REPORT

Cleanup After a Radiological Attack
U.S. Prepares Guidance

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Early in 2005, the Department of Homeland Security (DHS) is expected to release much-needed guidelines to assist public officials in responding to the detonation of a "dirty bomb," or radiological dispersal device (RDD).[1] Since the terrorist attacks of September 11, 2001, the threat that a terrorist group might detonate an RDD in a major U.S. city has commanded increasing public attention, but the federal government has yet to provide local officials with recommendations on protecting public health from radiation exposure in the specific event of such an attack, including long-term cleanup of an RDD-contaminated area.[2]

In contrast to existing regulations governing the release of radiation at a nuclear facility or industrial waste site, the guidelines for RDD cleanup must anticipate the high likelihood that such an attack would occur in a heavily populated area, where the extensiveness of the decontamination effort will have to be balanced with a community's need to access the affected zone. The proposed guidelines will also face the challenge of minimizing the disruptive impact of a dirty bomb attack in the face of intense public fear about exposure to even extremely low levels of radiation. With an RDD attack widely considered an imminent terrorist threat, the federal government should give increased priority to preparedness efforts, including releasing the proposed guidelines, and importantly, should make a sustained effort to engage the public in response planning.

If a dirty bomb were detonated today in a U.S. city, local decisionmakers would have no clear guidance on acceptable levels of public exposure to the radioactive materials released in the attack, either for short-term emergency response efforts or long-term cleanup. While the Environmental Protection Agency (EPA) has issued nonbinding recommendations for response in the early and intermediate stages of a radiological emergency in its *Manual of Protective Actions Guides* (PAGs), this guidance was developed to address accidental re-

leases of radiation, principally from nuclear power plants, and its applicability to incidents of radiological terrorism has not been affirmed.[3] For longer-term cleanup of radiation contamination, various federal agencies that oversee cleanup at sites under their jurisdiction issue a wide range of legal standards—such as the EPA's Superfund standard—applicable to remediation at federal and nonfederal hazardous waste sites. However, none of the existing regulations addressing acceptable radiation exposure specifically addresses remediation in the unique circumstances of an RDD attack.

Although DHS has neither published its proposed recommendations for responding to an RDD attack nor set a definite date for releasing them, the contents of the guidance have been previewed in several sources, including a draft "interim final" version of the guidance published in November 2003 by the trade publication *Inside EPA;* an article by EPA senior scientist John MacKinney in the Spring/Summer 2004 edition of the U.S. Army Nuclear and Chemical Agency's *NBC Report*; and in recently published interviews with government officials.[4] These sources, along with personal interviews undertaken for this article with U.S. officials involved in drafting the guidance, indicate that the DHS recommendations will advise use of the EPA's 1992 PAG values for radiation exposure in the early and intermediate stages of a radiological terrorist attack.[5] For long-term remediation, the proposed guidance reportedly does not set a single numeric guideline, but recommends a process by which local stakeholders and decisionmakers would develop cleanup plans tailored to the specific characteristics of an attack.

A number of public interest and anti-nuclear groups have recently protested the pending guidance in anticipation of its recommended long-term cleanup approach and failure to explicitly uphold the protectiveness of EPA Superfund levels.[6] Based on the draft version published in *Inside EPA* in November 2003, they believe that the federal guidance will "dramatically weaken requirements for cleaning up radioactive contamination from a terrorist radiological or nuclear explosive."[7] This report responds to that critique by exploring the merits of the DHS approach in the context of a dirty bomb attack. First, however, it is essential to examine the risks posed by radiation and radiological terrorism.

THE DIRTY BOMB THREAT

While an RDD might take a variety of forms, the most commonly discussed type is a so-called dirty bomb, which would use conventional explosives to spread radioactive material. The wide availability of radioactive sources in industrial, commercial, medical, and research uses, combined with clear evidence of terrorist interest in acquiring such material, has led many experts to conclude that an RDD attack in coming years is highly probable.[8] Depending on the type and quantity of radioactive material used in a device and variables such as weather

conditions and the size of particles released, the impact of an RDD attack could vary greatly.[9] However, experts generally agree that an RDD is most appropriately characterized as a weapon of mass disruption, rather than mass destruction. A typical attack would result in few, if any, immediate casualties from radiation exposure, but the ensuing contamination would likely prompt widespread panic, causing significant economic and psychosocial damage.[10] Long-term economic consequences, moreover, could be very significant if affected areas included major commercial or industrial sites and could not be readily restored to public use.

While various uncertainties complicate efforts to assess the likely impacts of an RDD attack, scientists at the Federation of American Scientists (FAS) have used a simple, two-dimensional model—called HOTSPOT and developed by Lawrence Livermore National Laboratory—to make rough estimates of the contamination that might result in different dirty bomb scenarios.[11] Their widely referenced, *low-end* impact scenario explores the effects of a device containing the same amount of cesium-137 found in many medical gauges (a few curies of radioactivity) and exploding 10 pounds of TNT to disperse the radioactive material in downtown Washington, DC. Assuming a relatively calm day (wind speed of one mile per hour), the dispersal of fine radioactive particles spread downwind in a cloud, and both internal (inhalation or ingestion) and external exposure, the FAS simulation predicts that residents in an area of five city blocks from the site of detonation would be exposed to radiation doses equivalent to a one in 1,000 chance of getting fatal cancer.[12] Radiation doses are expressed in "rem," a scientific unit equating absorption of ionizing radiation with its biological effect on humans. These individuals would receive a radiation dose of approximately 150 millirem (mrem), or 0.15 rem per year.[13] Furthermore, a strip of the city approximately one mile long, covering an area of 40 city blocks, would be contaminated to a level where radiation doses exceeded 15 mrem, or 0.015 rem per year. According to the EPA's cleanup standard at Superfund sites, this radiation dose corresponds to a risk level which, over a 40-year period, would result in one additional cancer death in 10,000 people.[14] Were the cesium-137 device detonated at the National Gallery of Art, the zone contaminated to this level would include the Capitol, Supreme Court, and Library of Congress.[15] For comparison, on average, a person living in the United States is exposed to an annual effective dose of approximately 360 mrem, or 0.36 rem, from "background" natural and artificial radiation sources. This dose might increase if a person frequently travels by air, receives medical X rays, or lives at a higher elevation, all of which are examples of everyday sources of radiation exposure.[16]

