EM Feature

Environmental Research in Response to 9/11 and Homeland Security

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INTRODUCTION

The terrorist attacks of September 11, 2001, resulted in a disaster unlike any other witnessed on U.S. soil. The collapse of the World Trade Center (WTC) twin towers in New York City, as well as the underground fires that burned for months afterward, required the efforts of numerous federal, state, local agencies, and universities to help provide a better understanding of the potential environmental and public health impacts in the aftermath of the disaster. This article describes how the U.S. Environmental Protection Agency's Office of Research and Development (EPA-ORD) responded to the WTC disaster with air quality monitoring, modeling, and risk assessments, and initiated a research program devoted to homeland security issues.

ENVIRONMENTAL CONCERNS

The attacks on the WTC affected air quality in New York City's lower Manhattan and beyond for months. The airplanes used in the attacks contained approximately 91,000 liters of jet fuel[1] that ignited intense fires that burned at temperatures of more than 1000 °C and produced enormous quantities of black smoke (much of the smoke went out to sea on 9/11 without impacting nearby communities due to strong westerly winds aloft). The immense heat of the fires weakened building structures, leading to the collapse of the twin towers, which, in turn, created a cloud of dust that engulfed lower Manhattan, exposing residents and rescue workers to a complex mixture of substances, primarily pulverized building materials such as concrete and glass, but also asbestos, which had been used as fire-proofing in one of the towers. The smoke and dust from the collapsed buildings remained in the air for hours afterward, obscuring visibility and exposing people in the area, mostly rescue workers, to airborne particulate matter (PM) derived from the pulverized materials and smoke from the fires. All told, the collapse of the WTC towers deposited an estimated one million tons of dust on lower Manhattan, both indoors and out.[2]

The six-story pile of rubble where the WTC towers once stood, dubbed "Ground Zero," became a source of irritating air contaminants. However, the potential impact on the general public was considerably less compared to the rescue workers at Ground Zero because the workers were very close to the source. First, the underground fires, which were the result of residual jet fuel from the airplanes and combustible materials from the collapsed buildings (e.g., plastics and other materials from computers, carpeting, and furniture), produced irritating and potentially toxic gases and particles. Because the fires were somewhat starved of oxygen, they did not burn efficiently. As a result, the smoldering nature of the fires with occasional flaring produced copious amounts of smoke, partially oxygenated hydrocarbons, and other products of incomplete combustion. Second, the process of removing debris from the disaster site caused additional particles to be released into the air. Each time a steel beam was cut for removal, workers were exposed to respirable-sized (<10 μm) particles of iron and steel. Since many of the beams were coated with asbestos, there was the potential for the release of asbestos fibers as the beams were cut and removed by heavy machinery. It is possible that site workers at Ground Zero could have inhaled these asbestos fibers. Third, the large number of diesel trucks, generators, and heavy machinery used around Ground Zero during the cleanup also contributed to air pollution in lower Manhattan.

EPA'S RESPONSE

EPA responded to the WTC disaster in several ways. Ambient air monitoring was conducted simultaneously by EPA-ORD's National Exposure Research Laboratory (NERL), the EPA Region 2 office in New York, other federal, state, and local agencies, and university researchers to better understand the levels of air pollutants in and around Ground Zero and Manhattan and their impacts on the local community and outlying regions. In addition, the EPA Region 2 office, in conjunction with EPA-ORD's National Center for Environmental Assessment (NCEA), compared measured levels of pollutants on an ongoing basis to the National Ambient Air Quality Standards (NAAQS), for pollutants where a standard existed, and other relevant benchmarks to assess potential impacts on human health. The NCEA incorporated data made available to EPA (data collected by EPA and others) into a comprehensive risk assessment to evaluate the potential short- and long-term impacts on the public's health from airborne contaminants.[3] EPA-ORD's

Photo courtesy of Newscom.

Dust cloud created by the collapse of the World Trade Center.

