A First-Order Estimate of Debris and Waste Resulting from a Hypothetical Radiological Dispersal Device Incident

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ABSTRACT

Management of waste and debris resulting from a Radiological Dispersal Device (RDD) will likely contribute a significant portion of the overall remediation effort in terms of time and remediation costs. A reasonably detailed waste/debris inventory has not been developed for any of the National Level Exercises directed at RDD response and cleanup. As the waste management issues are raised to a heightened degree of visibility from a planning standpoint, there is a critical need to scope out the magnitude and characteristics of the waste and debris so that staging, storage, treatment, and disposal pathways can be identified. Determination of waste characteristics and categorization of the generated waste as construction and demolition debris, municipal solid waste, hazardous waste, mixed waste, or low level radioactive waste, and characterization of the wastewater that is generated from the event or subsequent cleanup activities will all influence the cleanup costs and timelines. Characterization and management of wastewater that is generated during the immediate response to the event or during subsequent cleanup activities will also present challenges. Selected decontamination techniques, whether they involve chemical treatment, strippable coatings, abrasive removal, or aqueous washing, will also influence the amount and types of waste generated and associated cleanup costs and timelines. This paper describes an effort to develop a waste inventory based on the RDD scenario and plume maps utilized in the National Level Exercise “Top Officials” (TOPOFF) 4, held in 2007.

INTRODUCTION

The detonation of a Radiological Dispersal Device (RDD) into an urban area by terrorists is one of the National Planning Scenarios [1] for which the U.S. Department of Homeland Security

(DHS) has tasked various government agencies with response preparation requirements. A recent survey by the Government Accountability Office (GAO) found that almost all city and state governments would be overwhelmed by an RDD response and would request aid from the Federal government [2]. Roles and responsibilities of the various government agencies during emergency response activities are described in the National Response Framework (NRF) [3]. Under the NRF, the U.S. Environmental Protection Agency (EPA) is the lead agency for cleanup activities in the aftermath of an RDD event, including decontamination and waste disposal. Other Federal agencies, including the U.S. Department of Energy (DOE), U.S. Department of Defense (DoD) through the U.S. Army Corps of Engineers (USACE), and the U.S. Nuclear Regulatory Commission (NRC) also have major roles in an RDD cleanup [4].

As of yet there has not been an RDD event to respond to, and there have been numerous exercises performed by agencies at the federal, state, and local level to help prepare for an RDD event. However, GAO notes that in spite of there having been over 70 RDD and improvised nuclear device (IND) exercises over the last several years, only 3 have included interagency recovery discussions following the exercise [2], and none have directly included activities related to the disposal of contaminated waste and debris in the exercise activities.

An integrated RDD response will require inclusion of many competing considerations, including risk to occupants and residents from post-cleanup radiation levels, prioritization of cleanups, costs associated with cleanups, speed of cleanup, decisions to demolish/remove or decontaminate, costs due to denial of access to essential facilities, and waste/debris treatment, transportation, and disposal costs. Determination of waste characteristics and whether the generated waste is considered to be construction and demolition debris, municipal solid waste, hazardous waste, mixed waste, or low level radioactive waste (LLRW), and characterization of the wastewater that is generated from the event or subsequent cleanup activities will influence the cleanup costs and timelines. Selected decontamination techniques, whether they involve chemical treatment, strippable coatings, abrasive removal, or aqueous washing, will also influence the types and amounts of waste generated and associated cleanup costs and timelines.

In order for emergency planners to scope out the waste and debris management issues resulting from an RDD response and recovery effort, it is critical to understand not only the quantity, characteristics, and level of contamination of the waste and debris, but to understand the implications of response and cleanup approaches regarding waste generation. As the waste management issues are raised to a heightened degree of visibility from a planning standpoint, there is a critical need to scope out the magnitude and characteristics of the waste and debris so that staging/storage areas and treatment/disposal pathways can be identified. This paper describes an effort to develop a first order estimate of a waste inventory based on the RDD scenario and plume maps utilized in the National Level Exercise “Top Officials” (TOPOFF) 4, held in 2007 [5].