This scenario, to reiterate, represents the low-end of potential impacts from a dirty bomb attack. In a more threatening, but still realistic FAS scenario, an RDD containing an americium source used in oil well surveying is exploded with one pound of TNT in central Manhattan. The detonation of such a device would

contaminate a region 2 kilometers long and 60 city blocks in area with radiation in excess of 15 mrem—still the equivalent to an increased cancer risk of one death in 10,000 individuals, but a larger area of contamination.[17] Cleanup after an RDD attack would likely involve removing radioactive particles from the cracks and crevices of city buildings and streets, a challenging task that U.S. officials would have to approach with neither well-developed technologies nor direct experience.[18] Depending on the extent of the contamination and the desired level of cleanup, the affected area could be closed off for months or years. In the case of the FAS scenario involving an americium RDD, "if the buildings in this area [of central Manhattan] had to be demolished and rebuilt, the cost would exceed fifty billion dollars."[19] Losses in trade and business in the contaminated area, as well as the decline in property values, would also add to the potentially exorbitant economic costs of an attack. In a recent simulation of a dirty bomb attack on the twin ports of Los Angeles and Long Beach, researchers at the University of Southern California's Center for Risk and Economic Analysis of Terrorist Events (CREATE) estimated that the total economic loss from such an incident may be as much as $34 billion.[20]

As noted, the economic disruption resulting from an RDD attack would likely be compounded by widespread panic, largely stemming from public fears of radiation. Fueled by historical associations with nuclear events such as Hiroshima and Chernobyl and the disturbing nature of a hazard that cannot be perceived with the physical senses, the public fear of radiation exposure is an opportune target for terrorists.[21] The likelihood that societal disruption would be the most dangerous consequence of a dirty bomb attack implies that the severity of the impact, and thus the effectiveness of the attack, may very well depend on the preparedness of first-responders and government officials, as well as members of the public, to deal with radiation contamination.

EXISTING CLEANUP STANDARDS

The release of new guidelines covering radiation exposure after an RDD attack will address a critical deficiency in existing federal planning for radiological emergencies—the failure to plan for a radiological terrorism event. For emergencies involving the accidental release of radioactive materials, federal response plans have undergone several decades of evolution and development.[22] To date, this response planning has focused primarily on accidental releases from nuclear power plants.[23] In 1975, the EPA published its first PAG manual, which provided guidance for decisionmakers responding to a nuclear reactor accident. Following the accident at the Three Mile Island nuclear reactor in 1979 and the identification of several coordination gaps in federal and state response plans for radiological emergencies, President Jimmy Carter issued an executive order establishing the Federal Emergency Management Agency (FEMA) as the single lead agency co-

ordinator for off-site radiological emergency response planning and preparedness, a responsibility it retains today as part of DHS.[24] Subsequent regulations issued by FEMA in 1982 required the EPA "to establish PAGs for all aspects of radiological response planning in coordination with appropriate federal agencies."[25]

In 1992, the EPA issued its *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents,* which billed itself as providing "radiological protection guidance that may be used for responding to any type of nuclear incident or radiological emergency, except nuclear war."[26] The manual sets out a series of PAGs establishing projected doses from an unplanned release of radioactive materials, for which certain protective actions are recommended in order to reduce public exposure to that radiation. It specifies that "PAGs do not imply an acceptable level of risk for normal (non-emergency conditions)" nor do they "represent the boundary between safe and unsafe conditions"; rather, they establish approximate levels for certain protective actions to be undertaken in the event of a nuclear incident.[27]

While the manual notes the possibility that a nuclear incident may be deliberate, according to a senior EPA official commenting in 2004, it was "not written with current terror scenarios in mind" and was "designed principally to meet the needs of NPP [nuclear power plant] accidents, the worst type of incident under consideration."[28] Nuclear power plants are normally located in rural or less densely populated suburban areas and benefit from long-standing emergency evacuation plans. In contrast to an accident at such a facility, which would unfold over a period of hours, if not days, an RDD attack would likely occur without advance warning and in a major city where a large population, critical public services, and extensive commercial activities would be affected. Moreover, the manual's relevance for a dirty bomb scenario is limited by its lack of protective guidance for the late phase "recovery" period of a radiological incident; this was "to be developed at a later date" but remained an unfinished chapter.[29]

The manual does, however, specify PAGs for addressing the early and intermediate stages of a nuclear incident. These phases are not defined by precise time intervals, but rather by the sequence of emergency response and recovery actions that would occur in any incident. Time spent in each phase would depend on the severity of an incident, and phases would likely overlap.[30] For the early stage of a radiological emergency, extending from hours to days after an initial release, the manual sets a PAG of 1-5 rem. At this level of exposure, the public should be evacuated, or possibly "sheltered-in-place," depending on the conditions of the release, age of the affected population, and other site-specific variables.[31] The intermediate stage of a radiological emergency would begin after a radioactive release had been brought under control and the level of contamination and radiation exposure reliably measured, and may last from weeks to many months.[32] During this phase, the manual recommends that affected residents relocate if projected doses are 2 rem or greater over the course of the first

year, or projected to exceed 0.5 rem for any subsequent year.[33] Late-phase cleanup would begin with the initiation of recovery actions designed to reduce radiation contamination to acceptable levels and would end when such efforts are completed, possibly extending from months to years.[34]