National Health and Environmental Effects Research Laboratory (NHEERL) conducted experiments to determine the respiratory effects of the dust that settled after the collapse of the WTC towers.[4] Finally, discussions between scientists at NERL and the Environmental and Occupational Health Sciences Institute (EOHSI) led to the development of a program involving computer modeling[5,6] and wind tunnel simulations[7] to better understand the spatial extent of the impacts of pollutants originating from Ground Zero and the extent of human exposure to these pollutants.

Ambient Air Monitoring

Extensive monitoring of a variety of air pollutants was conducted in Manhattan and the surrounding areas following the collapse of the WTC towers (see Table 1). The New York State Department of Environmental Conservation (NYSDEC) operated continuous $PM_{2.5}$ (PM <2.5 µm in diameter) and PM_{10} (PM <10 µm) monitors before and after 9/11, as part of its routine monitoring network. However, the nearest station was located several kilometers from Ground Zero and only measured PM concentrations and not levels of air toxics. The EPA Region 2 office in New York began monitoring for airborne asbestos shortly after 9/11, recognizing the need to better understand concentrations of this known carcinogen. Shortly thereafter, numerous federal, state, and local agencies and university researchers began measuring airborne pollutants, ranging from PM and criteria gases such as carbon monoxide and sulfur dioxide to the extremely toxic and lethal gas phosgene, which is produced by combustion of Freon. Fortunately, phosgene was not detected in the atmosphere and the large subterranean Freon tanks located at the WTC were found to be intact under the rubble. Other carcinogens and toxics were added to the list of measured pollutants mainly due to health concerns. These included dioxins and furans, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), including benzene and chlorinated hydrocarbons, heavy metals, and silica dust.

EPA-ORD was among the first to focus its air monitoring efforts on characterizing the emissions produced by the underground fires and to what extent those emissions were reaching the public. Three monitoring sites were established approximately 100 m from the rubble pile at Ground Zero and a fourth site was established approximately 500 m from Ground Zero. At these sites, EPA-ORD measured levels of pollutants that could serve as markers of combustion, including semi-volatile organic compounds (SVOCs; gas and particle phase), VOCs, and elemental carbon (EC). In addition, levels of heavy metals, including lead and chromium, as well as other elements that were markers of iron and steel and other building components, were also measured. The myriad of measured pollutants were useful in determining the types of pollutants originating from Ground Zero that were specifically related to the WTC disaster and not related to the variety of pollutants constituting the urban background of New York City. Additional information on the results of EPA-ORD's air monitoring can be found in the article on page 23 ("Air Pollution Measurements in the Vicinity of the World Trade Center").

Sampling and Analysis of Settled WTC Dust

Samples of settled dust were collected one and two days after the collapse and were separated into several size ranges: >53 µm, 10–53 µm, 2.5–10 µm, and <2.5 µm. The latter two size ranges, representing respirable-sized particles, constituted 1–4 % by mass of the total dust sample.[2] $PM_{2.5}$ can be inhaled deep into the lungs and is associated with adverse cardiovascular and respiratory health effects. Since extremely high levels of dust of various particle sizes were produced as a result of the collapse of the towers, even a relatively small proportion of $PM_{2.5}$ could have contributed to breathing problems in exposed rescue workers and others who were not wearing respiratory protection.

Extensive chemical analyses and toxicological studies were carried out on the $PM_{2.5}$ fraction of the dust from the WTC.[4,8] Settled dust samples were collected from sites within a half-mile of Ground Zero, and the $PM_{2.5}$ fraction was aerodynamically separated from the higher size ranges. Samples of the $PM_{2.5}$ fraction of the dust were characterized using scanning electron microscopy/energy dispersive X-ray analysis (SEM/EDX), X-ray diffraction (XRD), neutron activation analysis (NAA), X-ray fluorescence (XRF), and carbon fraction analysis.[8] Analysis of size-separated and bulk dust showed that the particles were enriched with calcium sulfate (gypsum) and calcium carbonate (calcite). Aqueous extracts of the $PM_{2.5}$ fraction were alkaline (pH range 8.88–10.00), but showed relatively little endotoxin content. Overall, the composition of the $PM_{2.5}$ fraction of the dust could be attributed to crushed building

Table 1. Outdoor monitoring conducted in response to the WTC disaster.

