response activities) in the context of the complex system of activities occurring during the response. Prior to the response, it is anticipated that some degree of pre-incident waste management planning and preparation has been conducted. The definition of the "early phase" of a response may vary based on the incident, but for this document generally includes the first 72 hours.

> Early Phase (generally within the first 72 hours) is defined as the beginning of a radiological incident when immediate decisions for effective use of protective actions are required and must therefore be based primarily on the status of the radiological incident and the prognosis for worsening conditions. When available, predictions of radiological conditions in the environment based on the condition of the source or actual environmental measurements may be used. Protective actions based on the Protective Action Guides (PAGs) may be preceded by precautionary actions during the period.

Beyond the initial life-saving operations immediately following a radiological incident, responding to such an incident may involve containment, gross decontamination and mitigation, and waste management. Waste is generated after the initial contaminating incident and as soon as the first responders enter the area of contamination ("hot zone").[3] Most activities related to casualty management, medical care, personnel decontamination, containment of contaminants, and gross mitigation will generate waste, which is why pre-incident waste management planning and preparation is important (discussed in Section 3.1). From an overall response strategy, it will be of utmost importance to prevent waste management issues from interfering with the path to recovery. In standard project management parlance, it is important to remove waste management from the critical path to recovery.

[3] Zones are identified based on the degree of actual or potential contamination and the radiation levels in the area: http://www.remm.nlm.gov/zones_radincident.htm, accessed March 24, 2015.

2.1 Intended Audience

The intended audience ("user") of the application could potentially include first responders (fire, police), EOC director/personnel, IC/UC, federal response personnel, public health officials, nuclear power plant emergency planners, etc. The user audience is intended to be broad because many decision makers have specific roles during a radiological incident. For example, not all first responders are HAZMAT specialists, and not all the audience may be experienced in handling low-level radioactive waste. If the waste is handled improperly during the first 72 hours, it can end up costing more time and money and potentially increase radiation exposure of the public and first responders. The uniqueness of how these types of waste is regulated needs to be recognized. It is also important to recognize the different agencies involved in LLRW to include the NRC for NPPs and whatever existing NPP emergency response plans that exist. Urban responders may have more training and expertise than responders in rural areas. It is critical that decision-makers establish a site-specific pre-incident WMP before an incident occurs.[4]

> As part of pre-incident planning, reaching out to first responders with specialized capabilities and proper training and knowledge is important. After a radiological incident, there will be a need for identifying isolation distances, radiation exposure, and contamination levels. Specialized capabilities and proper training and knowledge all play a part in "pre-incident" waste management planning and early phase waste staging.

2.2 Response Management and Agency Roles and Responsibilities

In the United States, all levels of government – federal, state, territorial, tribal, and local – respond to disasters. Federal agencies provide critical assistance to state, tribal, territorial, and local response organizations in the event of a disaster that overwhelms state and local capabilities. The National Response Framework (NRF) (DHS, 2013) provides guidance for response functions immediately following a disaster. For radiological incidents, the policies, situations, concept of operations, and responsibilities of federal agencies as well as potential roles (but not in a proscriptive manner) of local, tribal, territorial, state governments, and private entities are described in the Nuclear/Radiological Incident Annex (NRIA) to the NRF. The NRIA applies to two categories of radiological incidents: (1) inadvertent or otherwise accidental releases (such as NPP accidents) and (2) releases related to deliberate acts (such as RDDs or INDs). These incidents may also include a potential release of radioactive material that poses an actual or perceived hazard to public health, safety, national security, and/or the environment. Given the differences of these types of radiological incidents, different early phase practices may need to be applied.

The NRIA sets out the roles of primary federal radiological response and support agencies such as the U.S. Department of Energy (DOE), the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Defense (DoD), the U.S. Department of Health and Human Services (HHS),

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[4] Resources to develop a WMP can be found here: http://www.epa.gov/osw/homeland/plan.htm#contents, accessed January 14, 2015.

EPA, DHS, and the U.S Department of Agriculture (USDA). The Federal Radiological Monitoring and Assessment Center (FRMAC) is a multi-agency response asset to assist state and local officials with monitoring, assessment, and health guidance for radiological incidents. DOE leads the FRMAC (along with representation from DHS, EPA, and DoD) for the initial early phase and intermediate-phase response for incidents involving nuclear/radiological materials, while EPA leads the FRMAC for long-term response (after the early phase) (FEMA, 2008). For large incidents, FRMAC transition is likely to occur sometime during the intermediate phase[5], and Pre-Incident WMPs need to be coordinated with local and state agencies, but also the federal agencies involved in the response (DHS, FEMA, DOE, NRC, HHS, and EPA).

Recognizing that every incident is unique (see Section 2.2.1 for one example) and that decisions will likely be made under the auspices of an incident command structure (see Figure 1 below), this document describes recommendations that could be applied to a radiological incident (i.e., NPPs, RDDs, or INDs) and highlights the advantages and disadvantages of those recommendations, without being prescriptive. Any reference to a response or recovery process described in this document does not rely on and does not affect any authority including CERCLA and the NCP. This document expresses no view as to the availability of legal authority to implement this process in any particular situation.

2.2.1 Radiological Dispersal Device (RDD) Incident Example

Procedures currently exist for developing appropriate temporary staging and storage areas for waste from natural disasters and other conventional incidents; however, these procedures do not address the many unique considerations associated with RDD or IND scenarios, especially wide-area urban release scenarios, as called out in the National Planning Scenarios.[6] Disadvantages with current procedures include very limited final disposal options, difficulty in finding adequate short term staging locations within urban environments, economic impacts that could exceed any incident that the country has ever had to respond to, public concerns of the staging of waste, and the importance of the interrelation of decisions made about decontamination, sampling, and waste management. In addition, because of the type of contamination, one has to consider that consolidating the waste may increase its activity, thereby causing additional exposure. This makes it much more difficult. You cannot just apply typical waste processing procedures without considering the potential exposure being caused by consolidating the waste. It may require shielding from waste handlers, haulers, first responders, and/or the public.

For an RDD incident, the roles and responsibilities of local, tribal, territorial, state, and federal governments and private entities are set out in the NRIA. Response to an RDD will be managed using the incident command system (ICS) based on the National Incident Management System (NIMS) (DHS, 2008a). ICS is a standardized, on-scene, all-hazards incident management approach allowing its users to adopt an integrated yet flexible organizational incident command

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[5] Five criteria have been developed to determine when the transfer is appropriate (see http://www.nv.doe.gov/library/publications/frmac/FRMAC%20Division/FRMAC-EPA%20Post%20Emergency/FRMAC_Transfer.pdf), Accessed March 1, 2016.

[6] Specific information about National Planning Scenarios associated with a RDD or IND can be found at: https://www.llis.dhs.gov/sites/default/files/NPS-LLIS.pdf, accessed January 14, 2015.

structure (Figure 1) to match the complexities and demands of single or multiple incidents, including multi-agency and multi-jurisdictional responses. ICS allows facilities, equipment, personnel, procedures, and communications to be integrated and operated within a common organizational structure. ICS coordinates response among various jurisdictions and public and private entities and establishes a common process for planning and managing resources. ICS includes both Command Staff and General Staff. General Staff is broken into four sections: (1) Operations, (2) Planning, (3) Logistics, and (4) Finance/ Administration. An IC/UC is typically used for the command function of multi-jurisdiction ICS response; an IC/UC consists of the appropriate local, state, and federal incident commanders representing the principal jurisdictions and lead agencies. IC/UC has proven to be a highly effective means of managing multi-agency and multi-jurisdictional responses. A strong coordinated IC/UC will be instrumental in overcoming the challenges of radiological waste management. Figure 1 shows an example of the ICS/IC/UC structure following an RDD incident.

Because waste management is a major RDD response challenge, the ICS will have Operations and Planning Sections that are assigned waste management-related responsibilities that occur from the early phase through the intermediate and later phases of the response[7]. Although the primary intent of this document is to be useful as Pre-Incident WMPs are developed (before the incident) and the waste staging operations are identified and located (during the early phase of the incident), much of the waste staging activities described herein would be done during the intermediate- and late-phase of the response. The ICS organizational structure may include, for example, a Disposal Division or Group in the Waste Management Branch of the Operations Section and a Waste Management Group in the Environmental Unit of the Planning Section. The Operations Section Waste Management Branch is responsible for collecting, staging, characterizing, documenting, shipping, and/or treating all wastes generated or collected on-site during field activities, including radiological wastes, solid wastes, liquid wastes, and other hazardous materials generated by such activities. Waste management can also include on-site disposal and design and fabrication of temporary or permanent storage/disposal facilities. The Planning Section Waste Management Group is responsible for conducting waste planning, identifying waste treatment and disposal options, obtaining appropriate waste disposal approvals, working with policy/regulatory authorities, etc.

In responding to an RDD incident, the Environmental Unit should include or consult with local and state waste regulators, federal waste regulators (including the EPA Office of Resource Conservation and Recovery [ORCR] and NRC waste personnel), state and local officials, and private disposal facilities in waste planning. Cleanup and waste planning discussions should also include state water regulators, local wastewater and drinking water treatment facility operators, and the public. These initial discussions may have a profound effect on waste staging, screening, segregation, treatment, transportation, and disposal that will occur as the the staging sites are identified and response progresses to the intermediate and late phases.

[7] It is advisable to have an integrated waste management group made up of representatives from EPA, NRC, DoD, DOE, state/local water and solid/hazardous waste management authorities, and appropriate State Radiation Control Officers.

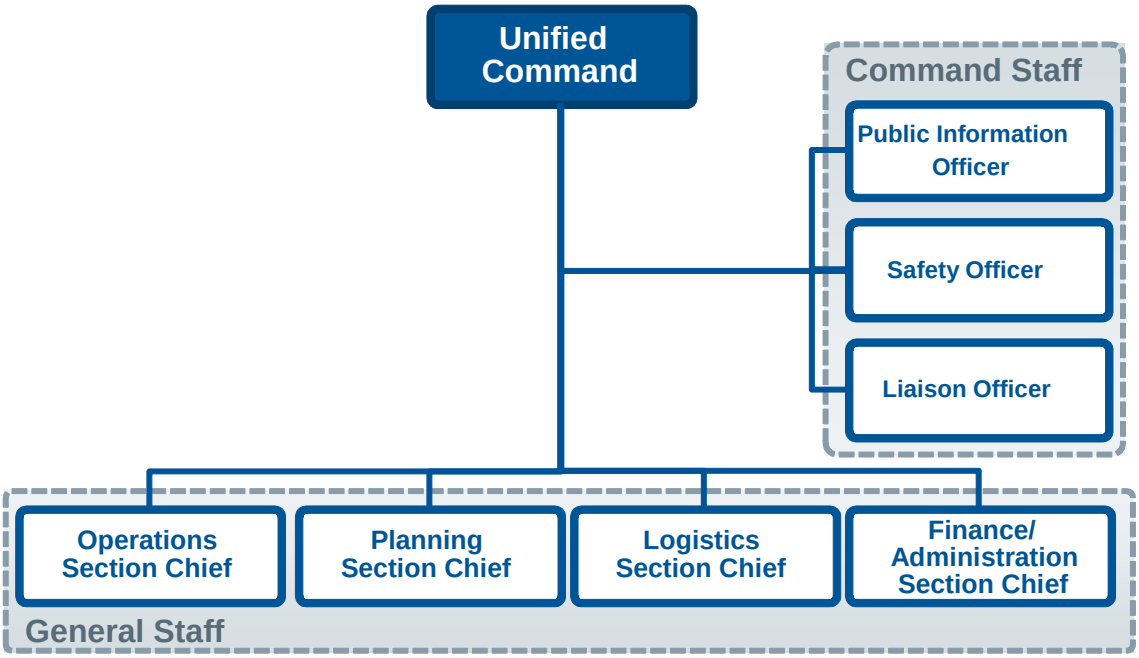

Figure 1. Example of Incident Command Structure for RDD Incident.

3. PLANNING ASSUMPTIONS

These operational recommendations are based on several planning assumptions related to the appropriate identification of waste staging areas that are large enough to allow for temporary storage of waste, on-site treatment, packaging, and segregation during the early phases (i.e., within the first 72 hours) of the response. Note that it is unlikely that significant quantities of waste would require transportation during the first 72 hours of an incident. It is important to understand the basic nature of a radiological incident and the factors that guide response and recovery following the incident. Recognizing that planning is unlikely to capture all the contingencies that may arise during an incident, this document will not be regulatory guidance, but rather will present options and relevant technical information, along with advantages and disadvantages that could be applied by first responders and decision-makers based on incident- and site-specific considerations.

It is important to recognize that the recommendations in this document are likely to be part of a framework of an overall integrated containment/decontamination strategy and WMP for the response and recovery. Strategies and plans will depend on factors such as the exact nature of the contaminant and the size of the contaminated area, the statutory and regulatory framework governing the response, the timeline within which the response is operating, the resources available to implement the response, cleanup goals, and decisions on final disposal locations. Regardless, waste management decisions must protect public health and the

environment.[8] These and other factors affecting the response involve important policy considerations, which are beyond the scope of this document to address.

Waste handling and staging decisions must protect public health and the environment, and the community potentially receiving the waste should be provided with an opportunity to provide meaningful input on receiving radioactive waste. As part of the Liberty RadEx exercise, a committee of Philadelphia citizens was able to reach consensus on their own cleanup prioritization and local staging/storage (DOE, 2012a), but these discussions occurred much later than the early phases of the response for the purposes of Liberty RadEx. In fact, these discussions were one of the primary motivations for performing the work described in this document, highlighting the need to not only include waste staging as a critical piece of Pre-Incident Waste Management Planning, but observing that pre-identification of specific waste staging sites may be controversial to include in the Pre-Incident WMP; however, identification of criteria that could be used to select the waste staging sites was not as controversial

3.1 Pre-Incident Waste Management Planning

> The concept of pre-incident waste planning and preparation is important and supports early phase waste staging. Waiting until the incident to have a WMP is too late.