The EPA's responsibility for developing protective guidelines for radiation exposure, as well as for monitoring and assessing radioactivity at affected sites, was included in FEMA's Federal Radiological Emergency Reponses Plan (FRERP), which was approved in 1985 and revised in 1996. The plan, together with a subsequent interagency agreement, attempts to coordinate the roles of 17 federal agencies in the event of a radiological emergency, as well as clarify the responsibilities of federal, state, and local responders. In the event of terrorist use of an RDD, the most recent plan contains only brief guidance—three paragraphs assign the Federal Bureau of Investigation responsibility for investigating acts of radiological terrorism and sabotage and direct other responders to treat such incidents as "complicating dimension[s]" of other types of emergencies, not separate types.[35]

THE CASE FOR DEVELOPING RDD GUIDANCE

The events of September 11 have underscored the heightening risk of terrorists' using a radiological weapon and the necessity of such an event warranting a tailored response plan.

In the absence of federal recommendations for responding to an RDD attack, existing standards developed for radiation cleanup in other contexts would likely be looked to for guidance. But these standards, developed by a number of regulatory authorities with different oversight responsibilities, are not always consistent. A recent study by Deborah Elcock of Argonne National Laboratory and her colleagues at DHS and the Department of Energy (DOE) identifies provisions in six different laws addressing the cleanup of radioactive materials that might be applied following at RDD attack.[36] In an earlier examination of existing federal policies governing releases of radiation, the Government Accountability Office (GAO) uncovered at least 26 standards or guidelines containing numerical radiation limits—a finding it attributes to "a lack of overall interagency consensus on how much radiation risk to the public is acceptable."[37]

Interagency debate about what constitutes a sufficiently protective standard for radiation exposure partially reflects the scientific controversy surrounding the health effects of radiation. The generally used approach to assessing the effects of radiation exposure, termed the "Linear, No-Threshold" (LNT) model, makes the conservative assumption that even very low levels of radiation exposure carry a quantifiable cancer risk.[38] While the LNT hypothesis is valuable for regulatory purposes because of its relative mathematical simplicity and remains "the fundamental basis for U.S. radiation standards," the model's scientific va-

lidity is contested by many scientists who cite the lack of conclusive evidence for radiation effects below individual total doses of 5 to 10 rem.[39]

Federal disagreements on radiation standards are most visible in the contrasting approaches to radiation protection adopted by the EPA and Nuclear Regulatory Commission (NRC), which together administer the majority of federal standards.[40] Generally, the EPA has jurisdiction for cleaning up hazardous waste, including radiation, at federal and non-federal sites, which can overlap with the NRC's authority to regulate civilian sources of nuclear radiation, particularly in nuclear cleanup and decommissioning activities.[41] In overseeing the cleanup of environmental hazards, the EPA has historically pursued a risk-based radiation protection strategy aimed at protecting both human health and the environment. It is important to note the difference between the agency's nonbinding guidance, such as its 1992 *Manual of PAGs* for nuclear incidents, and its binding standards for long-term remediation of environmental contamination. Under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), known as the Superfund law, the EPA has set an upper limit on allowable radiation after cleanup corresponding to a 1 in 10,000 increased lifetime risk that an individual would develop cancer. As described earlier, the EPA's "cleanup rule," which sets an individual protection limit of 15 mrem a year above background radiation levels, with more protective limits on groundwater contamination, roughly corresponds to that risk level.[42] (As noted above, the average individual in the United States receives an annual dose of 360 mrem, or .36 rem, from natural and human-made sources.)

In contrast to the EPA approach, which has been described as a "bottom-up" strategy in which a very low risk goal is set and then pursued through the best available technology, the NRC generally adheres to a "top-down" approach. Under the NRC strategy, which focuses exclusively on human-health protection, officials set a relatively less restrictive dose limit and then work to reduce that dose "as low as reasonably achievable" considering economic, social, and technical factors.[43] In contrast to the EPA's cleanup rule, the NRC has consistently enforced a standard of 25 mrem a year above background radiation levels for all sources of exposure, and generally considers a 1 in 1,000 increased lifetime cancer risk from excess radiation to be acceptable for the general public.[44]

Historically, differences in federal agencies' radiation standards have resulted in regulatory delays and higher cleanup costs at nuclear sites, and have raised public questions about acceptable levels of decontamination.[45] While federal regulations on cleanup levels at industrial waste sites or decommissioned nuclear power plants would not be legally applicable to response efforts after an RDD attack and were not formulated to address such an event, in the absence of guidance for response at any stage of a dirty bomb incident, such standards would likely play a central role in informing decisions about decontamination, especially in the public arena. However, unresolved conflicts between these stan-

dards might delay first responders in assisting victims, postpone intermediate- and late-phase site remediation, and undermine public confidence in the recovery process.[46] Delaying cleanup could also unnecessarily increase costs, as the fine dust particles released from an RDD detonation were ground progressively deeper into porous surfaces on city buildings or bound with petroleum derivatives in asphalt streets, making an already challenging cleanup job more difficult.[47] The social and economic disruption likely to result from an RDD attack would also be exacerbated if disagreement about acceptable levels of radiation exposure delayed response and recovery efforts.