Lead Organization	Location	Parameters	Type	Start Date
EPA-ORD	Ground Zero,[a] lower Manhattan[b]	$PM_{2.5}$, PM_{10}, metals, EC/OC, VOCs, SVOCs, continuous PM and EC, meteorology	Outdoor air and settled dust	9/21/01
EPA Region 2	Ground Zero, lower Manhattan, landfill[c]	Asbestos, $PM_{2.5}$, PM_{10}, CO, dioxins, furans	Outdoor air, worker protection	9/15/01
EPA Emergency Response Team	Ground Zero, lower Manhattan, landfill	Metals, VOCs, PCBs, Freon, phosgene, H_2S, CO, SO_2, PM	Outdoor air, worker protection	9/15/01
NY State Dept. of Environmental Conservation	Ground Zero, Manhattan[d]	Asbestos, $PM_{2.5}$, PM_{10}	Outdoor air	Asbestos 10/1/01; PM prior to 9/11
NY State Dept. of Occupational Health	Lower Manhattan	VOCs, aldehydes, acids, TSP	Outdoor air	9/28/01
NY State Dept. of Labor	Ground Zero	Asbestos, metals, aldehydes, CO	Worker exposure	9/26/01
NY City Dept. of Environmental Protection	Manhattan	Asbestos	Outdoor air	9/14/01
Occupational Safety and Health Admin.	Ground Zero, Financial District[e]	VOCs, asbestos, PCBs, CO, silica	Worker exposure	9/13/01
Port Authority	Ground Zero	VOCs	Worker exposure	9/28/01
U.S. Geological Survey	Ground Zero	Metals, asbestos	Settled dust	9/16/01
U.S. Dept. of Interior	Ground Zero	Meteorology	Outdoor	10/15/01
Columbia University	Manhattan	Metals	Outdoor air, sediment cores	9/01; ongoing
Environmental and Occupational Health Sciences Institute	Ground Zero	Metals, SVOCs, dioxins, furans, asbestos	Settled dust	9/16/01–9/19/01
Johns Hopkins University	Ground Zero	PM, asbestos, metals	Outdoor air, worker exposure	10/01
New York University	Lower Manhattan	$PM_{2.5}$, metals	Outdoor air, settled dust	9/01
University of California, Davis	Manhattan	PM (various sizes), metals, PAHs, SVOCs	Outdoor air	10/3/01
University of North Carolina	Ground Zero, lower Manhattan	PAHs	Outdoor air	9/21/01

[a]Ground Zero is site of the WTC complex. Monitoring took place either on the rubble pile or in the immediate vicinity (~ 100 m). [b]Lower Manhattan is approximately south of Canal St. (see Figure 1 for street locations); [c]Landfill is the Fresh Kills Landfill located on Staten Island. [d]Manhattan is approximately north of Canal St. [e]Financial District is located in the southeast quadrant of lower Manhattan.

materials, such as cement, concrete aggregate, glass, ceiling tiles, and wallboard.

Respiratory Effects of Settled WTC Dust

EPA-ORD's NHEERL conducted toxicological studies on the dust. Thousands of residents and workers were exposed to the dust on 9/11 when the towers collapsed, and rescue workers—including firemen and construction workers—were exposed to the dust for months afterward as they worked on the rubble pile. Particulate matter derived from the dust was one of the major classes of substances that elicited the greatest health concerns for rescue workers and nearby residents.[3] There are also several ongoing laboratory, clinical, and epidemiological studies being conducted by university researchers to determine potential health effects caused by exposures from the WTC disaster (see Table 2).