APPROACH

General Approach

The general approach that was used for developing a waste inventory from the TOPOFF 4 scenario is as follows:

- Using the geographic information system (GIS) shapefiles created during exercise modeling efforts by the Federal Radiological Monitoring and Assessment Center (FRMAC) supporting

the TOPOFF 4 exercise, define the geographical areas affected by the hypothetical RDD blast and subsequent radionuclide deposition;
- Using the HAZUS®-MH software developed by the Federal Emergency Management Agency (FEMA), generate an inventory of building structures and other items within the affected geographical areas;
- Using overhead satellite imagery, estimate the outdoor ground media (asphalt, concrete, vegetation/soils) surface area;
- Based on the inventory of buildings, outdoor areas, and other items, generate an estimate of the amount and characteristics of debris resulting from the initial RDD blast and waste/debris resulting from building demolition and/or ground surface and building decontamination activities; and
- Based on the above, use a database and spreadsheet to calculate variable waste/debris estimates based on demolition/decontamination decisions and selected decontamination techniques, including estimates of wastewater.

The intent of developing this approach is that a methodology would be available for planning purposes, future exercises, or actual responses that would enable initial waste disposal planning to be performed early in the event timeline, so that effective decision making can be assured. These bulleted items are elaborated upon in the following text.

Scenario Description

The TOPOFF 4 scenario is based on National Planning Scenario 11 (NPS-11) [1]. Terrorists were assumed to have attacked locations in Oregon, Arizona, and the U.S. Territory of Guam [6] using radioactive material and high explosives. The first of three coordinated attacks was assumed to occur in Guam, with the detonation of an RDD causing casualties and widespread contamination in a populous area. Within hours, similar attacks were assumed to occur in Portland and Phoenix.

The exercise then activated participants at the federal, state, territorial, local, and the private sector level to work through various aspects of the response. The full-scale exercise offers agencies and jurisdictions a way to test their plans and skills in a real-time, realistic environment, and to gain the in-depth knowledge that only experience can provide. Participants exercised prevention and intelligence-gathering functions, which are critical to preventing terrorist attacks. Lessons learned from the exercise provided valuable insights to guide future planning for securing the nation against terrorist attacks, disasters, and other emergencies.

The TOPOFF 4 exercise terminated after the initial emergency response activities were completed, where lifesaving measures were completed and the situation was stabilized. The later parts of the event, including cleanup and recovery, were outside the scope of the exercise. However, the information generated during the development and execution of the scenario provided a useful starting point to work through issues related to the recovery, in this case, the waste and debris disposal issues [7]. The effort described in this paper is based on the scenario activities surrounding the Portland, OR aspects of the hypothetical event.

FRMAC Plume Shape Files

Some of the products developed by the FRMAC during the exercise are the GIS shapefiles which describe the predicted deposition plume from the RDD as it moves downwind from the blast event. These shape files include predictions of ground-level deposition of radionuclides in terms of surface activity concentrations. The model predictions were segregated into 3 different levels of surface activity concentrations, designated high, medium, and low, reflecting the isopleths at 367, 37, and 3.7 MBq/m^2 (10,000, 1,000, and 100 µCi/m^2) predicted surface activity concentrations. These surface activity concentration levels are designated in the tables below as “Zone 1,” “Zone 2,” and “Zone 3,” respectively. In the process of doing this analysis, it was discerned that using the study areas defined by the Protective Action Guides (PAGs) (exposure levels based on health benchmarks that are used to help determine cleanup options) would be more appropriate than using study regions based on arbitrary levels of surface contamination. However, for the TOPOFF exercises, surface activity concentrations were not estimated for study regions that matched the study regions defined by the PAGs. Future uses of this methodology would use study regions based on the PAGs.

HAZUS®-MH Software

A database was created to compile aggregated building stock identified within each area of the plume using the HAZUS®-MH software, developed by FEMA. HAZUS®-MH is a nationally applicable standardized methodology that estimates potential losses from earthquakes, hurricane winds, and floods [8]. HAZUS®-MH includes databases of:

- General building stock (including building counts and building square footage by type of construction and occupancy type);
- Essential facilities (hospitals, police stations, fire stations, schools and emergency operations centers);
- High potential loss facilities (dams and nuclear power plants);
- Transportation systems (highways, railways, light rail, bus, ports, ferries and airports);
- Lifeline utility systems (potable water, wastewater, oil, natural gas, electric power, and communication systems);
- Hazardous materials;
- Agricultural products (crops);
- Trees; and
- Vehicles.