The importance of developing standardized radiation protection guidelines mutually agreed upon by federal agencies was highlighted in Top Officials (TOPOFF) 2, the May 2003 interagency training exercise simulating a terrorist dirty bomb attack on the Port of Seattle. TOPOFF 2 was the second in a series of exercises mandated by a 1998 law requiring the federal government to work with "top" state and local officials in strengthening emergency response preparedness for terrorist threats, including the coordination of short- and long-term recovery efforts across multiple levels of government.[48] In addition to identifying weaknesses in coordinating communication and dividing responsibility clearly among local, state, and federal agencies, the simulation underscored the need for uniform federal guidance concerning response and recovery in the event of radiological terrorism.[49] Reportedly, participants examined the range of existing radiation exposure standards, such as those from the EPA and NRC, but struggled to determine what to apply in the RDD case.[50] In the end, officials issued contradictory assessments about contaminated areas, with some declaring areas safe for the public and others advising evacuation.[51] The application of what some perceived to be excessively protective standards on radiation exposure from an attack on an urban area was noted by at least one federal observer: "Do you really want to shut down the Port of Seattle because you don't want to get 5 or 10 millirem of dose? Do you want to economically cripple an entire country because of that, an infinitesimally small risk, if it is any risk at all?"[52] Outgoing DHS Secretary Tom Ridge, who attended the simulation, later commented that "it took too long to reconcile differences" between potentially applicable radiation standards.[53] According to an EPA participant in the exercise, the lack of interagency agreement on long-term site remediation was a "particular priority" for Ridge and the White House Homeland Security Council (HSC):

> the EPA has clean up standards and procedures, and DOE [the Department of Energy] and NRC have standards for the clean up of their respective sites (by ownership, control, or license), but no clear approach or standard emerged as suiting the needs of federal, state, and local governments in the aftermath of radiological and nuclear terror.[54]

DEVELOPING NEW GUIDANCE

Following TOPOFF 2, DHS officials incorporated lessons learned from the RDD simulation into the Initial National Response Plan (INRP), an ongoing federal effort to develop an integrated national plan coordinating local, state, and federal emergency responses to incidents involving weapons of mass destruction and terrorism.[55] A February 2003 presidential directive assigned DHS responsibility for designing and implementing a National Response Plan (NRP), including the initial step of developing the INRP. These responsibilities were part of the DHS secretary's newly designated role of "principal federal official for domestic incident management," which includes coordinating crisis and consequence management for terrorist acts, major disasters, and other emergencies.[56] Under this authority, DHS established an interagency working group in the spring of 2003 to address the need for unified federal guidance on RDD incidents—the Consequence Management, Site Restoration/Cleanup and Decontamination (CMS) Subgroup of the Working Group on RDD Preparedness. Subject-matter experts from nine federal agencies, including DHS, EPA, NRC, and DOE, participated in the working group, which began meeting in the late spring of 2003 to draft the new RDD guidance. [57]

In considering the task, officials examined the existing approaches to radiological cleanup, including the dose- and risk-based regulatory standards of the NRC, DOE, and EPA, as well as guidance from national and international advisory groups, such as the National Council on Radiation Protection and International Commission on Radiological Protection.[58] Given previous interagency disagreements over cleanup levels and divergences in agencies' approaches to radiation protection, the working group faced a difficult task in reaching a consensus on new federal guidance. Brooke Buddemeier, a DHS radiation specialist participating in the working group, told a *New York Times* reporter, "There's a lot of consternation over what the cleanup levels [for an RDD attack] should be. . .We had a pretty good idea what they should be for Superfund sites or a Nuclear Regulatory Commission power release."[59] Determining cleanup levels for an RDD attack, however, involves unique challenges, such as the likelihood an attack would occur in a more populated area where residents would have a greater need to resume normal access to the site.[60]

While official statements indicated that the recommendations of the task force would be released as early as June 2004, a prolonged interagency review of the guidance has reportedly delayed that release until early in 2005.[61] Notice of the preliminary guidance will be published in the *Federal Register* and then subject to a 60-day comment period, during which time interested parties may submit responses to be considered in the final draft. With the delay in the release of

the initial recommendations, publication of the *final* guidance, at one point planned for February 2004, will not occur until later in 2005. That release will largely depend on public reactions to the working group's recommendations. According to the DHS official heading the interagency group, "if the proposal is not well-received, the date [of release on the final guidance] could change significantly."[62]

Although the working group's recommendations are yet to be released, the recent summary provided in the article by EPA's MacKinney, "Guidance for Federal Protective Actions and Recovery After Radiological and Nuclear Incidents" and the "Interim Final" draft of the guidance published in *Inside EPA* in November 2003 concur about the contents of the forthcoming guidance and inform the analysis provided here.[63] Reportedly, the interagency task force determined that, in the early phase, "existing PAGs for evacuation, sheltering, relocation and protection of emergency workers are appropriate for RDD…incidents." The 1992 EPA values for PAGs in the intermediate phase, when decisions would be made about actions needed to "reopen critical infrastructure and return to some state of normal activities," were also deemed appropriate for an RDD event.[64]

As the 1992 values were established primarily in the context of an accident at a nuclear power plant, the working group reportedly noted several key issues unique to response planning for radiological terrorism. Whereas an emergency at a nuclear power plant would typically be anticipated early enough to provide an affected population with advance notice to evacuate, advance warning of an RDD attack would be unlikely. While the early-phase guidance contained in the 1992 PAG manual suggests evacuation and possibly sheltering "as an alternative in certain cases" at projected doses of 1-5 rem,[65] the working group, in addressing the unique threat of an RDD, reportedly emphasized the importance of encouraging sheltering-in-place. According to MacKinney, in the event of an RDD attack, it is likely that "sheltering in place, at least until orderly evacuation can be arranged, would likely be more appropriate guidance than a hasty evacuation when airborne contaminants may still be present."[66] The more rapid unfolding of an RDD incident would also mean that "most early, and some intermediate, phase protective actions must be made more quickly and with less information….if they are to be effective."[67]