The $PM_{2.5}$ samples isolated from settled dust were compared with reference $PM_{2.5}$ samples that have been well characterized with respect to chemistry and pulmonary toxicology in animal studies. These size-separated reference $PM_{2.5}$ samples included a relatively nontoxic sample of crustal origin (Mt. St. Helens dust; MSH), a relatively toxic emission source sample (residual oil fly ash; ROFA), and an ambient air sample (standard reference material [SRM] 1649a collected in Washington, DC). Samples of the $PM_{2.5}$ fraction of WTC dust induced mild to moderate degrees of lung inflammation when administered at a dose of 100 µg directly into the airways of mice, but the degree of inflammation was significantly less than that caused by the toxic reference $PM_{2.5}$ samples.[4] A dose of 100 µg in mice corresponds to an 8-hr exposure to 425 µg per cubic meter (µg/m³) of air for a person who is not equipped with respiratory protection. Although this concentration is approximately 20 times higher than normal background levels of $PM_{2.5}$, these conditions likely existed in the immediate aftermath of the collapse of the towers. The pulmonary inflammation, however, was relatively short-lived as the number of neutrophils in the lungs of the exposed mice was substantially reduced from 1 to 3 days after exposure. Lower doses (10 and 31.6 µg) of the $PM_{2.5}$ fraction of WTC dust did not cause any inflammation.

A 100-µg dose of the $PM_{2.5}$ fraction of the WTC dust caused airway hyper-responsiveness, indicating sensitivity to agents that trigger airway constriction. Airway responsiveness was

Photo courtesy of EPA.

Construction workers emerging from the debris at Ground Zero.

measured using methacholine aerosol, an airway-constricting drug that is often used to diagnose asthma. The airway hyper-responsiveness induced by the $PM_{2.5}$ fraction of the dust did not subside from 1 to 3 days after exposure, indicating the possibility of an enduring response. Lower doses (10 and 31.6 µg) of the $PM_{2.5}$ fraction of the dust did not cause airway responsiveness in mice. These results showed that a relatively high dose of the $PM_{2.5}$ fraction of the dust, above a certain threshold, could elicit short-term effects in healthy mice, and by corollary, that a comparable dose could elicit similar effects in healthy people. Firefighters present at the collapse of the WTC towers were found to have significantly increased levels of cough and airway hyper-responsivenes.[9] It is important to note that coarse PM (>2.5 µm) associated with the dust could have contributed to some of the respiratory problems reported in individuals working and living around Ground Zero, but only $PM_{2.5}$ was examined in these studies. However, university researchers are currently addressing this and other issues in subsequent studies (Table 2).

Assessing the Public's Risk from WTC Pollutants

Available air monitoring data collected in the vicinity of the WTC were evaluated by EPA-ORD's NCEA to determine the potential impacts to the public's health caused by the collapse of the towers and the pollutants emitted from Ground Zero. The risk assessment focused on monitoring results of six contaminants or classes of contaminants that were judged to pose the greatest human health concerns. The contaminants evaluated were PM, metals (e.g., lead, chromium, nickel), PCBs, dioxins, VOCs, and asbestos. While there were hundreds of other substances measured in various media (e.g., air, water, soil), these contaminants were determined to be of greatest danger to human health. In addition, air monitoring data indicated that these contaminants could be attributed to the disaster site.

The air monitoring data were evaluated for the WTC risk assessment by comparing the measured levels at locations near Ground Zero to levels typical of New York or urban areas in general and to established regulatory benchmarks for inhalation exposure. Where available, benchmarks established to protect against acute and subchronic exposures were used. Background or typical levels for New York City were not available for some pollutants. Background levels specific to New York City were used for evaluation where these data were available. Otherwise,

Table 2. Additional studies of toxicology, epidemiology, and health effects in response to the WTC disaster.

Lead Organization	Description
Columbia University	Epidemiological study to evaluate air pollutant exposures on pregnancy outcomes and child development.
Johns Hopkins University	Respiratory health assessment of workers; registry of truck drivers, heavy equipment operators, and laborers at Ground Zero.
Mount Sinai School of Medicine	Epidemiological study to evaluate the effects of the WTC disaster on pregnancy outcomes and child development; prevalence of persistent upper and lower airway disorders among exposed iron workers.
New York University and the Fire Dept. of NYC	Clinical study of NYC firefighters to assess cardio-pulmonary effects; respiratory screening of community residents affected by the WTC disaster.
National Toxicology Program	Animal toxicological studies on instillation of total WTC dust/smoke.
Environmental and Occupational Health Sciences Institute	Epidemiological studies on pregnancy and reproductive outcomes; relationship between exposure and worker/commuter stress and health outcomes.
University of Rochester	Toxicological assessments of settled dust and airborne PM from the WTC disaster to determine the susceptibility of organisms to infection; health effects of WTC dust on lung cells.