The general building stock information in the HAZUS®-MH databases is aggregated according to U.S. Census tracts and blocks and is considered default data. All of the databases are customizable and specific building information may be included if that information is known. HAZUS®-MH includes an accompanying comprehensive data management system (CDMS), which allows more detailed information to override HAZUS®-MH default data, if available. For the purposes of this effort, the default data in the HAZUS®-MH databases were used.

A listing of Census tracts that are contained in the affected area and within boundaries defined by the GIS shapefiles for the modeled plumes was generated. The databases were then queried to develop inventories of affected buildings, structures, and other items (listed above) that are contained within the identified Census tracts. For general buildings, the inventory consisted of total square footage for each building type (type of construction) and specific occupancy type (residential, commercial, government, hospital, etc.) contained within the affected areas. Inventories of essential facilities, high potential loss facilities, transportation systems, utility systems, hazardous materials facilities, and other items were specifically identified (by name) and characterized based on the information available in the respective HAZUS®-MH database. Interior and exterior building surface areas were calculated based on building square footage information and data on typical building heights and number of stories (from HAZUS®-MH).

Although this effort did not attempt to validate the data in HAZUS®-MH, there are several independent efforts among the wider community of HAZUS®-MH to benchmark the outputs of HAZUS®-MH against real events, and the results from these efforts will be incorporated into future versions of HAZUS®-MH and subsequently the methodology described in this paper.

Analysis of Blast Effects

Estimates of blast-induced effects on structures were generated based on the event epicenter and the estimated blast radius data contained in the GIS shape files developed from the TOPOFF 4 exercise. The blast epicenter and radius were geospatially located on a satellite image, and affected structures (within the modeled blast radius) were identified. Using incident overpressure estimates provided with the GIS shapefiles specific range-dependent blast effects and qualitative estimates of the resulting damage to structures were developed [9], however, waste and debris quantities resulting from the blast were not used in the resulting waste inventory because the default data from HAZUS®-MH is not specific and not of fine enough detail to generate reliable estimates for areas smaller than census tracts. It is assumed that all structural material generated within the blast zone from the blast will be disposed as waste/debris, but to make an estimate, the HAZUS®-MH default data will need to be overridden with actual building information.

Radionuclide Dispersal and Contamination

Based on the GIS shape files that contain modeled radionuclide deposition at various distances from the event epicenter, debris and waste quantities were estimated according to the estimated surface activity concentration for each deposition area. Partitioning factors (ratio of street/soil surface activity concentration to various other types of media) were used to estimate the surface activity concentrations for other types of media (e.g., building exterior and interior walls, roofs, floors) relative to the ground deposition predicted values.

HAZUS®-MH default debris factors were utilized to estimate total debris for a group of similar affected structures according to the type of construction. Spreadsheet calculations were used to estimate waste/debris quantities from these results based on user-controlled settings to demolish or decontaminate aggregated building stock. Resulting debris quantity estimates are subcategorized as “brick, wood, and other” and “reinforced concrete and steel.”

For inventory items other than buildings, such as trees, complete removal will be assumed. To the extent possible, actual volumes of expected debris for those items were estimated. Where possible, the estimated debris were then classified according to the NRC waste classification regulations 10 CFR 61.55 [10].

Except for residential structures, the HAZUS®-MH databases do not include building construction date information. Therefore, estimates of building ages (and subsequent likelihood of containing asbestos or lead paint) were made using the residential construction age data included in HAZUS®-MH. If specific data on building ages were available (such as from County records), a refined estimate could be made to include lead- and asbestos-containing waste. Although it seems that lead and asbestos would be seemingly minor considerations when compared to the overall RDD remediation effort, past events have highlighted the special considerations that these wastes require [11].

The initial waste estimation included the assumption that all material within the zone with the highest levels of contamination would be disposed as waste/debris.

Estimation of Debris from Outdoor Areas

The composition and surface area of outdoor sites was estimated by analyzing overhead satellite imagery of the affected areas. Outdoor areas were separated into the following area types:

- Asphalt;
- Concrete;
- Soils (including exposed soils, vegetation, grassy areas, parks, etc);
- Bodies of water.

As was the case for the buildings themselves, outdoor areas were assigned user-definable parameters for decontamination technologies and associated quantities of decontamination debris and decontamination wastewater were estimated.