Nearly every incident involving contamination will generate waste. The amount of waste generated will vary, but for many of these incidents, the amount of waste generated may be greater than the amount of waste many communities typically handle in a year. In addition, homeland security incidents may generate waste streams (e.g., chemically, biologically, and radiologically-contaminated wastes) that are not typically handled by the local communities or waste management facilities. For the purposes of these recommendations, finding treatment and disposal facilities to accept radiologically contaminated wastes may be challenging. Therefore, pre-incident planning is very important. Communities should develop a WMP detailing how they will manage the potential radiologically-contaminated wastes before an incident occurs. The key elements for a Pre-Incident WMP follow.

I. Plan Overview
   a. Scope
   b. Planning assumptions
   c. List of officials who should be notified in the case of an incident
   d. Regulatory requirements
   e. Record of plan reviews and updates
II. Materials and Waste Streams
   a. List of anticipated waste streams
   b. Description of each waste stream

[8] See Statement of Michael Shapiro, then Principal Deputy Assistant Administrator, Office of Solid Waste and Emergency Response (OSWER), before the U.S. Senate Committee on Environment and Public Works (July 25, 2000). Also see related letter from Robert Perciasepe, then-EPA Assistant Administrator of the Office of Air and Radiation, and Timothy Fields, Jr., then-Assistant Administrator of the Office of Solid Waste and Emergency Response, to The Honorable Clint Stennett, Minority Leader, Idaho State Senate, June 26, 2000.

III. Waste Quantities
    a. Forecast quantity of each type of anticipated waste
    b. Method for estimating actual waste quantities during/after incident
IV. Waste Characterization Sampling and Analysis
    a. Sampling
    b. Analysis
    c. Quality assurance
V. Waste Management Strategies/Options
    a. General principles
        i. Minimization (actions to minimize waste generation, toxicity, physical size)
        ii. Collection (procedures; health and safety requirements)
        iii. Segregation (procedures)
        iv. Decontamination (people, equipment, waste/materials; health and safety requirements)
        v. Accumulation/Storage (site location selection criteria; documentation; health and safety requirements)
    b. Pre-selected waste management sites
        i. Waste staging and storage (temporary and permanent) locations
        ii. Equipment staging and storage (temporary and permanent) locations
        iii. Decontamination stations
VI. Waste Management Facilities
    a. Anticipated types of waste management facilities needed
    b. Specific facilities identified
VII. Transportation
    a. Logistical options
    b. Routes (including maps)
    c. Hauler information
VIII. Waste and Material Tracking and Reporting System
    a. General principles
    b. Databases or other tracking software to be used
    c. Waste tracking report templates
IX. Community Communications/Outreach Plan
    a. Contact information for key stakeholder groups
    b. Pre-scripted information for waste management activities involving the public
    c. Information for a response website
X. Health and Safety for Waste Management Activities
XI. Resource Summary
    a. Resource needs
    b. Resource sources
        i. Mutual Assistance Agreements (MAA)
        ii. Pre-negotiated contracts
    c. Specialized Technical Assistance Contacts
    d. Contracting
        i. Emergency procurement procedures

e. Contract oversight plan
f. Cost Accounting/Financial Management
g. FEMA Cost Reimbursement Forms and Guidance

XII. Oversight Activities and Exit Strategy

A health and safety (H&S) plan is a critical component to waste staging. The objective of the H&S plan is to assure that all work conducted is performed as safely as possible. The H&S plan is site specific and involves conducting a hazard assessment to identify and evaluate all potential risks.

3.2 Scalable and Adaptable Strategies

A radiological incident has unique dimensions and characteristics requiring that response plans and strategies be flexible enough to address emerging needs and requirements effectively. For example, a radiological incident may include other hazards such as chemical or biological contaminants, or physical hazards like fire or unstable structures, which may require concurrent implementation of other local, state, and federal plans and procedures.

In response to a large-scale RDD incident, resources such as equipment and personnel are expected to be assigned to various waste staging areas to join teams or to be deployed. Some limiting factors for scaling this type of deployment include the availability of resources, the number and size of staging areas, and physical constraints such as the actual size of the affected area.

3.3 Types of Resources Needed

Personnel resources will be needed during a radiological incident. Depending on where the incident occurs and how large it is these people may not be available. This further highlights the need to address these key personnel resource issues in a Pre-Incident WMP. It is likely that more responders will be needed in an urban setting because contamination will be concentrated through entrainment by the densely packed buildings. Local response capabilities and resources may be insufficient and quickly overwhelmed. It is possible that some local emergency personnel who normally respond to incidents may be among those affected and unable to perform their duties following the radiological incident. Resources should include federal, state and local subject matter experts in areas that support waste management activities (such as emergency planners/managers, public works operators, water and wastewater treatment operators, sanitation, public health information officers, local professional organizations), as well as unique resources like contractors capable of handling radiological waste issues (pre-placed contracts, mutual aid agreements, etc.) and equipment for personnel and public radiation monitoring.

4. CONCEPT OF OPERATIONS

Handling a radiological incident is unique compared to an incident involving other hazards such as chemical or biological hazards. If every incident, lifesaving activities take priority over decontamination. Radiation dose to first responders is of paramount importance but can be managed so first responders can complete critical activities (i.e., assuring public health and safety goals are compatible with the criminal investigation of a terrorist attack). Unlike chemical and biological agents, which can usually be altered or destroyed to eliminate or reduce toxicity and infectivity, radiological materials cannot be destroyed.

> A strategy that is likely in the early phase is a temporary transfer location. There is no assurance that an incident will occur in the most convenient location with regard to pre-selected staging areas.

While the focus for response and recovery after a radiological incident will be on cleanup, effective strategies for waste management in the early phase will also be required. These strategies include:

- Identification of appropriate waste staging areas that are large enough to allow for temporary storage of waste;
- On-site treatment and packaging; and
- Transportation to the final disposal.

The strategies presented will not minimize the size of the cleanup itself as that is dictated by the amount of the urban area that is contaminated, the level of radioactivity, and concerns for resuspension of contamination due to atmospheric events, human activity, or precipitation. Implementing these strategies can potentially expedite and minimize cleanup and recovery times by improving cleanup efficiency, reducing waste volume, maximizing the segregation of waste into homogeneous waste streams, and separating higher-activity materials from lower-activity materials.

4.1 Importance of Waste Staging

Identification of appropriate waste staging areas that are large enough to allow for temporary storage of waste, on-site treatment and packaging, and transportation to the final disposal destination will include a set of decisions made during (and often prior to) the early phases of the response. The total quantity, activity, and type of waste, along with which technologies are being used for containment and mitigation during the early phase, will largely determine the requirements for waste staging areas. These staging areas will be selected in the context of the rest of the response, including personnel deployment activities, transportation of response personnel and equipment into and out of the safety zones, and activities intended to repopulate evacuated areas and resume economic activities.

Identifying temporary storage sites has been identified as an obstacle when initiating waste management activities. This becomes even more complex when dealing with radiological waste management options. The lack of final disposal options (i.e., limited availability of disposal sites) makes locating early phase staging areas for waste critical, especially within an urban

environment. Planning to procure staging/temporary storage sites is best done before an incident so that arrangements such as leases and permits for the land can be accomplished quickly. Having waste staging sites available in advance gives a jurisdiction additional time to develop diversion strategies and programs to handle the waste from the incident and can help prevent repeated handling of this waste.

5. WASTE MANAGEMENT

For the purposes of this document, debris and waste are used somewhat interchangeably, but in general, debris refers to co-mingled materials that are generated due to some sort of destructive force, whereas waste refers to discarded materials in general, including co-mingled materials as well as materials that may be relatively undamaged. Waste is the broader term; debris is a subset of waste that refers to damaged materials that are not easily amenable to separation processes.

Early phase waste management is an integral part of cleanup planning and response operations during all phases of response and recovery. During the early phase, waste management activities may largely be confined to the activation of waste staging areas and staging of waste generated. Waste is expected to be generated as soon as the first responders arrive at the site; therefore, it is just a matter of “activating” the locations that have been pre-identified as part of a larger pre-incident WMP to temporarily stage waste and debris. During the early phase, waste management should consist of supporting first responders by removing debris that could cause an immediate threat to public safety (e.g., unstable structures), clearing roadways, and removing fallen limbs and curbside debris that may hinder emergency vehicle movement along access pathways and egress routes.

The selection of appropriate waste staging areas that are large enough to allow for temporary storage of waste, on-site treatment and packaging, and transportation to the final disposal will depend on total quantity, activity, and type of waste, along with which technologies are being used for containment, gross decontamination and mitigation during the early phase. Given that each situation will be unique, it should not be assumed that all waste and debris will be declared contaminated.

It will also be important to identify and determine, hopefully prior to the incident, available waste management facilities and to determine and establish waste acceptance criteria (WAC) for those facilities. If site personnel (either emergency responders or the personnel from the waste facilities) know the WAC ahead of time, field surveys could create a site model that correlates portions of the site with the WAC for the various disposal facilities and level of hazard associated with the waste (low, very low, etc.). If Low-Level Radioactive Waste (LLRW) is going to be sent to a LLRW facility outside of a state’s LLRW compact, appropriate approvals will be necessary. Having these pieces of information prior to the incident will be useful during the first 72 hours after the incident to help the decision making process to site waste staging/temporary storage facilities. Again, it will not be the first responders making these decisions, but they will be impacted by these decisions.

5.1 Waste Type

Depending on the radiological incident, differences in waste types are likely which pose an inherent challenge. For example, a wide area radiological incident could potentially result in the generation of millions of tons of solid waste and billions of gallons of aqueous waste, all lightly contaminated with radionuclides. Generally, physical damage outside the blast zone is expected to be minimal, and the amount of blast-related debris is likely to be relatively small compared to the amount of undamaged contaminated materials. It is probably not possible to systematically segregate contaminated waste during the early phase, which includes debris, from uncontaminated waste from a wide-area radiological incident.[9] However, decisions made during the early phase of the response may facilitate these segregation activities in the later phases of the response.

> The question of whether RDD or other incident waste would be considered LLRW is a legal determination that may depend on situation-specific factors. Allow flexibility in these situations compared to assigning everything as LLRW, as greater effort will be needed to remove that designation once assigned.

A radiological incident like an RDD will likely result in a small area containing high-concentration/high-activity wastes within the hot zone found immediately surrounding and immediately downwind of the blast. These higher-activity wastes may be contaminated with radionuclides at levels consistent with Class B or Class C LLRW. Any waste above Class C is generally not suitable for near surface burial. Beyond this area of higher-activity waste, it is anticipated that the remaining contaminated materials will be significantly less concentrated. Most wastes (95 to 99+%) will be contaminated at levels consistent with Class A (the lowest level) LLRW. All classes of LLRW are shown in Table 1.

Table 1. Classes of Low-Level Radioactive Waste* (LLRW)

Radionuclide	Class A	Class B	Class C
Cs-137 *	<1	≥1 and <44	≥44 and <4600
Sr-90 *	< 0.04	≥ 0.04 and <150	≥ 150 and < 7000
Alpha emitting transuranics with half-life greater than 5 years +	<10	NA	≥ 10 and < 100

* Units: curies/m³ (per NRC Waste Classification Regulations, 10 CFR 61.55)
\+ Units: nanocuries/gram (per NRC Waste Classification Regulations, 10 CFR 61.55); if the concentration exceeds the upper end value of Class C, the waste is not generally acceptable for near-surface disposal.

Given that much of the waste will be only lightly contaminated (Class A), local disposal options that can provide the necessary level of protection should be considered as a first option, in the contaminated area (considering state and local requirements). This approach may be a more efficient use of resources and expedite cleanup.

[9] The terms “contaminated” and “uncontaminated” will be defined based on the cleanup goals and the waste acceptance criteria (WAC) of the disposal facilities.

Waste generated during the early phase from an RDD (adapted from the Liberty RadEx exercise[10]) could be characterized into the following categories:

- Class A LLRW (majority of the waste material)
- Class B LLRW (higher levels from blast zone or onsite concentration efforts)
- LLRW with asbestos (i.e., old steam pipes from demolished buildings)
- LLRW with polychlorinated biphenyls (PCBs) (i.e., PCB transformer oils coating demolished building exteriors)
- LL Mixed Waste (LLMW) (RCRA Hazardous Waste [HW] and LLRW)
- Personal protective equipment (PPE) waste
- Sludge from onsite decontamination efforts
- Sludge from wastewater treatment plants (WWTPs)
- Laboratory samples (e.g., for mobile laboratory analysis)
- Contaminated clothing from off-site health facilities
- Bags of contaminated clothing outside homes and businesses
- Non-radiological solid or HW for disposal in RCRA C or D landfills
- Normal urban trash for disposal in RCRA subtitle D landfills.

Radiologically-contaminated waste will specifically consist of:

- Inorganic materials (construction and demolition waste, buildings, sidewalks, streets, motor vehicles, buses, light rail trains, contaminated soils, household furnishings, white goods, electronics, etc.)
- Organic (petroleum products/fuel, vegetative debris, food, animal carcasses[11])
- Liquids (aqueous wastes, household hazardous waste, etc.)
- Hazardous Materials (e.g., asbestos, PCBs, other toxic industrial chemicals).