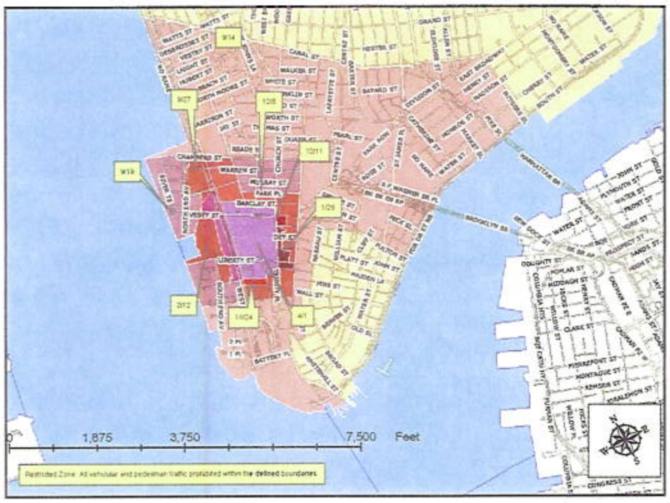

Figure 1. Map showing how the restricted zones changed over time. Shaded areas show the date when the public was allowed access to the area.

Figure 2. Model of Manhattan used in wind tunnel simulations of pollutants emitted from the site of the collapsed World Trade Center towers.

general urban or background concentrations were identified and used to put the post-9/11 monitoring results into perspective. The WTC risk assessment addresses approximately a 7-month time frame from mid-September 2001 to mid-April 2002. For most chemicals, the database provides very little data prior to September 18, 2001, and, therefore, exposures occurring on 9/11 and the week after could not be well characterized.

Elevated concentrations of several contaminants were observed within and near Ground Zero, especially close to 9/11 in time. However, many of the elevated concentrations were

Photo courtesy of EPA.

Scientists from EPA–ORD monitoring air pollution adjacent to the World Trade Center.

found to have occurred in the "restricted zones" (see Figure 1), where access was limited to only emergency management and rescue personnel and other credentialed people. The New York City Mayor's Office of Emergency Management established the restricted zones and lifted the restrictions for specific areas on the dates indicated in Figure 1 to allow access to the public. From September 11 to September 14, this restricted zone included all of lower Manhattan south of 14th St. In general, monitoring data through April 2002 indicate that ambient air levels for all of these contaminants had decreased to background concentrations that are characteristic of pre-9/11 levels in the New York City metropolitan area.

The risk assessment was retrospective in that it dealt with exposures that had already occurred. This made the assessment challenging to evaluate the extent of health impacts that may have resulted, or may still result, from past exposures to contaminants. This approach differs from the type of assessment typically conducted to support proactive establishment of environmental standards or to set emission limits on sources of air pollution. In a prospective risk assessment, risk managers can make active choices regarding the level of protection to be achieved and how the uncertainties will be weighed in the process. However, these options were not available to the scientists addressing exposures resulting from 9/11. For additional details on EPA-ORD's WTC risk assessment, see the article on page 27 ("Assessment of Inhalation Exposures and Potential Health Risks that Resulted from the Collapse of the World Trade Center").