Waste Implications of Decontamination Technologies

In the event of an RDD, several options for decontamination exist, including strippable coatings, chemical decontamination technologies, washing and cleaning, and various abrasive techniques such as scabbling [12]. Each of these techniques removes the contaminated material, producing varying amounts of waste in solid or liquid form. The decision making process for the overall remediation effort will need to take several issues into consideration, including human health risk, effectiveness of decontamination technology, cost of application of the decontamination technology, rate at which materials can be decontaminated using that technology, and the quantity of waste (and level of contamination) produced by that technology and associated disposal costs.

Based on up to four decontamination technologies that EPA identifies that are likely to be used (the tool currently has strippable coatings, abrasive removal, washing, and "no decontamination" as the available options) for various structures and inventory items, decontamination waste quantities and characteristics were estimated, using user-definable parameters in the spreadsheet. The estimates included:

- Decontamination residues (e.g., the layer of radioactive material that must be removed from structures, roads, soil, etc);
- Residues from the decontamination technologies (e.g., removed strippable coatings); and
- Wastewater and sludges from onsite decontamination efforts.

Methodology

The plume shapefiles were imported into HAZUS®-MH, and the information on the aggregated building stock within the different zones was exported into a Microsoft Access database using the CDMS, an add-on to HAZUS®-MH that allows, among other things, default data to be overridden with more detailed information, if available. The data from this database, along with the estimates of ground media (asphalt, concrete, soils) surface area fractions, were imported into an Excel spreadsheet to allow for recalculation of the waste inventory based on user-adjustable demolition and decontamination approaches.

RESULTS

Blast

Due to the hypothetical placement of the device, it is estimated that there will be complete destruction of a bridge, some structural damage to a grain elevator, and minor exterior damage to a convention center. The bulk of the physical debris from the blast will be concrete and steel from the damaged bridge and a fair amount of shattered glass in and around the vicinity of the blast. For the purposes of this estimate, further quantification of the amount of debris that would result from the blast itself has not been attempted. The amount of blast debris is assumed to be small compared to the estimated amount of waste and debris that would result from the activities of the baseline response scenario. Future efforts will include this analysis.

Deposition

The following number of buildings and the total aggregated building square footage (Table I) is estimated for each of the three deposition zones. As mentioned earlier, Zones 1, 2, and 3 represent surface activity concentrations of 367, 37, and 3.7 MBq/m^2, respectively.

Table I. Aggregated Building Counts and Building Floor Areas.

General and Specific Occupancy Type	Zone 1		Zone 2		Zone 3	
	Count	**Total m^2**	**Count**	**Total m^2**	**Count**	**Total m^2**
Residential						
Single Family Dwelling	13	1,636	280	39,789	3,250	511,276
Mobile Home	0	0	0	0	6	614
Multi Family Dwelling	17	4,505	272	80,787	889	172,031
Temporary Lodging	1	1,241	2	3,058	1	1,494
Institutional Dormitory	1	99	2	2,382	10	16,791
Nursing Home	0	0	1	107	3	3,142
Commercial						
Retail Trade	3	2,111	20	19,879	56	26,767
Wholesale Trade	2	1,568	11	8,413	28	12,551
Personal and Repair Services	3	746	18	6,806	55	16,118
Professional/Technical Services	5	11,795	36	37,119	110	39,365
Banks	1	122	3	997	4	1,189
Hospital	0	0	1	85	1	2,436
Medical Office/Clinic	3	1,215	11	4,800	30	10,765
Entertainment & Recreation	4	1,026	21	7,103	39	11,032
Theaters	1	17	1	535	1	258
Parking	0	0	0	0	0	0
Industrial						
Heavy	1	480	3	1,370	6	2,955
Light	1	339	6	2,890	19	6,307

General and Specific Occupancy Type	Zone 1		Zone 2		Zone 3	
	Count	**Total m²**	**Count**	**Total m²**	**Count**	**Total m²**
Food/Drugs/Chemicals	1	209	2	870	4	1,917
Metals/Minerals Processing	0	0	0	0	0	0
High Technology	0	0	0	0	0	0
Construction	1	194	9	1,826	47	6,819
Agriculture	1	12	2	406	9	1,265
Religion/Church/Non-Profit	2	836	26	34,071	69	81,773
Government						
General Services	2	1,112	7	5,533	4	2,233
Emergency Response	0	0	0	0	0	0
Education						
Grade Schools	1	487	4	1,850	12	5,535
Colleges/Universities	1	8	1	502	1	1,578
TOTALS	**65**	**29,758**	**739**	**261,177**	**4,654**	**936,212**

Table II presents the total area for each of the three deposition zones and the total area of each type of ground surface material located in each zone. Included also are the estimated total building exterior surface areas, total area of roofs, interior floors, and interior wall surfaces. Table III presents the estimated total and daytime resident counts, hotel population, vehicle counts, and tree counts (from HAZUS®-MH).