5.2 Waste Quantity

Because of the potentially massive amount of waste that may be generated, WAC for municipal solid waste landfills (regulated under Subtitle D of the Resource Conservation and Recovery Act [RCRA]) may be considered because not all waste may be classified as contaminated material that needs to be shipped to a low-level waste facility.

Following a radiological incident, there will be an urgent need to put in place all of the elements of an integrated waste management system to safely gather and manage the large volumes of waste that are being generated; it is also unlikely that all needs will be addressed within the first 72 hours of a response; it may be up to weeks before all needs are put into place. Contaminated waste and debris volumes from a radiological incident could be significantly larger than the volumes of LLRW typically generated annually in the United States from decommissioning activities, DOE cleanup activities, and nuclear power production by the public and private sectors combined, further

[10]Liberty RadEx http://yosemite.epa.gov/opa/admpress.nsf/90829d899627a1d98525735900400c2b/28c5b280d311903a8525771100525103!opendocument

[11] It should be noted that human remains are not classified as waste

emphasizing the importance of staging waste based on knowledge of pre-identified waste management staging options. Quantities of waste expected to be generated from a radiological incident will likely far exceed the capacity of nearby landfills, and unless that landfill is approved by the regulator and the local community, the landfill likely cannot be used.

6. WASTE STAGING

Determining where to locate staging areas early will help reduce spread of contamination and the timeline of the recovery to come. Local and state agencies may need to be self-sufficient during the early phase (or even longer) until federal resources are available to assist. A complete understanding of the situation may not be achievable for 24 to 48 hours (or weeks) after the incident.

Based on input from the stakeholder workshop and the three-city meetings, the first responders who were in attendance indicated that since they would be focusing on life saving operations, they would not be intentionally focused on any waste management activities during the first 72 hours. This is why waste management activities should be planned out prior to the incident and documented, trained, and exercised on ahead of an incident. To date, very few national, regional or local level exercises focus on waste management activities for radiological incidents. Section 7 presents a hypothetical radiological incident scenario in the U.S. along with generated waste quantities, waste source, and structures affected. This scenario focused on a wide urban area radiological release.

The overall information within Section 6 is the type of information and considerations needed to prepare the Pre-Incident WMP document.

6.1 Waste Staging Decision Tree

The preceding sections have discussed the importance of pre-incident planning and preparation, waste management, waste types, and waste quantities. This section addresses the general steps associated with pre-establishing a temporary waste staging/storage area and the many operational and logistical aspects of selecting the appropriate site(s).

Figure 2 presents a decision tree that may assist in establishing waste staging areas. The decision tree is used to pre-establish areas based on specific scenarios and conditions. Then, after an event, the pre-selected sites can be further vetted based on actual incident data (incident data may also affect decisions that were initially made based only on planning assumptions). The decision tree offers recommendations and best practices that could be considered when determining the magnitude of the problem i.e., Step 1 – identify characteristics and quantities of waste; Step 2 – develop criteria to evaluate potential sites; and Step 3 – pre-establish temporary staging sites for waste and debris storage following a radiological incident.

> All three of these steps in the decision tree should be conducted within a pre-incident WMP. Do not rely on the decision tree after there is a confirmed need.

Before applying this decision tree, it should be assumed that the need for waste staging sites has already been determined and confirmed. Given this, the next step should focus on developing criteria to evaluate potential staging sites. Step 2 of the decision tree lists several criteria that may be considered for pre-establishing temporary storage sites. These criteria are discussed in greater detail in Section 6.2 in a format similar to the display of the Rad Decon "app" that could be used to assist with waste management decision-making in the early phases of a radiological incident.

Other potential factors affecting establishment of temporary waste staging areas are:

- Incident location and distance to a (licensed or public) disposal facility;
- Transportation modes serving the site and disposal facility (rail, truck, vessel);
- Types of waste;
- Volume of the waste;
- Status of appropriate permits and/or licenses that would allow facilities to accept the waste;
- Design of the disposal facility receiving the waste;
- Performance of the treatment or disposal facility (a history of leaking contaminants, etc.);
- Capacity (both daily and total) of treatment/disposal facility receiving the waste;
- Proximity to populations, including populations that may be disproportionately impacted by contamination;
- Length of storage time; and
- Temperature.

The first five factors generally drive transportation and disposal costs, while the remaining factors would be considered in determining whether waste would be shipped to a given facility (Beckman et al., 2011).

Radiological wastes must be managed consistently with relevant local, state, tribal, and federal regulations. At the time of this publication, commercial options for the disposal of LLRW in the United States are limited, but include EnergySolutions, U.S. Ecology, and Waste Control Specialists. In the event of a wide-area radiological incident, other disposal options, including in-state disposal options, may need to be considered and/or developed to handle the vast quantities of wastes that will not likely be resolved within the early phase of the incident. Decision-makers should be aware of provisions in their state regulations that allow for expedited regulatory approval in the event of an emergency. These strategies could be documented as part of the Pre-Incident WMP.

> The focus of the decision tree is not just for solid waste; liquid waste, secondary waste, and mixed waste are also taken into consideration.

Another challenge includes inadequate on-site storage space for water or wastewater contaminated with radionuclides, and for treatment and storage of secondary waste (e.g., sludges, loaded zeolites, filter media) produced from cleanup activities. For liquid waste, some degree of on-site treatment at the waste staging/storage area might be possible, although this treatment may produce solid wastes. If on-site treatment is selected, then the temporary

storage area of the liquids should be selected with the treatment in mind. Also, for wastewater plants receiving radiologically-impacted water, storage of the sludge (secondary waste) may need consideration.

Locations of a staging area(s) for radiological material should be carefully chosen because radiological material has the potential to cause risk to human health due to the higher levels of radiation. Considerations for the waste staging locations should extend beyond debris segregation and storage to include sufficient space for operations to screen the debris for human remains, ensuring site security, avoiding environmental and human health impacts, and any applicable waste management requirements. For example, when selecting appropriate temporary staging areas, one should consider staging location (e.g., out of flood zones), space requirements, the amount of material that has to be handled, waste volume generated, coordination among utilities, and worker exposure. Considerations should also include secondary containment, space for possible use of decontamination technologies, shielding (especially gamma ray emitting waste) capability, vehicle traffic, vehicle decontamination, utilities to support activities, signs, infrared cameras, waste record keeping, radiological monitors throughout the site, etc.

Step 1. Characteristics and Quantities of Waste (Magnitude of Problem).

Assuming pre-incident plans and agreements have been established, do existing landfills have sufficient capacity for the expected volumes of waste and can they accept it immediately?

YES

Use existing landfills

NO

- Site a temporary storage area at a landfill, vacant lot, etc., for waste segregation operations ***(focus of this document)***
- Expand disposal facilities to handle the increased demand (if possible, via renovation or enhancement to facilities)
- Haul to intermediate sites and reduce the amount of waste through segregation

Volume of Waste generated: The information gathered during the preliminary damage assessment immediately after the radiological incident should give a **rough order of magnitude** indication of the types and amounts of waste to be handled. (See Sections 5.1 and 5.2, for a discussion of waste types and quantities).

Avoid unintended consequences: The use of specific technologies could impact contamination levels of quantities of waste that have to be treated and disposed of later. An example of an unintended consequence could be accumulating plowed, contaminated snow into a staging area in a manner that creates an unintended hot spot, or washing an area in a manner that generates difficult to treat aqueous waste.

Step 2. Develop Criteria to Evaluate Potential Sites.

Consider the following in developing criteria for potential temporary waste staging sites for solid, liquid, mixed, and secondary wastes. These topics are discussed in section 6.2.

- Length of storage time
- Truck or railcar size
- Equipment needed
- Site Ownership/Site Leasing
- Location
- Waste staging site size or capacity
- Site operations
- Condition of materials
- Sites for designated materials
- Security and signage
- Ease of accessibility
- Travel conditions

Step 3. Identify Temporary Staging Sites for Radiological Waste.

List sites: Prepare a list of potential temporary staging sites based upon the type and amount of materials projected to be collected, processing techniques, and transportation constraints.

Check on available public and private sites for use as temporary staging or storage sites. Explore the possibilities of using city/county-owned land, state lands, and private property. Private property will probably be the last resort given the liability associated with this. Large open areas will be needed with capability of storage of large volumes of liquid and solid waste.

Temporary waste staging areas will likely be critical element of the overall response – waste can be first moved to these temporary locations while landfill capacity is being constructed or negotiated.

Examples of Temporary Staging Sites:

- Commercial/industrial facilities (rail yards, industrial parks, licensed rad users, nuclear power plants)
- Federal facilities (DOE and DoD facilities)
- State/local facilities (Solid Waste Management and HW Facilities)
- recycling facilities
- landfills
- transfer stations
- vacant lots or buildings
- corporation yards
- parks
- parking lots
- right-of-ways
- city/county-owned properties
- private properties
- For liquid waste, consider storage areas, tanker trucks and rail cars, ponds, or “deep tunnels”, etc.

Figure 2. Decision Tree to Pre-establish Waste Staging Areas

6.2 Criteria to Evaluate and Pre-Establish Potential Staging/Temporary Storage Sites

6.2.1 Location

Sites should be located within the outer cordoned area that is secured and preferably in a structure to prevent the spread of contamination (e.g., by wind or rain). The sites should be in the contaminated area, out of flood zones, and away from people, CI/KR, and locations targeted for early cleanup. One possible location for temporary storage is in the exclusion zone, which limits public access. [2,3,4]

Sites should:[5]

- Be sufficient in size with appropriate topography and soil type (if possible, work with national and local environmental agencies to determine this);
- Be located away from potable water wells and rivers, lakes, streams and drainage channels. If possible, work with national and local environmental agencies to determine appropriate setback distances; and
- Be located close to the affected area, but far enough away from residences, infrastructure, and businesses that could be affected by site operations during the recovery period; and Be on public lands because approval for this use is generally easier to obtain (however, private land may be more convenient and logistically necessary).

The site should be established in an area that does not impede the flow of traffic along major transportation corridors, disrupt local business operations, or cause dangerous conditions in residential neighborhoods or schools. Whenever possible, avoid locating a site near residential areas, schools, churches, hospitals, and other such sensitive areas.

The site requires good ingress/egress to accommodate heavy truck traffic. The planning staff should consider adjusting traffic signals to accommodate projected truck traffic on critical haul routes. The site selection criteria should consider access to major routes to allow for trucks to transport material to final disposition locations.

When selecting public or private sites, pre-existing conditions should be considered because the sites will have to be restored upon site closeout. Proper management of the site allows the site to be closed with manageable efforts. For site closure reasons, planning staff should refrain from aggravating an existing environmental issue during the debris management operations.

Therefore, a site should not be established in an environmentally or historically sensitive area such as wetlands, critical animal and plant habitats, sole source aquifers, freshwater well fields, historic districts, or archeological sites. Site selection criteria should also take into consideration any disproportionately high or adverse impacts on minority or low-income populations. Adverse impacts should be avoided or minimized where possible. If an environmental or historic preservation concern is found in the preliminary site search, the potential site should be ranked lower than others. However, if use of such areas is unavoidable, the State and local environmental and historic preservation requirements may be required to be followed.[9]

The topography and soil/substrate conditions should be evaluated to determine the best site layout. When planning site preparation, the designer should consider ways to make site closure and restoration easier. For example, if the local soils are very thin, the topsoil can be scraped to

bedrock and stockpiled in perimeter berms. Upon site closeout, the uncontaminated soil can be re-spread to preserve the integrity of the tillable soils.[9]

Potential site location - things to avoid:[10]

- Wetlands. If near wetlands, establish buffer and/or turbidity barriers;
- Public water supplies; well fields or surface waters;
- Threatened and endangered species;
- Critical habitat;
- Rare ecosystems;
- Historic sites;
- Archaeological sites;
- Sensitive surrounding land uses – schools, nursing homes, hospitals, residential, etc.; and
- Consider prevailing winds for dust and odors.

Potential site location - things to look for:[10]

- Good ingress/egress;
- Good transportation arteries nearby;
- Open flat topography; and
- Ability to establish a buffer zone to abate concerns over dust, noise and traffic.

Finding the right location - when selecting a proposed waste staging site, the following should be considered:[11]

- What is the proposed use for this site?
- Is it easily accessible?
- Is it removed from obstructions such as power lines and pipelines?
- Is the site considered to be a wetland area, as defined by the U.S. Army Corps of Engineers?
- Is the general site topography conducive to the activity that will be conducted there?
- Are there nearby residences and/or businesses that will be inconvenienced or adversely affected by use of this site?
- Is the size sufficient for its intended use?
- Is the soil type suitable for its intended use?
- Is the site a previously authorized location that is being reactivated for use?
- Is the site located near water bodies such as rivers, lakes or streams or does it have proximity to occupied dwellings?
- What is its proximity to the impacted area?
- Does the site have historical significance? Contact the State Historical Preservation Office, U.S. Department of Interior and National Parks Service.
- Can the site easily be cleaned up after temporary use?