A second issue unique to radiological terrorism considered by the working group was the high likelihood that terrorists preparing an RDD might use a radioactive isotope with a relatively long half-life, such as cesium-137, meaning that the decay of that radioactive material, and thus long-term cleanup, may be an extensive process. In the absence of such cleanup, residents living in an area contaminated by an RDD may be subjected to radiation doses that do not significantly diminish in the years following an attack, in comparison to an accident at a small nuclear facility where relatively shorter-lived materials might be released.[68] The 1992 intermediate phase PAGs recommend relocation if projected doses exceed 2 rem in the first year and 500 mrem in later years. In addressing

the threat of an RDD, the working group reportedly noted the possibility of needing to scale the 1992 PAG values to longer-term contamination: "…if projected doses were 1 rem each year for a number of years out [for example], relocation orders may be warranted in the first year."[69]

At least one professional organization of U.S radiation safety specialists, the Health Physics Society (HPS), has issued a position statement generally supporting the application of the 1992 PAG values to incidents of radiological terrorism. While maintaining that the threat of radiological terrorism in the wake of September 11 may require new processes and infrastructure for prevention and crisis management, such as increasing radioactive source security, the HPS also affirmed the appropriateness of adapting existing federal guidance on radiological incidents to a terrorist event: "…the responsibilities for establishing recommendations to the responding state and federal agencies is [sic] well established and appropriate for responding to an RDD."[70]

The 1992 EPA intermediate-phase guidance establishes an upper limit on radiation exposure in the immediate months and possibly year(s) following an RDD attack but do not apply to long-term cleanup. In preparing recommendations for late-phase site remediation, the working group faced the challenge of developing guidance for a broad range of potential RDD effects, "ranging from light contamination of one building to widespread destruction of a major metropolitan area."[71] While applying a very protective radiation standard and quickly restoring an affected site to its former condition might be quite feasible in a scenario involving a small RDD, such a task would be far more difficult if the incident involved a powerful device that spread contamination over a large area.[72] Ultimately, the working group determined that it could not recommend "a preestablished numeric guideline…best serving the needs of decision makers in the late phase."[73] Given the diversity of potential impacts from an RDD attack, "it would be inappropriate to issue one-size-fits-all guidance on how thoroughly to clean up such areas."[74]

Instead of issuing a specific cleanup level, the working group developed "a site-specific process."[75] Reportedly, the forthcoming proposed guidance outlines an optimization strategy that would allow a group of key community stakeholders, technical experts, and local decisionmakers to consider multiple factors in deciding on a long-term remediation plan, including areas affected, types of contamination, public health, technical feasibility, costs and available resources to implement and maintain remedial options, long-term effectiveness, timeliness, public acceptability, and the potential economic impact on residents, tourism, business, and industry.[76] As envisioned in the "Interim Final" guidance, this process would also include consideration of existing federal cleanup regulations, such as those from the EPA and NRC, and recommendations from national and international advisory bodies, which would serve as benchmarks to be adjusted depending on specific characteristics of an incident.[77] Specifically, the workgroup

reportedly developed an implementation plan for the "site restoration analysis and decision process," which calls for the creation of both stakeholder and technical expert working groups that would jointly develop a solution for the contaminated area. While the stakeholder group would represent community interests and concerns on land use, public health, and welfare, the technical group would have the responsibility to "perform analyses, evaluate technologies and options, assess cost-effectiveness, and estimate timelines for completion."[78] Discussions by the two groups would be overseen by a third group of senior local, state, and federal officials who would have final approval authority on any cleanup plan. According to MacKinney, "the goal of the whole process is to reach an agreed upon approach to site clean up and restoration within a reasonable timeframe that is effective, achievable, and meets the needs of local stakeholders."[79]

AN EARLY ASSESSMENT

The number of variables affecting both the magnitude of a dirty bomb attack and its impact on a community greatly complicates efforts at response planning. Importantly, the new guidance promises to ensure that site remediation occurring after an RDD incident is tailored to both the effects of an RDD and the unique needs of local residents. For response efforts in the early and intermediate phases of an incident, the working group provides much-needed, official affirmation that existing PAGs for nuclear incidents are sufficiently protective for radiological terrorism—a public health judgment that cannot soundly be made in the frantic moments following a terrorist attack.

For long-term cleanup, which might start months or years after an initial incident, the participatory decisionmaking process recommended by the working group should encourage consideration of all variables affecting cleanup decisions and promote public confidence in the selected plan. Although some analysts have assumed the applicability of existing decontamination regulations in the event of an RDD attack—and thus the subsequent demolition of any structure that could not be cleaned up to an EPA Superfund or NRC-mandated level—under the new guidance, such standards would reportedly not be applied to cleanup unless adopted by local decisionmakers.[80] Instead, such standards would inform a decisionmaking process that could balance the protection of public health with the economic and social priorities of what would likely be a densely populated community. Maintaining access to social services, such as hospitals or transportation networks, and places of employment may be critical to a community's recovery: "Unless the hundreds or thousands of individuals affected by a radiological dispersal event resume normal activities as soon as possible, they could face economic and health hardships that could outweigh the radiation health risks associated with current cleanup standards."[81] While some have criticized the lack of a single long-term cleanup standard in the forthcoming guidance as

"punt[ing]" the issue,[82] such action ensures communities the ability to craft a remediation plan sensible to local needs, including, most importantly, the protection of local public health.

In particular, an affected community may want to consider the economic costs of various cleanup options. As one would expect, cleanup costs vary substantially depending on the stringency of the targeted decontamination level. Recent GAO studies of the cleanup costs associated with various radiation standards have revealed multimillion dollar differences in implementation costs between the EPA's and NRC's respective standards of 15 mrem and 25 mrem a year.[83] In recommending a consultative optimization process for determining long-term cleanup plans, the working group's guidance should allow local decisionmakers to balance such social costs with the necessary protection of public health.