Table II. Estimated Contaminated Areas (m^2) of Ground Surfaces and Building Surfaces.

Media	Zone 1	Zone 2	Zone 3
Ground Surface Area (m^2)			
Total Deposition Area	92,994	721,907	4,255,153
Asphalt	25,957	245,611	748,313
Concrete	19,582	122,662	719,903
Soils	10,498	100,164	1,786,773
Water	0	1,271	3,497
Building Surface Area (m^2)			
Exterior Walls	23,056	250,937	1,189,766
Roofs	22,368	216,279	857,753
Interior Floors	29,758	261,177	936,212
Interior Walls	39,578	347,365	1,245,162

Table III. Estimated Population, Vehicle, and Tree Counts.

	Zone 1	Zone 2	Zone 3
Total Residents	105	2,197	11,307
Daytime Residents	43	646	3,213
Hotel Population	14	20	18
Cars, Light Trucks, Heavy Trucks	787	4,959	6,222
Trees	230	2,195	39,147

Assumptions for Baseline Response Effort

For the purposes of this estimate, it is assumed that 30 days have elapsed since initial deposition and that remediation efforts will begin at this time. Table IV presents the estimated remaining surface activity concentrations for each media type considered in this analysis. The remaining surface activity concentrations were estimated based on an equation for radionuclide weathering and decay and the application of average weathering correction factors [13]. Overhead satellite imagery can be used to estimate the surface area of potentially contaminated bodies of water, however data on the volume of those bodies of water is not available in HAZUS®-MH, so impact on potentially contaminated water sources was not considered in this first-order estimate.

Table IV. Estimated Remaining Surface Activity Concentrations (MBq/m^2) After 30 Days.

Media	Zone 1	Zone 2	Zone 3
Streets	348.7	34.9	3.5
Soils	367.2	36.7	3.7
Exterior Building Walls	180.9	18.1	1.8
Roofs	368.6	36.9	3.7
Interior Building Floors	34.9	3.5	0.3
Interior Building Walls	18.1	1.8	0.2

It is also assumed that various decisions concerning demolition and decontamination activities have already been made. For the purposes of this baseline analysis, we have assumed the following:

- All ground surface materials in all zones will be mechanically decontaminated (physical removal of contaminated material);
- Soil is removed to a depth of 0.304 m;
- Asphalt and concrete is removed to a depth of 0.0254 m;
- All buildings in Zone 1 (370 MBq/m^2) will be demolished;
- All buildings in Zones 2 and 3 (37 and 3.7 MBq/m^2, respectively) will be decontaminated;
- All building exteriors in Zones 2 and 3 will be decontaminated via water wash;
- All building interiors (not building contents) in Zones 2 and 3 will be decontaminated with strippable coating technology;
- Building exterior walls are composed of 30% non-porous materials;

- Building roofs are composed of 10% non-porous materials;
- Building interior walls are composed of 25% non-porous materials;
- Decontamination wash water used is estimated to be 4,000 liters per square meter of surface area [14];
- Strippable coating use is 0.5 kilograms per square meter of surface area [15];
- Fire hose dust suppression water rate is 9,000 liters per cubic meter of demolished material [16]; and
- Tree volume is 2.03 cubic meters per tree trunk. Tree mass is 297 kilograms per cubic meter [17].

Potential Debris Quantities for Baseline Assumption

Based on the estimated ground surface materials distributions, building characteristics, and the assumptions outlined in the previous section, the following amounts of waste/debris are estimated for each of the three deposition zones. Estimates are presented in both mass (metric tons) and volumetric (cubic meters) amounts. Any wastewater generated (either from dust suppression during demolition or from water wash decontamination) is estimated in total liters generated. Tables V through IX list the estimated masses and volumes of waste generated from the mitigation activities after the hypothetical RDD described in the TOPOFF 4 Portland, OR scenario.