Understanding the local land use provides information as to the types of debris that will be generated and offers insight as to the type of handling that would be necessary to manage the debris safely. For example, rural areas may have more vegetative debris, whereas urban residential areas may have more construction and demolition debris. Industrial areas may have special environmental concerns compared to parks/recreation areas.[12]

- Consider the impact of noise, traffic, and environment.
- Look for good ingress/egress at sites to maximize efficiency of flow of traffic.
- Consider impacts on neighboring communities of trucks hauling to sites.
- Consider geological site conditions (stable ground, groundwater levels, soil or rock relatively impervious). Is the area geologically stable?
- Relatively impervious ground conditions are preferable. Pervious soils (gravel or coarse sand) and fractured rock will allow leachate to potentially contaminate groundwater.
- Abandoned quarries, which offer large open space, should not be used due to their potential for exposing groundwater to the debris leachate.
- Consider prevailing winds that tend to carry air particulates and noise in a particular direction
- Consider visibility from the surrounding area
- Avoid environmentally sensitive areas, including the following:
  - Rare (threatened) and critical animals or plant species;
  - Well fields and surface water supplies—there is the potential for runoff from hazardous and toxic waste pollutants; and
  - Historical/archeological sites[12]

Avoid locations near susceptible populations. Location must have access to roads, bridges, power, communications and water. Consider truck routes and distance trucks must travel when selecting a location.[13]

Waste staging areas should be located in the same area as, or next to, possible decontamination areas. Siting waste management areas adjacent to decontamination areas will eliminate the need to transport the waste from its original location to a decontamination center. **Double-handling of waste (i.e., moving the waste around without some process being performed on the waste) should be reduced as much as possible.**[1]

Waste management accumulation areas should be protected from inclement weather conditions (e.g., flooding, ice, snow, heavy rains). Also, high humidity environments may cause accelerated corrosion of storage containers.[1,8]

Higher activity wastes from the blast zone and areas immediately downwind of the blast zone (high contamination zone) should be kept separate, sealed in appropriate containers, and stored in the high contamination zone.[4]

Consider setting up sites for specific materials (e.g., concrete, bricks, metal, asphalt, etc.) that do not threaten public health and safety. [5]

Ensure the site can hold rubble, natural debris such as organic waste, as well as conventional waste.[5]

Measures should be taken to minimize multiple interim waste storage sites because in the future, some, if not all, are likely to require decommissioning and remediation.[2]

If sufficient capacity is not available to store waste temporarily, local authorities must make other plans, including:[5]

- expanding existing recycling, processing and disposal facilities to handle the increased demands;
- hauling waste to intermediate sites and minimizing the amount of debris through recycling;
- identifying a temporary storage area at a landfill or vacant lot for recycling operations; and
- establishing recycling, processing mechanisms/facilities.

The best way to select a temporary storage site that incorporates environment, public health and other issues is to conduct a full Rapid Environmental Impact Assessment.[5]

The planning staff needs to consider public acceptability when selecting a potential site. Public acceptability is largely dependent upon the activities planned for the site. Around-the-clock light and noise from equipment operation, dust, and traffic are generally tolerated early in a disaster recovery operation but may have to be curtailed later. The planning staff is strongly encouraged to notify citizens early about planned site activities and possible ramifications.[9]

Example:

Denver's Temporary Debris Management Sites:[6]

- 25 locations
- typically Denver parks
- Envisioned for catastrophic debris-generating event
- Selected for "conventional debris"
- Limited space available for segregation of waste streams
- One likely site having paved surface
- Facilitate post-operations cleanup
- Separated from residential areas.

Example: Temporary near-surface storage of large volumes of radioactive waste from the Chernobyl NPP site and vicinity was located in the exclusion zone at distances of 0.5 to 15 km from the NPP site. Unlike at Chernobyl, temporary facilities should be established with proper design documentation, engineered barriers, and hydrological investigations. The temporary storage facilities at Chernobyl were constructed without these considerations. At these facilities, waste was stacked and stored in trenches 1.5 to 2.5 meters deep in sandy soil; the radioactive material was overlain by a layer of alluvial sand 0.2 to 0.5 meters thick to avoid dust spread. However, due to the lack of engineering control, retention capacity of the trenches varied. Without proper design and engineering control and consideration of hydro-geological conditions, radionuclide dispersion may threaten groundwater.[7]

References

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[3] IAEA, Manual for First Responders to a Radiological Emergency, 2006.

[4] National Response Team (NRT) Quick Reference Guide: Radiological Dispersion Device, December 2012.

[5] United Nations Office for the Coordination of Humanitarian Affairs, Environmental Emergencies Section. Disaster Waste Management Guidelines. January 2011.

[6] Wide Area Recovery and Resiliency Program (WARRP). Decon-13 Subject Matter Expert Meeting, August 14, 2012.

[7] Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty Years of Experience, Report of the UN Chernobyl Forum Expert Group "Environment," August 2005.

[8] Steinhausler, Chernobyl and Goiânia Lessons for Responding to Radiological Terrorism, 2005.

[9] FEMA 325 Debris Management Guide, July 2007.

[10] Connecticut Dept. of Energy & Environmental Protection, Storm Event Preparedness and Response Fact Sheet for Municipalities, Site Selection Guide for Temporary Debris Storage and Reduction Sites, 2011.

[11] Oregon Emergency Management, State of Oregon Debris Management Plan, Annex to the State Emergency Operations Plan, April 2011.

[12] FEMA. 2014. Debris Management Planning for State, Tribal and Local Officials. Online training course E202, offered by the Federal Emergency Management Agency, Emergency Management Institute. Accessed December 10, 2014, at http://training.fema.gov/emicourses/crsdetail.aspx?cid=E202&ctype=R.

[13] Janiec, Greg. Operational Considerations in Debris Management Planning. Presentation prepared by Sovereign Consulting, Inc.

6.2.2 Site Ownership/Site Leasing

The planning staff should consider public lands first to avoid costly land leases. Existing disposal or recycling facilities that are in close proximity to the disaster area are ideal locations for a site. Nearby landfill and recycling center capacities need to be evaluated for site feasibility. Applicant-owned sites such as parks, vacant lots, or sports fields that will not require extensive repair costs should be considered as well. State-to-State or county-to-county agreements may present possible solutions for public land use.

When use of public lands is not possible, the planning staff should develop criteria for identifying potential private property locations for the site. Private land leases need to be reviewed by the legal staff to avoid extensive damage claims upon site closeout.

The duration of the land lease agreement should be inclusive of all the time the applicant will be present at the site, beginning with the baseline environmental study and ending once the property owner takes back legal ownership.

The agreement should include a requirement to conduct a baseline environmental evaluation of the site before the site is occupied and an environmental evaluation before returning the property to the owner. Both documents may become an annex to the land lease agreement.

The land lease agreement should be for a specific time frame with the ability to extend the lease if debris removal and processing activities are not completed.[1]

Site ownership:[2]

- Use public lands to avoid costly leases.
- Use private land only if public sites are unavailable.
- Have attorneys review leases to avoid closeout claims.
  - Provide possible extensions to the lease if needed.
  - Ensure the lease covers technical issues such as closure criteria, environmental issues.

References

[1] FEMA 325 Debris Management Guide, July 2007.

[2] FEMA. 2014. Debris Management Planning for State, Tribal and Local Officials. Online training course E202, offered by the Federal Emergency Management Agency, Emergency Management Institute. Accessed December 10, 2014, at http://training.fema.gov/emicourses/crsdetail.aspx?cid=E202&ctype=R.

6.2.3 Length of Storage Time

Remove debris from the site in a timely manner.[1]

Significant liquid and solid wastes associated with CI/KR decontamination activities will be generated during the first week after an event and will likely increase as the incident progresses. Billions of tons of liquid and millions of tons of solid wastes associated with initial cleanup operations may be generated beginning in the first month after an event. It is anticipated that additional liquid and solid wastes will be generated throughout the response. These wastes may need to be temporarily stored until long-term storage locations are determined and/or permanent disposal can be accomplished.[2]

References

[1] United Nations Office for the Coordination of Humanitarian Affairs Environmental Emergencies Section. Disaster Waste Management Guidelines. January 2011.

[2] Wide Area Recovery and Resiliency Program (WARRP). Decon-13 Subject Matter Expert Meeting, August 14, 2012.

6.2.4 Truck or Railcar Size/Equipment Needed

Not any type of truck can be utilized to haul radioactive waste. There are very specific requirements of haulers of this type of waste. Refer to NRC and DoT regulations. There may not be enough trucks that are currently licensed, certified and qualified to handle this amount of waste available to haul the material. It is unlikely that a large quantity of trucks would be available during the early phase of the response.

Use land/sea boxes, roll-offs, drums, totes, bins, etc. to contain the waste, or cover waste with plastic tarps to keep wastes dry and prevent contaminant spread. Fukushima wastes were containerized, the containers placed over bentonite (to absorb cesium) and covered with a tarp.[2]

Trailer and tank capacities are type-dependent. Some examples of typical capacities include:

- A 48' open top semi-trailer can haul debris with a capacity of 50,000 pounds and 85 cubic meters.[5]
- A 53' tanker can haul liquid with a capacity of 9,000 gallons.[5]
- A 40' open top semi-trailer can haul debris with a capacity of 58,600 pounds and 67.7 cubic meters.[6]

Using a front end loader, it is possible to load eight 108-ton railcars per day with LLRWs, soils and raffinate in steady-state operational batch mode. *In an emergency situation,* it is likely that a facility could load more than eight railcars per day. Also, climate-controlled cabs for front end loaders are recommended.[4]

Waste disposal facilities often use “rollovers” where the railcar is clamped into a device that inverts the car upside down to empty contents. Not all railcars are made for such equipment and railcar lids and liners (if any) have to be removed before rollover and reattached after rollover. [4]

The following equipment is recommended for temporary storage activities:[3]

- Waste container boxes (e.g., B-25 waste box) available for transportation of debris
- Super Sacks available for debris handling
- Radioactive monitoring equipment
- Ludlum 12, 17, 19, 2241-2 meters
- Personal dosimeters
- High volume air samplers

Example (beyond early phase): An RDD incident producing 3 to 8 million tons of solid waste would fill 30,000 to 80,000 railroad hopper cars (100 ton capacity) or 94,000 to 250,000 tri-axle dump trucks (32 ton capacity). An RDD incident producing 16 million to 21 million tons of solid waste would fill 160,000 to 210,000 railroad hopper cars (100 ton capacity), 400,000 to 525,000 semi-trailers (64,000 pound net capacity), or 500,000 to 656,000 tri-axle dump trucks.[1]

Example (beyond early phase): An RDD incident producing 15 to 36 million gallons of liquid waste would fill 500 to 1200 railroad tank cars (30,000 gallon capacity) or 2,700 to 6,500 tanker trucks (5,500 gallon capacity). An RDD incident producing 1.5 to 3 billion gallons of liquid waste

would fill 50,000 to 100,000 railroad tank cars (30,000 gallon capacity) or 275,000 to 550,000 tanker trucks (5,500 gallon capacity).[1]

References

1. USEPA Office of Homeland Security, WARRP Waste Management Workshop, Denver, CO, March 15-16, 2012.
2. NRT Quick Reference Guide: Radiological Dispersion Device, December 2012.
3. WARRP. Decon-13 Subject Matter Expert Meeting, August 14, 2012.
4. Email correspondence with John Hall, USEPA ORD, National Homeland Security Research Center. October 24, 2014.
5. C.H. Robinson Trailer Equipment Guide. Available at http://www.chrobinson.com/en/us/-/media/ChRobinson/News-PDF/TruckloadEquipmentGuide.pdf. Accessed January 14, 2015.
6. Griffin & Company Logistics Container Information. Available at http://www.wlgriffin.com/reference/container_info.pdf. Accessed January 14, 2015.

6.2.5 Waste Staging Site Size/Capacity

Large equipment requires large areas for storage. When planning for small scale equipment, more but smaller sites are needed. Conveniently located sites will reduce travel time when transferring debris to processing or management facilities and result in expedited debris clean-up. Communities can also use these sites to distribute reusable or recycled products.[1]

The size of the site is dependent on the quantity of debris that is stored and processed. The site should be large enough to safely accommodate processing of various debris materials, storing heavy equipment, and maneuvering trucks and large processing equipment. **Historic disasters have shown that it takes 100 acres of land (on average) to process one million cubic yards of debris.** The U.S. Army Corps of Engineers (USACE) has found that approximately 60 percent of the area will be used for roads, buffers, burn pits, household hazardous waste (HHW) disposal areas, etc.[6]

A site requires sufficient area for the processing equipment and for the trucks to turn around in. A site also requires sufficient area to keep materials segregated to avoid contamination and to place materials that require special handling and transportation to a more appropriate recycling or disposal site.[7]

Size depends on volume of debris to be collected and planned volume reduction methods.[8]

Sites typically range between 50 and 200 acres.

The following are assumptions used by USACE when determining the minimum size required for debris storage:[8]

- Debris will be piled 10 feet (3.33 yards) high.
- One acre (4,840 square yards) of debris, 3.33 yards high, would equal 16,117 cubic yards (cy).
- However, there are other factors in the design and use of the site that significantly impact the required size:
  - Approximately 60 % of the area will be used for roads, buffers, burn pits, HHW disposal areas, etc.
  - Therefore, the number result of dividing the forecasted amount of debris by 16,117 cy must be increased by a factor of 1.66.

Sixty percent or more of the site will be designated for buffer zones and infrastructure; therefore, a large site is necessary.[9]

The following statistics are from the DOE Fernald remediation for which approximately 900,000 cubic yards of low level DoT class 7 waste was dried and shipped to off-site disposal via rail:[10] (Note: The DOE Fernald remediation was a much slower cleanup than what will need to be done for a radiological incident.)

- Railcar load out facility enclosed in 35,000 square foot building (~ 1 acre), with waste material holding bins for characterized waste, loading platforms, railcar weigh scale, overhead crane for railcar lidding/delidding operations and railcar decontamination equipment.