Physical and Numerical Modeling of WTC Pollutants

Following 9/11, there was intense interest in better understanding the spatial variations and complexities (both horizontal and vertical) of pollutants in lower Manhattan that originated from Ground Zero. While it's improbable to obtain a sufficient number of real-world measurements to truly characterize how pollutants varied through Manhattan's street canyons, computer simulations complemented by measurements using a scaled physical model of the area allow for estimation of the variations. To that end, scientists from EPA-ORD's NERL and the National Oceanic Atmospheric Administration (NOAA) constructed a scale model of lower Manhattan replicating the topography of the landscape created by the numerous buildings in the area. The scale model was produced with an accurate likeness of the southern 2 km of Manhattan Island, roughly south of Canal St., as specified by a commercially available digital database (Vexcel Corp.) obtained prior to 9/11 for model development purposes through EPA-ORD's Scientific Visualization Center. The buildings were constructed of high-density polyurethane foam and more than 350 buildings were included in the physical model.

The model was placed into a wind tunnel where various wind flow regimes could be examined to determine how source emissions from the WTC rubble pile were transported and dispersed through lower Manhattan (see Figure 2). The results from the wind tunnel simulations are being used to validate computer models aimed at estimating human exposures to Ground Zero emissions. The simulations were conducted to provide information on the movement of pollutants from the underground fires and debris removal, not the collapse of the buildings themselves. For additional details about the scale model of Manhattan and the wind tunnel simulations see the article on page 31 ("Wind Tunnel Simulation of Flow and Pollutant Dispersal around the World Trade Center Site").

The collapse of the towers and the resulting smoke and dust plume can be simulated with computer modeling. This is especially valuable for estimating people's exposure during the collapse, and possibly even the week following 9/11, when little or no data exist. Scientists from EPA-ORD's NERL are currently working with researchers from the Environmental and Occupational Health Sciences Institute (EOHSI) through a university partnership agreement to couple information produced by computer models of the collapse of the WTC towers with human exposure models. A Computational Fluid Dynamics (CFD) model is being used to simulate the wind fields produced by the collapsing building and the dust and smoke plumes that were generated. The model can also simulate the behavior of particles of different size and weight to better estimate people's exposure to a variety of particle sizes and composition.

In addition, the meteorology of lower Manhattan is also being modeled to estimate plume dispersion from Ground Zero throughout the metropolitan area. These simulations are important because they provide information regarding the regional extent of the impact of Ground Zero emissions. Meteorological data collected in lower Manhattan were used as input or boundary conditions for a plume modeling system. The plume model produces results that are averaged hourly showing the spatial movement of the plume in varying degrees of dilution. Additional information on the results of EPA-ORD's WTC collapse and plume modeling can be found in the article on page 35 ("Modeling Air Pollution from the Collapse of the World Trade Center and Assessing the Potential Impact on Human Exposures").

WHERE DO WE GO FROM HERE?

Faced with the threat of further international terrorism, the possibility of environmental tragedies that impact our health and our lives now seems more real. The most likely targets are large cities where the impact and number of people affected would be greatest. And it's not just the air we breathe that could be contaminated, although this is an especially potent route of exposure and one that is not easily avoided. The water we drink and the buildings we live and work in could become targets as well. To protect the public's health and safeguard the environment, it is necessary for our nation to focus energy on the needs of the future while keeping a mindful eye on what's happened in the past so that we can learn from our experiences.

Environmental Monitoring and Modeling Workshop

Scientists from EPA-ORD hosted a two-day workshop in November 2002 to discuss issues associated with measuring, modeling, and assessing people's exposure to air pollutants generated as a result of national emergencies and disasters. Participants were invited to share their experiences from their responses to the WTC collapse and recovery efforts. Workshop participants convened in Research Triangle Park, NC, from offices and regions throughout EPA and other federal agencies, including the Centers for Disease Control, the National Institute for Occupational Safety and Health, and the U.S. Department of Energy. In addition, participants were present from Lawrence Livermore National Laboratory and EOHSI. The purpose of the workshop was to develop recommendations regarding how these parties could respond more efficiently in the event of a future attack or emergency in the areas of (1) measurement of pollutants released during and after an incident, (2) computer modeling of pollutant dispersion and human exposure, (3) risk assessment and risk communication, and (4) challenges associated with integrating scientific research into an emergency response.