Table V. Waste Generated from Decontamination of Ground Surfaces.

Media	Zone 1		Zone 2		Zone 3	
	MT	m^3	MT	m^3	MT	m^3
Asphalt	1,033	461	13,965	6,234	42,576	19,007
Concrete	837	349	7,481	3,117	43,885	18,286
Soils	6,389	3,195	61,010	30,505	1,086,358	543,179
Trees	139	469	1,327	4,474	23,676	79,813

Table VI. Debris and Waste Generated from Building Demolition in Zone 1.

Material	MT	m^3
Brick, Wood, and Other (structural and non-structural)	5,263	1,026
Reinforced Concrete and Steel (structural and non-structural)	12,910	2,517
Total Dust Suppression Wastewater (liters)	6,730,839	

Table VII. Waste Generated from Decontamination of Building Exteriors in Zones 2 and 3.

Media	Zone 2	Zone 3
	Liters	Liters
Total Wastewater	1,868,863,465	8,190,075,752

Table VIII. Waste Generated from Decontamination of Building Interiors in Zones 2 and 3.

Media	Zone 2		Zone 3	
	MT	m^3	MT	m^3
Strippable Coating Waste	304	1,618	1,091	5,802

Table IX. Estimated Total Waste and Debris

Media	Zone 1		Zone 2		Zone 3	
	MT	m^3	MT	m^3	MT	m^3
Ground Materials and Trees	8,398	4,474	83,783	44,330	1,196,495	660,285
Building Demolition	18,173	3,543	0	0	0	0
Building Decontamination	0	0	304	1,618	1,091	5,802
Wastewater (liters)	6,730,839		1,868,863,465		8,190,075,752	

Based on the estimated activity for all of the potential waste streams, it is estimated that all of the waste and debris generated would potentially be classified as Class A Low Level Radioactive Waste according to 10 CFR 61.55. This waste quantity, on the order of 1.3 million metric tons, is a prodigious amount of waste for a single incident. To put this into perspective, this would translate into:

- 71,500 loads of a 3-axle dump truck;
- nineteen times the 2007 generation rate of hazardous waste in the state of Oregon [18];
- roughly one-half the 2007 generation rate of municipal solid waste in the state of Oregon [19];
- roughly 1.1% of the municipal solid waste landfilled in the United States in 2008 [20];
- roughly the total receipts of LLRW at the three commercial disposal facilities for the period 2000-2008 (excluding Department of Energy waste) [21];
- 6.1% of the entire amount of LLRW expected to be generated by the Department of Energy between 2000 and 2070 [22].

CONCLUSIONS

This effort represents the first time a relatively detailed, first-order estimate of waste and debris from a hypothetical RDD has been developed. This first-order estimate illustrates the magnitude of mass and volume of radiologically contaminated materials that would require further treatment, processing, and/or disposal. The quantities are estimated by using a combination of FEMA's HAZUS®-MH loss estimation model, analysis of satellite imagery, and a reasonable application of potential decontamination and mitigation technologies.

The potential quantity of materials that would be generated from remediation efforts would be very large, and a combination of waste management approaches would be necessary in order to achieve the effective disposal of the waste and debris in a reasonable period of time. These waste management approaches would include:

- Careful consideration of waste implications when selecting decontamination options and strategies;
- Use of on-site treatment to reduce waste volumes;
- Use of RCRA-permitted disposal facilities for non-contaminated and minimally-contaminated materials; and
- Judicious use of LLRW capacity for materials contaminated at higher levels.

There are potentially other waste streams that may be generated during such an event that were not quantified in conjunction with this effort. Examples include mixed hazardous and radioactive wastes, asbestos-containing wastes, contaminated personal protective equipment, contaminated building contents such as furniture, appliances, heating, ventilation, and air conditioning (HVAC) systems, personal effects, etc. Also not included in the estimates presented here are the wastes that would result from the decontamination or disposal of vehicles, wastewater treatment, personal clothing, animals and other items, that when considered in the aggregate, would likely present significant additions to the estimated waste masses and volumes.

DISCLAIMER

The U.S. Environmental Protection Agency through its Office of Research and Development managed the research described here. 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.

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