- Material Handling Building was 65,000 square foot (~1-1/2 acres).
- Approximately 100,000 square feet of pre-engineered building was installed. The entire processing personnel area was 6 acres to include the loading, staging, drying, off gas, laundry, change-out, locker rooms, laboratory, administrative areas, etc.
- Rail yard was 11 tracks covering approximately 7 acres - ~1300 ft by 200 ft.
- Each railcar was ~ 55 ft long, so Unit Trains were 1/2 mile on the short side (50 cars) to 2/3 mile on the nominal length (60-65 cars).

Example: Decontamination of a single facility in Loudoun County, VA (Department of State Diplomatic Pouch and Mail Facility) generated more than 300 tons of debris waste and almost 79,000 gallons of wastewater from personnel decontamination alone. A wide-area incident may include hundreds of similar buildings. It is recommended that piles of discarded debris be staged at multiple sites throughout contaminated areas.[2]

Example: The Gioânia event (a radioactive contamination accident after an old radiotherapy source was stolen from an abandoned hospital site in the city) in 1987 resulted in ~123,601 cubic feet of topsoil waste that required storage, which was 150,000 times the volume of the original source.[3]

Example: After the NPP event in Fukushima, Japan, storage capacity was sought for ~3 billion cubic feet of soil. A facility capable of storing ~280 million tons of waste is expected to be built by 2015. While the scale of the Fukushima accident likely exceeds the impacts from an RDD, several aspects are relevant: cleanup goals affect the volumes of waste generated; decontamination strategies affect waste volumes; there is likely to be public pressure to accelerate cleanup.[4]

Example: After Hurricane Katrina, Mississippi Department of Environmental Quality (MDEQ) authorized emergency debris sites as follows:[5]

- 288 Vegetative Debris Management Sites
- 16 Building Debris Disposal Sites
- 22 Mixed Debris Staging and Segregation Sites

An emphasis on the number of authorized emergency debris sites was placed on coastal counties compared to inland counties. It should be noted that an RDD incident would likely impact a much smaller geographic area than a Category 5 hurricane (Category 4 at landfall), such as Katrina.

References

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[7] State of California Integrated Waste Management Board, Integrated Waste Management Disaster Plan Guidance for local government on disaster debris management, Chapter 4: Temporary Storage (Pre-staging) Sites, January 1997.

[8] FEMA. 2014. Debris Management Planning for State, Tribal and Local Officials. Online training course E202, offered by the Federal Emergency Management Agency, Emergency Management Institute. Accessed December 10, 2014, at http://training.fema.gov/emicourses/crsdetail.aspx?cid=E202&ctype=R.

[9] Janiec, Greg. Operational Considerations in Debris Management Planning. Presentation prepared by Sovereign Consulting, Inc.

[10] Email correspondence with Dave Lojek, USDOE Fernald Operable Unit 1 Team Leader. October 2014.

6.2.6 Site Operations

Make use of standard hot-zone, warm-zone and cold-zone work practices to prevent the spread of contamination.[1] Make use of safety zones for first responders, which are Low-Radiation Zone (<10-100 mR/hr); Medium-Radiation Zone (100-1000 mR/hr); High-Radiation Zone (1000-<10,000 mR/hr); and Extreme Caution Zone (≥10,000 mR/hr). Note that this will include survey/decontamination stations for vehicles entering/leaving the staging area and transitioning from one zone to another.

Temporary waste storage sites may need long-term monitoring, depending on waste stream, even after radioactive waste has been removed for final disposal.[4]

Sites should have controls to mitigate storm water runoff, erosion, fires and dust, if possible.[6]

The condition of the temporary disposal sites should be documented in print and photos prior to use. Depending on the radioactive waste to be staged there, it is advisable to assess the soil, groundwater and/or surface water at a proposed staging area prior to receiving radioactive waste and to re-establish pre-existing conditions.[6]

Areas to be used to process radioactive vegetation debris do not typically require groundwater monitoring, but should be monitored for fires. Areas for mixed rubble or hazardous wastes may need more extensive monitoring.[6]

Operations that modify the landscape, such as substrate compaction and over-excavation of soils when loading radioactive waste for final disposal, adversely affect landscape restoration.[9]

Operational boundaries are the boundaries or areas that clearly define the difference in use areas at the waste staging site. In establishing the operational boundaries, the site design staff may consider using earthen berms, temporary barriers, or any other physical restriction to aid traffic circulation and help keep debris amassing at the site to a minimum.

Common operational uses are:[8]

- Reduction
- Tipping areas (unloading)
- Loading areas for processed debris to go to its final disposition
- Drop-off centers for the general public (this may include vegetative, recycling, or construction and demolition debris)
- HHW storage
- Monitoring tower locations at both the ingress and egress points
- Equipment, fuel, and water storage

The separation between all of the areas listed above needs to be clearly delineated and defined. As operations proceed, the lines may be moved to accommodate either growing demand for space or a reduction in preparation for closure.

Optimally, the designed traffic pattern should allow trucks to enter and exit through different access points, as long as each is monitored. Haulers are typically paid by the volume of a load. The load is evaluated when entering the site as a percentage of the full capacity of the truck. Stationing monitors at ingress and egress points ensures every truck releases the entire load

prior to leaving the site. This avoids radioactive waste left in a truck from a previous load from being counted again in a subsequent load.

The empty trucks that enter the site to remove the processed (reduced) radioactive waste should enter and exit through an access point other than that of all other traffic. This reduces the site management and debris monitor confusion regarding debris being deposited or leaving the site.[8]

Other site considerations include:

- Establish and maintain buffer zones around the perimeter of the site but inside the boundaries.[9]
- Construct containment berms as necessary to separate and contain various types of debris.
- Ensure that incoming materials are segregated based on volume reduction methods.
- Develop holding areas for ash, HHW, and fuels. Line these areas with plastic or other approved liners.
- Implement an efficient process of keeping debris moving into the site, property separated and reduced, and out of the site.
- Environmental monitoring at the Radioactive Waste Management Site should begin with the onset of the operations.[9]
- Periodically take photographs of the operation, monitoring activities, etc.[9]
- Maintain up-to-date maps and sketches.
- Document changes, tests, problems, actions taken, and monitoring visits by other agency personnel.
- Implement a cradle-to-grave waste and material tracking and reporting system. Tracking the waste from cradle to grave helps increase transparency and aids in allaying community concerns. Keep in mind security concerns regarding sensitive information.[10]

Insurance may be required prior to commitment of hazardous waste storage operations. Additionally, regulations and permitting procedures for storage activities may need to take advantage of state authorities that allow for emergency approvals. Most state regulations allow for such emergency approvals.[2]

Occupational Safety and Health Administration (OSHA) worker protection and training may be necessary for on-site workers. Operations also include pre- and post-sampling, dust control and erosion control. Solid and hazardous waste permits may be required, as well as an environmental impact assessment.[11]

Technology development will be required on a case by case basis to adapt existing treatment and handling systems to manage the radioactive waste arising from an accident. These technology developments can include, for example, systems for volume reduction, stabilization and packaging.[5]

Radioactive waste volumes from an RDD incident could be significantly larger than the volumes of LLRW typically generated annually in the United States from decommissioning activities, DOE cleanup activities, and nuclear power production by the public and private sectors combined. This radioactive waste situation emphasizes the importance of segregating waste by

radiological content and knowledge of available disposal options. Not all of the waste from an incident will need to be handled as LLRW.[3]

Incoming loads should be inspected to ensure materials are handled properly and directed properly. Estimate quantities of incoming materials based on type of haul vehicle and capacity.[6]

All recoverable materials should be separated into major categories such as concrete, bricks, stones, metals, green waste, wood debris, white goods, etc. Keep materials as free from contamination as possible to increase reuse and recycling potential.[6]

There may be shortages of trained radioactive waste management personnel (including those with appropriate PPE) to characterize, treat, and dispose of radioactive waste properly. This, however, does not lessen any agency or jurisdiction obligations to comply with federal, state, or local government environmental laws, statutes, regulations, or ordinances. Regulatory and disposal experts should be consulted when considering waiving any environmental requirements.[4]

A mechanism will be needed to verify that contractors are qualified and comply with the radioactive waste management processes.[4]

The public information staff must take advantage of every information vehicle available if power, utilities, and other infrastructure have been damaged. Many times the best carriers of information are the responders in the field. The general public recognizes its role and frequently asks questions regarding the operations. Stocking the equipment and trucks with flyers, pamphlets, and other print media allows responders to perform their duties while also satisfying the public's need for information.[9]

Start a public information program immediately to notify the public and contractors of the site, the materials accepted, and the hours of operation.[6]

Consider the following safeguards for hazardous waste bulking sites:[6]

- Covering areas with two layers of plastic sheeting, tarps, or a concrete pad.
- Fencing off area with T-posts and orange barricade fencing to prevent vandalism and illegal dumping. Cordoning off nearby streets may discourage nuisance or illegal dumping.
- Posting signage that clearly identifies the temporary storage area, its operating hours, and types of materials accepted and prohibited, and contact person.
- If possible, surrounding fenced off-area with absorbent booms and/or sandbags to absorb potential leaks and prevent spills from seeping into the ground.
- Using wooden pallets to raise collection bins off the ground to determine if there are leaks.
- Consider the following safeguards for hazardous waste bulking sites (cont):[6]
- Providing adequate space for walking/carrying items between pallets.
- Segregating containerized gases, liquids, or solids by material type (e.g. corrosive waste, reactive waste), place each material type in a separate bin or barrel, and label the bin or barrel appropriately.
- Covering collection bins or barrels with plastic liners/lids or cover the entire hazardous waste collection site with a tent to prevent water collecting in bins.
- Placing cylinders containing compressed gas upright with cap on and secured in place.

- Providing sufficient fire extinguishers for the site in case fire breaks out. If allowed by local regulations, four fire extinguishers per 1000 square meters are recommended, placed at the corners or in easily accessible locations.

References

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[3] USEPA, Technologies to Improve Efficiency of Waste Management and Cleanup After an RDD Incident, Standard Operating Guidelines, October 2013.

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[9] FEMA. 2014. Debris Management Planning for State, Tribal and Local Officials. Online training course E202, offered by the Federal Emergency Management Agency, Emergency Management Institute. Accessed December 10, 2014, at http://training.fema.gov/emicourses/crsdetail.aspx?cid=E202&ctype=R.

[10] USEPA Office of Resource Conservation and Recovery (ORCR). Pre-Incident All Hazards Waste Management Plan Guidelines: Four Step Waste Management Planning Process (Working Draft, Not Yet Published), Draft 2014.

[11] Janiec, Greg. Operational Considerations in Debris Management Planning. Presentation prepared by Sovereign Consulting, Inc.

6.2.7 Condition of Materials (Debris and Waste)

The amount of activity or level of contamination present on debris will be important in determining the best methods for managing waste and debris. Debris found downwind of the blast area will likely be contaminated with radiation radioactive material; however, other debris found upwind of the blast area will likely have little to no contamination. The radioactivity of the debris and waste should be measured, the potential for contaminating material handling equipment considered, and the commingling of contaminated and uncontaminated waste and debris avoided.[1]

An RDD may result in millions of tons of radiological contaminated solids and billions of gallons of radiologically contaminated aqueous liquids. Most radioactive wastes (95 to 99+ %) will be Class A LLRW. There will be smaller amounts of Class B or Class C LLRW solid wastes. Initial waste streams will mostly be PPE, clothing and personal items from evacuees, and decontamination water but cleanup wastes will follow shortly and need to be segregated.[2]

Except for the immediate area of the explosion (one block radius), RDD wastes should be composed of undamaged materials, highly homogenous and not co-mingled debris:[3]

- Cars and residential property (anything not fixed)
- Trees and shrubs
- Building contents
- Tanks, drums, transformers, other hazardous waste
- Roof and siding
- Building materials
- Soils
- Concrete and asphalt

Another waste management activity that may be necessary during the initial hours is hot spot removal. Hot spots are small areas with higher concentrations of radioactive contamination than surrounding areas posing a greater threat to response workers and the public. Serious consideration should be given to the location of a staging area(s) for this material because it has the potential to cause risk to human health due to the higher levels of radiation. Other than materials immediately impacted by a blast, the majority of wastes will likely be undamaged but contaminated materials, amenable to segregation. Hot zone material should be kept separate from lower-activity wastes. Segregation will minimize wastes and enable an increased amount of alternate disposal pathways to be used for the lightly contaminated materials. Radioactive waste segregation has the potential to achieve significant efficiencies in time and cost while at the same time ensuring long-term protectiveness of the waste managed.[1]

An important consideration of waste management is that some of the radioactive waste piles may contain human remains and animal carcasses, which will require special handling procedures.[1]

Volume is a key consideration in waste management, transportation, and technical waste processes (i.e., decontamination and treatment).Therefore, moisture content and homogenization become critical factors for shipment. Also, it is more difficult to ship wet materials than dry materials because the shipping conveyance must be water tight.

Consideration should be given to air or solar drying and material mixing to achieve an optimally compactable waste product for shipment.[5]

Plus or minus 5 % of optimum proctor density can be a common waste acceptance criterion.[5]

Product mixing and homogenization is also useful to optimize weight and volume in railcars. Lighter uncompacted materials often "cube out" rail cars well before their rated load capacities of 90 to 110 tons, meaning they exceed the volume of the rail car before the waste exceeds the weight capacity of the rail car.[5]

Example: Analysis of the WARRP radiological scenario predicted types and quantities of radiological waste that would be generated. The waste would likely include a variety of aqueous and solid wastes, and the vast majority would be Class A LLRW, with minimal levels of contamination.[4]

References

[1] Planning Guidance for Response to a Nuclear Detonation, Second Edition, June 2010.