The workshop resulted in recommendations aimed at improvements in determining environmental and public health impacts from future emergencies. Key recommendations included recognizing the need for early information on the types and levels of environmental hazards to better understand the impacts on human health; responding quickly by pre-positioning personnel and equipment; appointing a single spokesperson to communicate results to the media and the public; making applicable reference data available to better relate pollution levels with potential health risks; and focusing more on collecting information on people's direct exposure to health risks from the disaster.

The workshop provided an opportunity for emergency responders to interact with scientists from EPA-ORD to gain a better perspective about how research might benefit the emergency response community. Outcomes from the workshop also included recognizing that the response to a major disaster involves many federal, state, and local agencies and universities, whose efforts should be coordinated to minimize duplication of effort and to use resources efficiently; establishing lines of communication between the various responding organizations prior to an event to result in an efficient, well-coordinated emergency response; and that training exercises are a useful preparation for a coordinated multi-organization response.

The WTC disaster also highlighted the need for a centralized data management infrastructure designed specifically for emergency response. The system should be able to receive various types of data electronically from multiple sources and rapidly provide data for modeling, risk assessment, and decision-making. The system should include standardized formats for data outputs for scientific and public relations purposes and delivery via multiple means, including the Internet, hard copy, and the news media.

EPA's Strategic Plan for Homeland Security

The terrorist attacks of 9/11 and the threat of future attacks toward U.S. interests have broadened the mission of the EPA from safeguarding the environment and protecting the public's health to include protecting the United States against the environmental and health impacts stemming from acts of terrorism. This expansion of activities is reflected in EPA's Strategic Plan for Homeland Security and organized into four mission-critical areas:

- Critical infrastructure protection
- Preparedness, response, and recovery
- Communication and information
- Protection of EPA personnel and infrastructure

On September 24, 2002, EPA announced the formation of a Homeland Security Research Center in Cincinnati, OH. The center, which is part of EPA-ORD, manages, coordinates, and supports a wide variety of homeland security research and technical assistance efforts. EPA-ORD reassigned existing staff with expertise and experience in relevant scientific and engineering disciplines to develop a research program for meeting national needs of protecting and decontaminating buildings and water distribution systems. According to EPA, the goal of the Homeland Security Research Center is to "provide, within three years, appropriate, affordable, reliable, tested, and effective technologies and guidance for preparedness, detection, containment, and decontamination of chemical and biological attacks on buildings and on water systems." Additional resources within the center are aimed at producing rapid risk assessments during an emergency response. This involves assembling readily available databases with which to compare measurements of environmental and indoor pollutants to determine potential health implications for building occupants and the public.

Recognizing the potential for human exposures to pollutants in ambient air, EPA-ORD has gained access to additional capabilities at EOHSI through its university partnership agreement. The agreement was previously established to enhance EPA-ORD's expertise in human exposure modeling research, but has been expanded to include homeland security efforts as well. Collaborative research underway between EPA-ORD and EOHSI focuses on developing applicable models to interface between atmospheric transport/dispersion models and human exposure and dose models. The purpose of this is to fully utilize the capabilities of existing atmospheric models to better predict when, where, and most important, how much the public may be exposed to contaminants resulting from terrorist attacks or other emergency disasters.

Within EPA-ORD, several response teams have been formed to advise EPA management in the event of a national emergency. The role of the response teams is to serve as an advisor to EPA management on matters concerning monitoring, modeling, and risk assessment of environmental pollutants, including chemicals, biologicals, and radiation. The response teams prepare for emergency response by conducting appropriate training to understand how best to utilize the available tools and resources, and advise EPA management on any deficiencies found in EPA emergency plans. In the event of an emergency, the response teams serve as EPA's on-site technical expertise, and provide advice and recommendations to senior EPA or other government officials. After an event, whether training or an actual emergency, the response teams evaluate the EPA's response and provide recommendations on how to better prepare for future events.

DISCLAIMER

The research described here was produced by the U.S. Environmental Protection Agency (EPA), through its Office of Research and Development, in collaboration with the National Oceanic and Atmospheric Administration (NOAA) through an interagency agreement. This article has been peer reviewed and approved by EPA for publication, but does not necessarily reflect the views and policies of NOAA or EPA. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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