COMMUNICATING THE GUIDANCE: THE CRITICAL CHALLENGE

While the forthcoming proposed federal guidance promises to be a marked improvement in federal preparedness for an RDD attack, a critical challenge remains in successfully communicating the new recommendations to the public.

The psychological terror produced by a dirty bomb attack is likely to be its most devastating impact, and likely out of proportion to the magnitude of the initial event.[84] Although people are exposed to both naturally occurring and commercial sources of low-level radiation on a daily basis, significant fear about exposure to any quantity persists, stemming in part from ignorance, historical associations, and the undetectable nature of the threat.[85] In a recent survey conducted as part of a New York Academy of Medicine study examining public attitudes about emergency response planning for terrorism, researchers found that after a dirty bomb attack, "79% of the population would be extremely or very concerned about the safety of the air they breathe, the water they drink, and the food they eat."[86]

Such concerns were exemplified in the 1987 radiological accident in Goiania, Brazil, which remains the closest historical approximation of an actual RDD attack. In that incident, scrap metal scavengers removed a radioactive source capsule containing cesium-137 from a teletherapy machine in an abandoned radiotherapy clinic, unleashing a chain of exposure that eventually resulted in five deaths and 249 cases of radioactive contamination.[87] Studies carried out in the wake of the accident on the affected population found that "anticipatory stress associated with potential exposure to ionizing radiation resulted in a level of stress similar to that from actual exposure to ionizing radiation."[88] The number of "worried well" who panicked and demanded monitoring for radiation contamination exceeded 110,000 people, demonstrating "the wide spread psychological and social effects that can grip a populace" in the aftermath of a dirty bomb attack.[89]

Establishing clear guidance for response and recovery that seeks to protect public health while also minimizing the disruption of an RDD attack is an important step, but the effectiveness of such efforts will be greatly reduced without public support. If the public does not have confidence in the adopted response and recovery guidelines, they will be far less likely to heed those recommendations in a radiological emergency. Decisionmakers responding to a dirty bomb incident must anticipate the virtual certainty that the public will compare guidance for the early and intermediate phases of an RDD incident to more protective decontamination standards, such as those established by the EPA for long-term remediation at Superfund sites, even though these were never developed for the purpose of addressing risks during the initial and intermediate phases of a nuclear emergency. Despite the inappropriateness of the comparison, the perception that only an upper limit of 15 mrem per year can ensure public safety will have to be addressed if the public is to be successfully convinced that a 1-5 rem PAG for immediate evacuation and sheltering is sufficiently protective following an attack, as specified in the forthcoming guidance.[90] Whatever standard is adopted for long-term cleanup will also likely be compared to the EPA's cleanup rule. Without public engagement on the rationale behind such plans, residents might refuse to remain in an affected area containing even very low levels of radioactive contamination, halting business activity and eroding property values in that community. One can easily imagine another scenario in which individuals misguidedly decide to self-evacuate rather than shelter-in-place, exposing themselves to far worse airborne contamination. "The public's reaction can be one of the best defenses or one of the greatest weaknesses in responding to radiological terrorism."[91]

Already, as noted earlier, anti-nuclear groups have criticized the guidance's failure to set a specific numeric standard for long-term cleanup, fearing that the absence of an upper limit on radiation exposure will significantly increase cancer risk.[92] A recent press release by the Committee to Bridge the Gap, which is heading up the protest, claims that "it is unacceptable to set final cleanup goals so lax that long-term cancer risks are hundreds of times higher than currently accepted for remediation of the nation's most contaminated sites."[93] The group's calculations assume a community's long-term cleanup plan might adopt standards for allowable doses ranging from 0.1 rem to 10 rem (100 mrem to 10,000 mrem) per year for a period of 30 years, standards only possible, however, if approved through the local decisionmaking process.[94]

Ensuring that the public signs on to the new guidance is a challenging but critical task for RDD emergency planners. While fine-tuning a risk communication strategy for use in the immediate aftermath of a dirty bomb incident should remain a priority, much can and should be done now to improve public preparedness. Simply improving public understanding of the realistic effects of a dirty bomb can do much to minimize the terror effects of an attack.[95] The upcoming

release of the DHS's preliminary guidance presents an important opportunity for federal planners to communicate this message, and in turn, receive feedback on what will likely remain a controversial issue—how to approach the cleanup of a city in the aftermath of a dirty bomb attack.

Planned outreach efforts to first responders and local, state, and federal government officials about the new guidance should be accompanied by a broader effort to engage the general public in response planning. Mere publication of the guidance in the *Federal Register* may not be enough. According to the New York Academy of Medicine study referenced earlier, 84 percent of the population believes it is moderately to extremely important "for people like them to work with government agencies or other community organization to develop plans" addressing terrorist threats, and 77 percent are moderately to extremely interested "in learning more about the plans that government agencies or other communication organizations currently have" to deal with these kinds of situations.[96] An effective communications campaign will inform the public of the substance of the new guidelines and encourage participation in their revision through submission of an official comment. Inviting several "public representatives" to assist the RDD working group in finalizing the guidelines might also help to facilitate public support. If previous decontamination efforts at nuclear facilities or the anticipatory criticism of the guidelines by anti-nuclear groups are any indication,[97] the publication of the new guidelines is likely to launch a vigorous public debate about safe levels of radiation exposure. By encouraging this dialogue and seeking broader representation in the approval process now, federal officials can help to prevent a backlash later, when successful implementation of the guidance might be critical.