[2] NRT Quick Reference Guide: Radiological Dispersion Device, December 2012.

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6.2.8 Sites for Designated Materials

Considerations for a site include:[1]

- Back-up facilities in different States or Regions
- Capabilities of facility
- Pre-negotiated contracts
- Cost
- Anticipated community concerns
- Environmental Justice concerns

Consider setting up sites that handle certain designated materials only, such as inerts -- concrete, bricks, metal, soils, etc., since they can pose less of a health and safety threat. This strategy can facilitate the collection and processing of materials.

A site will need sorting areas to stage and characterize rubble, scrap and soil. Large concrete slabs are best suited for this purpose to permit easy pickup by front-loading machines.[3]

Office/break buildings, areas for changing into protective clothing, and storage of tools, personal protective devices and radiation detectors, should be available on the site.[3]

When sites are being considered, make sure the site selection team includes a good cross section of:[4]

- Local agencies; those with major responsibilities for some of the actions involved: Department of Public Works, Solid Waste Management, Environmental Quality, for example.
- Be sure State agencies are represented, particularly Radiation Control, Solid Waste, Air Quality, Environmental Quality, and Emergency Management.
- Include local officials; mayor, member of city council, county administrator, or representative.

Site neighborhood concerns include:[4]

- Around-the-clock light and noise (24-hour operations may be required at the onset of the operation).
- Dust and Traffic. The USACE estimated that the amount of debris hauled during Hurricane Andrew would fill trucks end-to-end from the Statue of Liberty in New York to the Golden Gate Bridge in California and back to the St. Louis Arch.
- Emissions from combustion processes (e.g., volume minimization via incineration where advisable).
- Runoff from hazardous and toxic waste (consider berms and holding ponds in design).
- Avoid residential areas; schools, churches, hospitals; other sensitive areas.

Possible (longer term) waste disposal sites (at the time of this publication) to consider:[5]

- EnergySolutions
- Waste Control Specialists (Andrews County, Texas).

References

[1] USEPA Office of Homeland Security, WARRP Waste Management Workshop, Denver, CO, March 15-16, 2012.

[2] State of California Integrated Waste Management Board, Integrated Waste Management Disaster Plan Guidance for local government on disaster debris management, Chapter 4: Temporary Storage (Pre-staging) Sites, January 1997.

[3] Report on the Status of the Adaya Nuclear Site and Recommendations for Health and Risk Assessment, February 2011.

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[5] Email correspondence with John Hall, USEPA ORD, National Homeland Security Research Center. October 24, 2014.

6.2.9 Security and Signage

Sites should have limited access with only certain areas open to the public. Limit access to ensure that the site is secure. Some types of waste that present higher levels of concern should have additional storage controls and security measures.[1,2,3,4]

Fence off area to establish boundary for and technical control of area containing radioactive material. Signage should include all proper radiological postings.[1,2,3,4]

Rail yard security may be considered for unit train staging and railroad exchanges. (i.e., CSX to Burlington Northern).

References

1. IAEA Safety Guide No. WS-G-6.1, Storage of Radioactive Waste, http://www-pub.iaea.org/MTCD/publications/PDF/Pub1254_web.pdf
2. United Nations Office for the Coordination of Humanitarian Affairs Environmental Emergencies Section. Disaster Waste Management Guidelines. January 2011.
3. State of California Integrated Waste Management Board, Integrated Waste Management Disaster Plan Guidance for local government on disaster debris management, Chapter 4: Temporary Storage (Pre-staging) Sites, January 1997.
4. Email correspondence with John Hall, USEPA ORD, National Homeland Security Research Center. October 24, 2014.

6.2.10 Ease of Accessibility / Travel Conditions

During the early phase, waste management should consist of supporting first responders by removing debris that could cause an immediate threat to public safety (e.g., unstable structures), clearing roadways, and removing fallen limbs and curbside debris that may hinder emergency vehicle movement along access pathways and egress routes.[1]

Evaluate traffic logistics on and around the storage site.[2]

Conditions of entry roads and movement areas must be examined to ensure that large, heavy equipment can readily traverse the areas. Some gravel, compacted roads may need to be constructed.[3]

Make sure access roads are sufficient in number and size. Single lane unpaved access roads increase cost as a result of delays due to restrictions required to allow loaded and empty trucks to pass. In addition, poor weather conditions may make the access road impassable.[4]

Implement traffic control procedures. If there is a significant amount of debris, moving truckloads of debris through the rest of the response and recovery traffic, residents, and normal traffic can become a large logistics issue.[5]

Evaluating accessibility and terrain of various locations within a jurisdiction is critical to determining the types of debris collection program that should be undertaken. Remote areas may require storing the debris safely until accessibility is established.[5]

Zoning restrictions may be an issue, particularly for large vehicles, and highway weight restrictions may vary based on time of year.[6]

Consider all modes of transportation, including vessel and rail, as well as possible differences in restrictions for interstate highways and local roads. For certain waste streams, escorts may be required.[6]

Rail sidings in the Eastern US can be limiting for unit train lengths (number of railcars). Passenger trains have right of way and a unit train cannot be longer than the shortest siding en route to the waste disposal facility.[7]

Rail cars from East of the Mississippi River slated for Western US disposal will undergo at least one rail carrier exchange (e.g., CSX to Burlington Northern exchange in East St. Louis, IL). Security for these rail yards may need to be considered.[7]

There are web-based traffic maps that are provided by many states; they are easy to access and may contain useful information that could be used for the response.[8]

References

1 USEPA Office of Homeland Security, WARRP Waste Management Workshop, Denver, CO, March 15-16, 2012.

2 United Nations Office for the Coordination of Humanitarian Affairs Environmental Emergencies Section. Disaster Waste Management Guidelines. January 2011.

3 IAEA, Report on the Status of the Adaya Nuclear Site and Recommendations for Health and Risk Assessment, February 2011.

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[7] Email correspondence with John Hall, USEPA ORD, National Homeland Security Research Center. October 24, 2014.

[8] Indiana Department of Transportation, Traffic Wise, Accessed November 24, 2015 http://www.in.gov/indot/2420.htm.

7. ESTIMATED WASTE QUANTITIES UNDER THE WARRP RDD SCENARIO

In order for first responders to assess potential activities within the first 72 hours it may be useful to put the scenario into context in terms of what the intermediate and late stage cleanups will be dealing with. This section presents a description of hypothetical radiological release scenarios along with potential quantities and characteristics of waste the might be generated during the response.

DHS, in close coordination with EPA, DoD, DOE, HHS, and the Denver Urban Area Security Initiative (UASI), initiated the WARRP in February 2011. WARRP was designed to develop guidance to reduce the time and resources required to recover a wide urban area (specifically, Denver) following a chemical, biological, or radiological incident, including meeting public health requirements and restoring critical infrastructure (CI), and key resources (KR) (both civilian and military) and high-traffic areas. The WARRP RDD scenario described for the Denver urban area involves two RDD attacks: one at the U.S. Mint in downtown Denver, Colorado, and another at the Anschutz Medical Campus in Aurora, Colorado. The scenario assumes that tens of thousands of people are exposed at various levels and that hundreds immediately die from blast-related trauma. The primary fallout area is within tens of miles of the blast, although some of the radiological agent may be carried hundreds of miles. The downtown release scenario potentially impacts more than 20 square miles and 32,000 buildings (which include 82 million square feet of indoor space), while the Aurora release scenario impacts fewer buildings and people but contaminates a much larger area (DHS, 2012a). Both bombs were identical in explosive power and amount of radioactivity, but the difference in the plumes is due to the entrainment of contamination by the high-rise downtown Denver buildings.

This RDD scenario discussion focuses on the U.S. Mint (downtown Denver) scenario. In this scenario, higher concentrations of Cesium-137 (^{137}Cs) were deposited immediately around and downwind of the blast. Figure 3a shows the release scenario and levels of contamination at the U.S. Mint within the first 72 hours. (In the Aurora scenario, the cesium was spread out over a far larger area.) Based on this scenario, some tools that EPA has been developing to assist in wide-area remediation activities were used to estimate the quantity and residual activity of the waste generated from the hypothetical RDD incident at the U.S. Mint as described above. The Incident Waste Assessment and Tonnage Estimator (I-WASTE) tool (EPA, 2011a) was used to estimate the building contents, and the Waste Estimation Support Tool (WEST) (EPA, 2012a) was used to estimate building stock, building composition and square footages, and the makeup of the outdoor areas. WEST makes extensive use of the Federal Emergency Management Agency's (FEMA's) Hazards U.S. Multi-Hazard (Hazus-MH) loss estimation model (FEMA, 2010). Information on PPE waste generated from response operations was based on information derived from the Bio-response Operational Testing and Evaluation (BOTE) program (Lemieux et al., 2011). It must be caveated that every discipline has different procedures and different clothing used to prevent personal contamination and information generated from the BOTE program may have limited applicability to a radiological incident.

In the discussion on the following pages, the estimated contamination levels are used solely for development of the discussions on the quantity, makeup, and residual radioactivity of the waste. The estimated contamination levels should not be construed to be cleanup levels. For example, the 15-millirem-per-year dose level used to determine what is contaminated is not specified as a cleanup level by any federal program. In this scenario, there may be extensive contamination beyond the drawn plumes, and areas outside the drawn plumes may require decontamination as well.

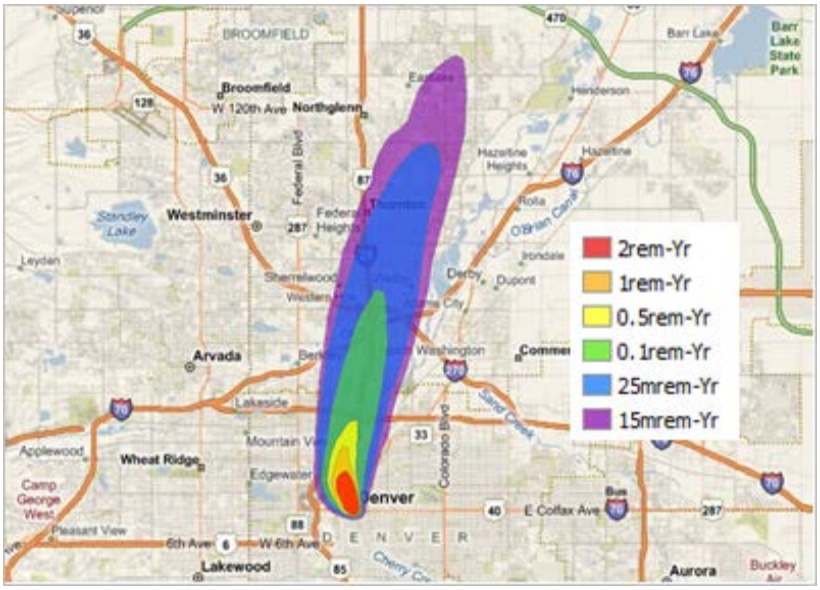

Figure 3a. WARRP RDD scenario releases at U.S. Mint.

Figure 3b shows how weather affects plume variability. Weather data from surrounding weather stations were used to analyze fallout patterns at noon on the 15th of each month in 2006. These images are not meant to portray all possible fallout patterns and do not illustrate the U.S. Mint scenario; however, they do illustrate the complexity and variability of plume patterns (Buddemeier, 2009).

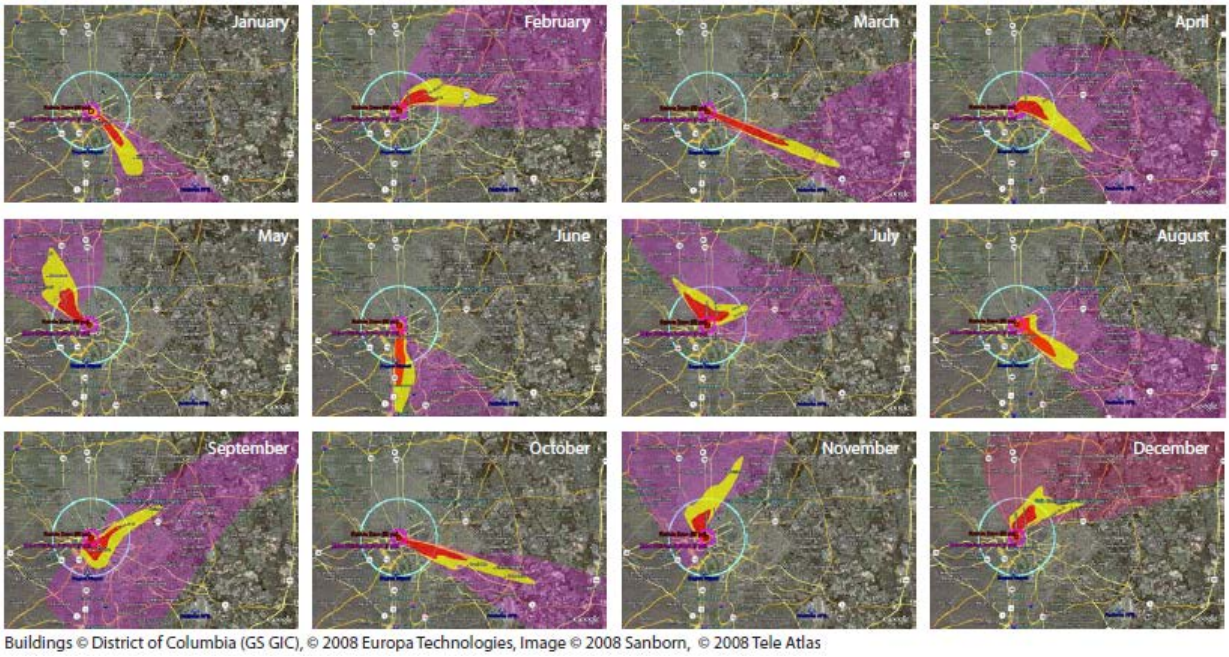

Figure 3b. Example of 12 different fallout patterns for Washington, DC.

A major wastewater treatment plant that serves approximately one million people in Denver and the surrounding area is situated within the plume impact zone shown in Figure 3a.[12] Contamination in this area may impact the ability to receive and treat wastewater. For combined systems, rain water runoff could transport the contaminant to both disperse the contaminant outside the area and to the wastewater treatment plant. For separate systems, storm drains could also disperse the contaminant outside the area impacted by the plume. If wastewater treatment is compromised, downstream water intakes for drinking water systems could be more highly contaminated than the facility is able to handle, which might necessitate implementing a temporary pre-treatment step or even shutting down the downstream water intakes and providing drinking water from another source.

Figure 4 shows the estimated number of affected structures in the primary contaminated area according to building use. The following assumptions about the affected infrastructure were used: (1) the number of schools and hospitals was determined from the Hazus-MH model output; (2) all small wood buildings and mobile homes were assumed to be residences; (3) the rest of the general building stock was assumed to be offices (99 %) and hotels (1 %); and (4) percentage breakdowns of building size were assumed to be small (50 %), medium (30 %), and large (20 %) (FEMA, 2010).

Based on these assumptions, two different hypothetical remediation scenarios were developed, using WEST to investigate the impact of different decontamination and demolition strategies on the total amount and characteristics of the waste. Both scenarios assume that all affected areas at 15 millirem or higher were remediated. It is possible that areas contaminated at levels below 15 millirem will also be remediated, but for the purposes of this hypothetical waste estimate,

[12] The wastewater treatment plant is just south of the intersection of I-76 and I-270.

they were not included. The “Extensive Decontamination” option included a significant amount of demolition and washing of outdoor areas, coupled with extensive interior decontamination. The “Limited Decontamination” option included less demolition, washing, and interior decontamination than the “Extensive Decontamination” option. Some of the following figures demonstrate the impact of these two hypothetical scenarios.

Figure 5 shows the estimated quantities and sources of waste from the affected areas. Figure 6 shows the estimated composition of the waste from the affected areas. Figure 7 shows the estimated average activity of the waste generated from the cleanup. Figures 5 through 7 also illustrate the differences between the “Extensive” and “Limited” decontamination strategies. Due to the overwhelming quantities of certain categories of waste materials potentially generated from the outlying regions of the plume, the differences between the two decontamination strategies chosen for this example may not appear to be significant for some categories of waste generated closer to the blast point. In addition, the WEST tool, in its current incarnation, assumes that whatever cleanup process is used achieves the stated cleanup goals, which may not be the case, particularly when comparing disparate cleanup approaches.

The upper end estimate (“Extensive Decontamination” option) of three billion gallons of liquid waste from demolition and decontamination operations shown in Figure 5 represents roughly 4 % of Denver’s annual water usage, suggesting that delivery of wash water in quantities necessary for the cleanup may be problematic, and that finding ways to reuse wash water and minimize its discharge as wastewater may be a critical aspect of the response. In addition, the waste estimate suggests that most solid waste was generated from only a few streams, with soil, concrete, ceiling tile, carpet, electronics, furniture, and paper constituting a significant fraction of the waste.

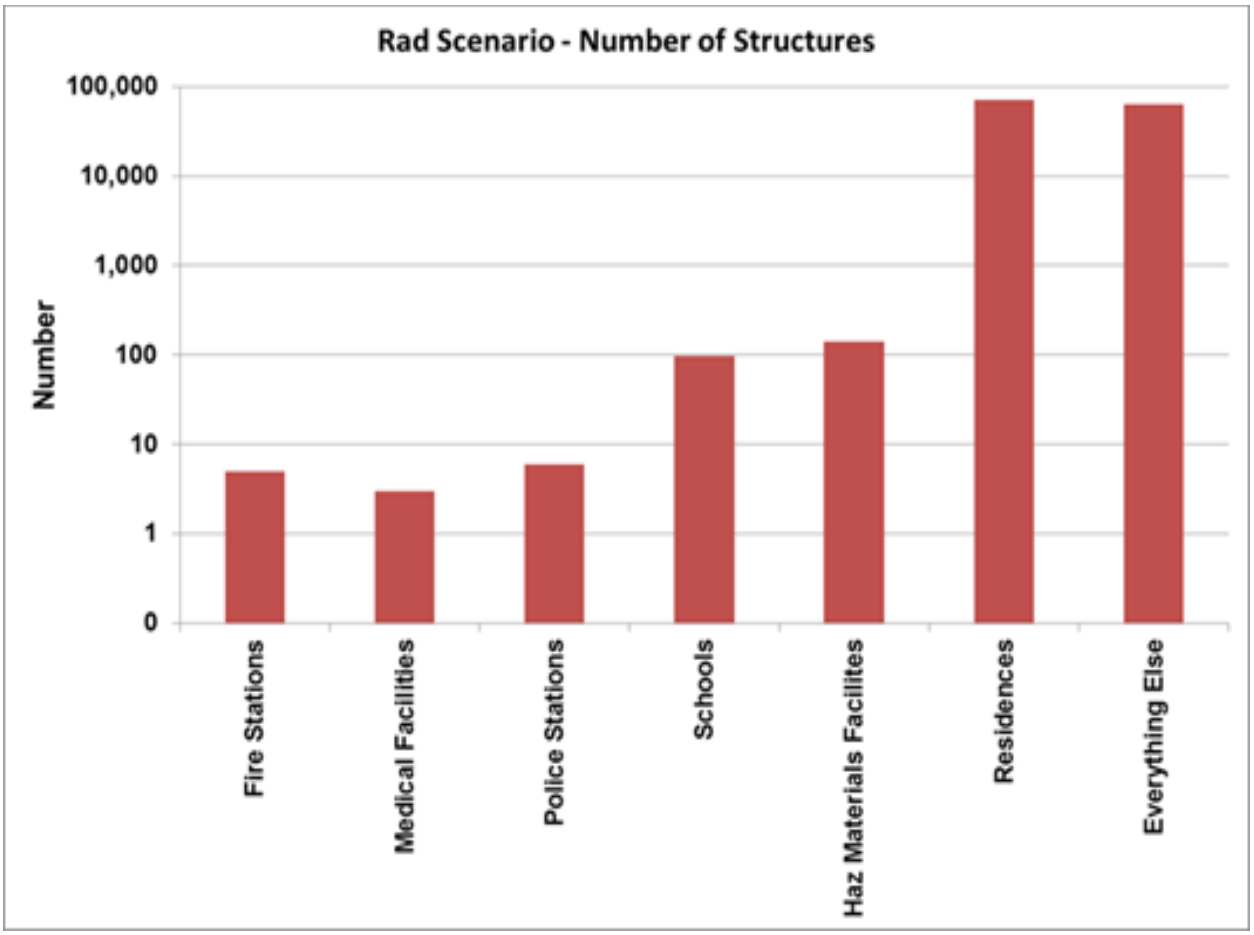

Figure 4. WARRP RDD scenario – estimated number of contaminated structures in area bounded by <15-millirem contamination zone.

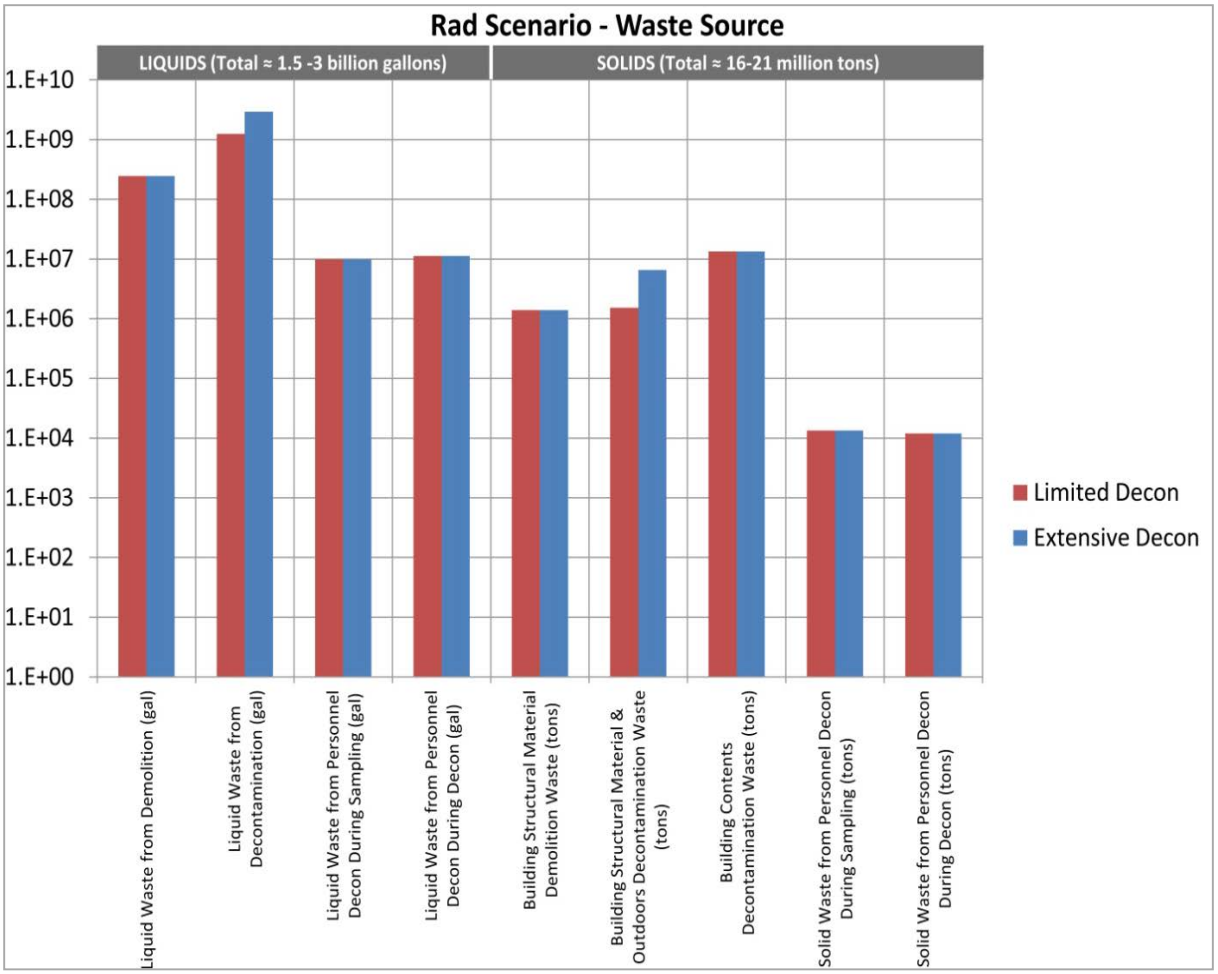

Figure 5. Estimated quantities and sources of waste from WARRP RDD scenario in area bounded by <15-millirem contamination zone.

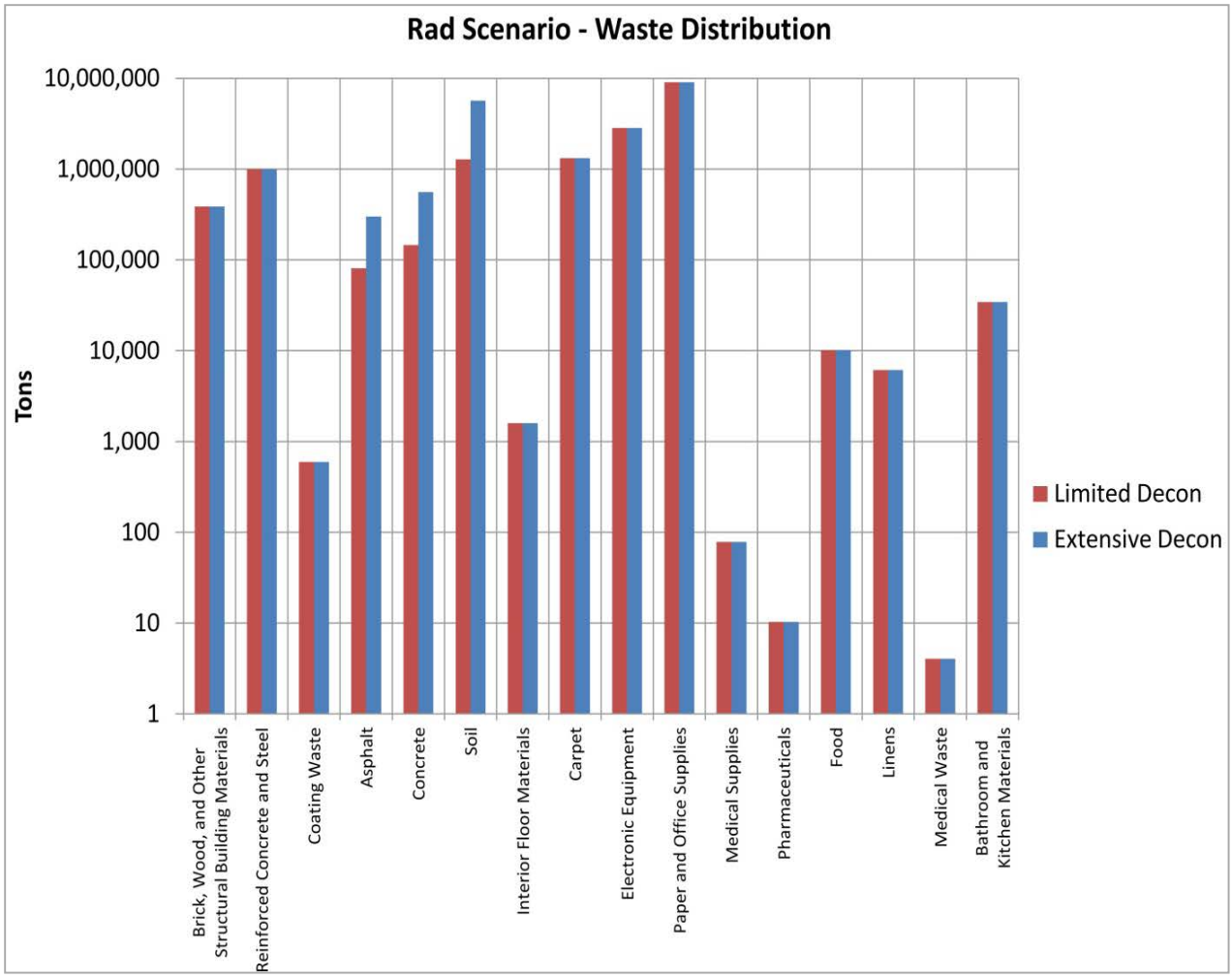

Figure 6. Estimated breakdown of solid waste from WARRP RDD scenario in area bounded by <15-millirem contamination zone.