Following the terrorist attacks on the World Trade Center in September 2001, the EPA Office of the Inspector General (OIG) conducted an evaluation of the agency's emergency response efforts, finding in part that early EPA reassurances about the safety of the air near Ground Zero were made without "sufficient data and analyses."[98] The agency's ability to communicate accurately to the public the risk presented by airborne dust generated from the towers' collapse was impeded in part by its lack of guidelines on acceptable levels of public exposure to those pollutants.[99] While the EPA had been funding a program to develop such guidelines for acute exposure, "none of these levels had been finalized at the time of the WTC disaster."[100] Since September 11, agencies across the federal government have intensified efforts to plan and prepare for likely terror scenarios, learning from deficiencies revealed in the attacks, such as the lack of EPA guidelines, and working to fill those gaps. While DHS has taken important steps to develop federal guidance on radiation exposure that would be applicable in the event of an RDD attack, much work remains to ensure those recommendations undergo an inclusive review. Given the high likelihood that terrorists could next strike with a dirty bomb, such efforts deserve priority attention. Finalizing guidelines later may be too late.

[1] The forthcoming guidance reportedly applies to response and recovery from incidents involving improvised nuclear devices (IND) as well, although the reporting and analysis provided here focuses exclusively on the RDD threat.
[2] In a recent example of the increased concern, radiation detection experts were dispatched to certain U.S. cities to thwart a dirty bomb attack during the 2003 holiday season; see John Mintz and Susan Schmidt, "'Dirty Bomb' Was Major New Year's Worry," *Washington Post*, January 7, 2004, p. A01.
[3] U.S. Environmental Protection Agency (EPA), *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents*, Office of Radiation Programs, #400R92001, May 1992.
[4] "Protective Action Guides and Operational Guidelines for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents, Interim Final—For Official Use Only," *The Inside EPA Enviornmental NewsStand,* November 2003, <http://www.environmentalnewsstand.com/secure/data_extra/dir_03/epa2003_2404.pdf>; John MacKinney, "Guidance for Federal Protective Actions and Recovery After Radiological and Nuclear Incidents," *NBC Report* (Spring/Summer 2004); Matthew L. Wald, "U.S. Plans to Offer Guidance For a Dirty-Bomb Aftermath," *New York Times*, September 27, 2004, p. 20.
[5] The author conducted interviews with EPA, Department of Homeland Security (DHS), and Nuclear Regulatory Commission (NRC) officials in the fall of 2004 in preparation for this report.
[6] H. Josef Hebert, "Planned Cleanup for Dirty Bombs Called Lax," Associated Press, December 2, 2004; Matthew L. Wald, "Pending U.S. Advice on 'Dirty Bomb' Exposure is Under Fire," *New York Times*, December 8, 2004.
[7] Nuclear Information and Resource Service (NIRS), Press Release, December 2, 2004, "Groups Criticize Homeland Security Plans to Relax Radiation Cleanup Standards for a 'Dirty Bomb' or Terrorist Nuclear Explosive," <http://www.nirs.org/press/12-02-2004/1>.
[8] Charles D. Ferguson and William C. Potter, with Amy Sands, Leonard S. Spector, and Fred L. Wehling, *The Four Faces of Nuclear Terrorism* (Monterey, CA: Center for Nonproliferation Studies, Monterey Institute of International Studies, 2004), p. 300.
[9] Federation of American Scientists (FAS), "Dirty Bombs: Response to a Threat," *FAS Public Interest Report* 55 (March/April 2002), p. 6. The article is an excerpt of testimony by FAS President Henry Kelly before the Senate Committee on Foreign Relations, March 6, 2002.
[10] Charles D. Ferguson, Tahseen Kazi, and Judith Perera, *Commercial Radioactive Sources: Surveying the Security Risks*, Occasional Paper No. 11 (Monterey, CA: Center for Nonproliferation Studies, Monterey Institute of International Studies, January 2003) , p. 19.
[11] See FAS, "Dirty Bombs: Response to a Threat," Steven G. Homann of Lawrence Livermore National Laboratory developed HOTSPOT, the code used by FAS.
[12] This assumes individuals would remain in the area for a 40-year period and would live or work in that zone for 16 hours every day. Ibid., p. 7.
[13] Author's conversion of cancer-risk level to equivalent dose, using an approximation of the EPA dose conversion equivalence of 15 mrem corresponding to a 0.0003 (3 x 10 ^ -4) increased risk of cancer. See Deborah Elcock, Gladys A. Klemic, and A.L. Taboas, "Establishing Remediation Levels in Response to a Radiological Dispersal Event (or 'Dirty Bomb')," *Environmental Science and Technology* 38 (2004), p. 2510. The FAS studies assume that individuals remaining in this area would receive this amount of radiation every year over a 40-year period and would live or work in that zone for 16 hours every day. The calculation is 0.0003 cancers per rem times 0.015 rem times 40 years times 16 hours/day times day/24 hours = 0.00012. Multiplying 0.00012 by 10,000 and rounding to the nearest integer gives 1 cancer per 10,000 people in the affected area.
[14] "Dirty Bombs: Response to a Threat," p. 7. EPA risk level of one cancer death per 10,000 is roughly equivalent to the Superfund cleanup standard of 15 millirem (mrem.).
[15] FAS, "Dirty Bombs: Response to a Threat," p. 7
[16] Radiation exposure resulting from a dirty bomb attack would occur on top of this average dose of 360 mrem from everyday sources. For more on the health effects of radiation, see Ferguson, et al., *Commercial Radioactive Sources,* p. 4-7, and National Safety Council (NSC), Understanding Radiation, "Determining Your Exposure," December 10, 2002, <http://www.nsc.org/issues/rad/exposure.htm>.