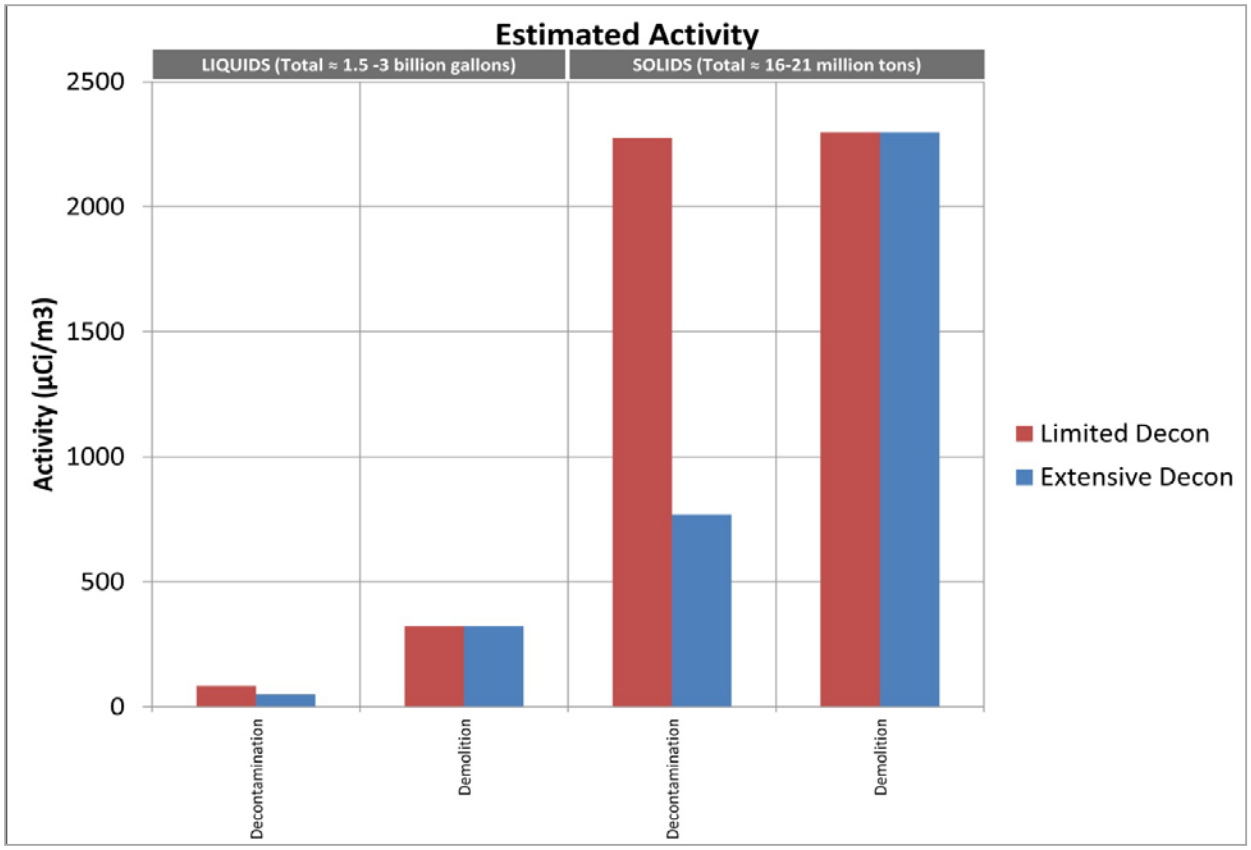

Figure 7. Average estimated activity concentration of waste from WARRP RDD scenario in area bounded by <15-millirem contamination zone.

The RDD scenario described impacts to the Denver urban area involving RDD attacks at the U.S. Mint in downtown Denver, Colorado, and another at the Anschutz Medical Campus in Aurora, Colorado. This RDD scenario was specific to the WARRP project, and has not been applied to other urban areas in the United States. WARRP planning documents generated for the Denver UASI could potentially be used as templates and adapted by other urban areas to plan for recovery from wide-area, all-hazards incidents.

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APPENDIX A: RADIOLOGICAL CONTAMINATION MITIGATION THROUGH TECHNOLOGIES FOR CONTAINMENT AND GROSS DECONTAMINATION WASTES

Based on input from the stakeholder workshop and the three-city meetings, the first responders who were in attendance indicated that they would not be intentionally focused on any waste management activities during the first 72 hours. This is why waste management activities should be planned out prior to the incident and documented, trained, and exercised on ahead of an incident. In this manner, they become an inherent part of the early phase response process, not just an afterthought.

In addition to the activities described previously, Radiological Contamination Mitigation (RCM) can be accomplished through containment and gross decontamination. Containment technologies for RCM help prevent resuspension, migration, and movement of radioactive solids from a surface, but do not remove them from the surface. Gross decontamination technologies for RCM remove radioactive contaminants from surfaces, potentially reducing radiation exposure. The selection of site-appropriate containment and gross decontamination approaches will reduce the waste management burden. To develop effective and efficient cleanup strategies, a systems approach should generally address containment, gross decontamination, and waste management simultaneously. Implementing these strategies will expedite and minimize cleanup by improving cleanup efficiency, reducing waste volume, maximizing the segregation of waste into homogeneous waste streams, and separating higher-activity materials from lower-activity materials.

Mitigation may implement the same technologies used for decontamination, but in accelerated or different manner than used in decontamination for reoccupancy. However, planning for mitigation has distinct elements as planning for decontamination, and selection of mitigation approaches may influence choices for decontamination approaches, potentially impacting the timeline and resource requirements of decontamination, both positively and negatively. In the worst case, improper mitigation approaches make decontamination of an area to return it to its former use impossible. It may also greatly complicate waste management, for instance, by inadvertently creating hot spots through ill-considered staging of waste.

Participants in the stakeholder workshops and the three city meetings were asked their preference about which containment and gross decontamination technologies to emphasize; their responses helped to focus on-going research efforts into the development and application of these technologies. At the time of writing of this SOG, this research is on-going and will be presented in the application being developed as part of the project. When available, this information will be available through the application, as well as conventional avenues.

Table A-1 lists containment technologies considered by Stakeholder Workgroups. Table A-2 lists gross decontamination technologies considered by the Stakeholder Workgroups. The technologies in Table A-2 were considered in conjunction with a number of options/approaches for containing contaminated water resulting from the use of the gross decontamination technologies (Table A-3). Finally, stakeholders were interested in a number of surfaces to which gross decontamination might be applied (Table A-4).

Table A-1. Containment Technologies considered by Stakeholder Workgroup

No.	Containment Technology
1	Water application/ fogging nozzle
2	Fire-fighting foam: Wet foam (protein, fluoroprotein, aqueous film-forming)
3	Gels/Polymers (e.g. DeconGel, ANL Supergel, NEI WES Strip)
4	Decon Foams (InstaCote Autofroth, Global Matrechs, NuCap, SNL AFC-380 and SF-200, CTRI CASCAD SDF, Dow FrothPak, Celcore GeoFill)
5	Montmorillonite, kaolinite, illite
6	Chloride Salts($CaCl_2$, $MgCl_2$ w or w/o road salt)
7	Hazmat materials SDF-200 (in addition to typical foams)
8	Dry firefighting foam (high expansion)
9	Dust Wetting Agents (e.g. propylene glycol products)
10	Rad-Specific Epoxys (e.g. InstaCote CC Epoxy SP, InstaCote M-25 [ML])
11	Rad-Specific Acrylics (e.g. InstaCote CC Strip, CC Wet and CC Fix, Bartlett Stripcoat TLC and Polymeric Barrier System, Isotron RADblock, ALARA and IsoFix)
12	Commercial Paint
13	Dust Surface Crusting Agents (e.g. acrylics)
14	Fire-extinguishers: CO_2; Purple K (potassium bicarbonate)
15	Mulch
16	Gravel
17	Dust Binding Agents (e.g. lignin, emulsions)
18	Sand
19	Cakes (e.g. AGUA A3000)
20	Lignin
21	Imported Soil (non-local, non-contaminated)
22	Straw
23	Road oil
24	Emulsified Petroleum Resins

Table A-2. Gross Decontamination Technologies considered by Stakeholder Workgroup

No.	Gross Decontamination Technology
1	Additives to water used for fire hosing, high pressure washing, or garden hosing that help remove contamination and allow on-site collection and treatment of wash water.
2	Fire hose (low pressure, high flow)
3	Additives to water used for fire hosing, high pressure washing, or garden hosing that help remove contamination but allow release of water from site to sewer system or the environment. Downstream exposure to radiation is possible unless downstream treatment is feasible.
4	Debris removal (by “hand”, by street sweepers, and other mechanical means)
5	High pressure washers (high pressure, low flow)
6	Scrubbing (prior to fire hosing, high pressure washing, or garden hosing)
7	Garden hose (low pressure, low flow)

Table A-3. Approaches to contain water generated from gross decontamination technologies listed in Table A-2

No.	Gross Decontamination Technology Containment Approaches
1	On-site waste water containment option: Berm
2	On-site wash water containment option: Vacuuming runoff
3	On-site waste water containment option: Storage ponds/tanks

Table A-4. Surfaces of interest to Stakeholders for possible application of gross decontamination technologies

No.	
1	Asphalt (roadways)
2	Brick (buildings)
3	Concrete (roadways)
4	Granite (building and floors)
5	Asphalt and composition roofing materials
6	Tarmac
7	Tar roofs
8	Exterior cement board on buildings.
9	Lawns
10	Exterior vinyl siding on buildings.
11	Dirt
12	Painted metal on vehicles
13	Glass (windows)
14	Exposed wood (pressure treated)
15	Exposed wood (other construction materials)
16	Shattered Glass
17	Slate shingle roofing
18	Stucco
19	Exterior paint on buildings
20	Railroad rails and gravel beds
21	Metal roofing material
22	Clay tile roofing
23	Soils and rocks near shoreline
24	Wood roofs
25	Muddy surfaces
26	Limestone

It should be noted that the mitigation technologies presented in Tables A-1 and A-2 overlap with technologies potentially used for decontamination as summarized in documents such as:

- US EPA, 2006, Technology Reference Guide for Radiologically Contaminated Surfaces, EPA-402-R-06-003, https://www.epa.gov/sites/production/files/2015-05/documents/402-r-06-003.pdf, Accessed March 8, 2016.
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Table A-5 replicates the UK Handbook summary of “management options” along with their purpose, which is similar to the information presented by EPA. The reader is encouraged to visit the Rad Decon “app” and supported materials for the latest information on the technologies and topics summarized in the text and tables above.

Table A-5. UK Handbook's Listing of Management Options for Decontamination Planning

No.	Purpose	Management Option
1	Protection	Control workforce access
2	Protection	Impose restrictions on transport
3	Protection	Permanent relocation from residential areas
4	Protection	Restrict public access
5	Protection	Temporary relocation from residential areas
6	Remediation	Cleaning vehicle ventilation systems and vehicle wheel washing
7	Remediation	Collection of leaves
8	Remediation	Cover grass/soils with clean soil/asphalt
9	Remediation	Demolish/dismantle and dispose
10	Remediation	Fixative/strippable coatings
11	Remediation	Grass cutting and removal
12	Remediation	Manual and mechanical digging
13	Remediation	Modify operation/cleaning of ventilation systems
14	Remediation	Natural attenuation (with monitoring)
15	Remediation	Plowing methods
16	Remediation	Pressure and fire hosing
17	Remediation	Reactive liquids
18	Remediation	Roof cleaning including guttering and downpipes
19	Remediation	Snow/ice removal
20	Remediation	Storage, covering, gentle cleaning of precious objects
21	Remediation	Surface removal (buildings)
22	Remediation	Surface removal (indoor)
23	Remediation	Surface removal and replacement (roads)
24	Remediation	Tie-down
25	Remediation	Topsoil and turf removal
26	Remediation	Treatment of walls with ammonium nitrate
27	Remediation	Treatment of waste water
28	Remediation	Tree and shrub pruning and removal
29	Remediation	Turning paving slabs
30	Remediation	Vacuum cleaning
31	Remediation	Water-based cleaning

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