[17] FAS, "Dirty Bombs: Response to a Threat," p. 8. Author's conversion of cancer-risk level to equivalent dose, using an approximation of the EPA conversion equivalence. See note 14.
[18] Jamie Yassif, "How Well Did TOPOFF 2 Prepare Us for Mitigating the Effects of a Dirty Bomb Attack?" *FAS Public Interest Report* 56 (Summer 2003), p. 24.
[19] FAS, "Dirty Bombs: Response to a Threat," p. 8.
[20] David Pierson, "'Dirty' Bomb's Impact Studied," *Los Angeles Times*, August 22, 2004.
[21] Ferguson, et al., *Four Faces*, p. 268.
[22] Health Physics Society, "Background Information on 'Guidance for Protective Actions Following a Radiological Terrorist Event, Position Statement of the Health Physics Society," January 2004, pp. 1-2.
[23] Ibid., p. 2; see also MacKinney, "Guidance for Federal Protective Actions and Recovery After Radiological and Nuclear Incidents," p. 23.
[24] "Radiation Protection at EPA: The First 30 Years," U.S. EPA, Office of Radiation and Indoor Air, EPA 402-B-O0-001, pp. 45-46, <http://www.epa.gov/radiation/docs/history.pdf>.
[25] U.S. EPA, Radiological Emergency Planning and Preparedness; Title 44, Part 351.22, *Code of Federal Regulations* (revised as of October 1, 2002), in Elcock, et al., "Establishing Remediation Levels, p. 2507.
[26]U.S. EPA, *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents*, Office of Radiation Programs, #400R92001, May 1992, p. iii.
[27] Ibid., p. 7.
[28] MacKinney, "Guidance for Federal Protective Actions," pp. 21, 23.
[29] U.S. EPA, *Manual of Protective Action Guides,* p. iii.
[30] Ibid., p. 1-2.
[31] Ibid., p. 2-6.
[32] Ibid., p. 1-3.
[33] Ibid., p. 4-4.
[34] Ibid., p. 1-3.
[35] FEMA, "Federal Radiological Emergency Response Plan (FRERP)," Operational Plan, *Federal Register*, May 8, 1996, pp. 25-26; see *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism* (Washington, DC: National Academies Press, 2002), p. 58.
[36] Elcock, et al., "Establishing Remediation Levels."
[37] "Nuclear Health and Safety: Consensus on Acceptable Radiation Risk to the Public is Lacking," General Accounting Office (now the Government Accountability Office; GAO), GAO/RCED-94-190, September 1994, pp. 1, 4.
[38] Ibid., p. 10. See report for more on alternative models used to assess radiation risks.
[39] Ibid. Based on the GAO's survey of expert opinions on this matter. In its recent position statement, "Radiation Risk in Perspective," the Health Physics Society "recommends against quantitative estimation of health risks below an individual dose of 5 rem in one year or a lifetime dose of 10 rem above that received from natural sources." Kenneth L. Mossman, Marvin Goldman, Frank Masse, William A. Mills, Keith J. Schiager, and Richard L. Vetter, "Radiation Risk in Perspective," Health Physics Society Position Statement, March 1996 (revised August 2004), p. 1.
[40] "Scientific Basis Inconclusive, and EPA and NRC Disagreement Continues," GAO, GAO/RCED-00-152, June 2000, p. 8.
[41] Ibid.
[42] Elcock, et al., "Establishing Remediation Levels," p. 2508. The EPA's commonly used dose conversion equates 15 mrem with a 0.0003 (3 x 10 ^ -4) increased risk of cancer, roughly one death in 10,000 people.
[43] GAO/RCED-94-190, p. 7.
[44] See GAO/RCED-00-152, pp. 16-20, for a discussion of the differences between EPA and NRC cleanup strategies in the context of radioactive waste at Yucca Mountain.
[45] Ibid., p. 21, n. 28.
[46] In part, Elcock, et al., "Establishing Remediation Levels," p. 2510.
[47] Yassif, "How Well Did TOPOFF 2," p. 24.
[48] Ferguson, et al., *Four Faces*, p. 295.
[49] Ibid., p. 307.

[50] National Public Radio, "Analysis: Homeland Security to Release Guidelines Related to Responding to Dirty Bombs," transcript from June 27, 2004, and Yassif, "How Well Did TOPOFF 2," p. 25.
[51] Harvey Simon, "Ridge Wants to Develop Single Radiological Contamination Standard," *Aviation Week's Homeland Security and Defense*, July 2, 2003, p. 4.
[52] Wald, "U.S. Plans to Offer Guidance For a Dirty-Bomb Aftermath."
[53] Simon, "Ridge Wants to Develop."
[54] MacKinney, "Guidance for Federal Protective Actions," p. 21.
[55] DHS Office of the Press Secretary, "Department of Homeland Security (DHS) Release Summary Conclusions From National Exercise," DHS, December 19, 2003.
[56] White House, Homeland Security Presidential Directive 5, February 28, 2003, <www.whitehouse.gov/news/release/2003/02/20030228-9.html>.
[57] "Protective Action Guides, Interim Final," p. 2.
[58] MacKinney, "Guidance for Federal Protective Actions," p. 24.
[59] Wald, "U.S. Plans to Offer Guidance."
[60] Ibid.
[61] Peter A. Buxbaum, "DHS Nears Release of Guidelines for Cleanup After 'Dirty Bomb,'" *Aviation Week's Homeland Security and Defense*, May 5, 2004, p. 7, and Jenny Weil, "Groups Object to DHS Standards Proposed for Dirty Bomb Cleanup," *Nucleonics Week* 45, December 9, 2004, p. 6-7.
[62] Buxbaum, "DHS Nears Release of Guidelines."
[63] MacKinney, "Guidance for Federal Protective Actions," and "Protective Action Guides, Interim Final,"
[64] "Protective Action Guides, Interim Final," pp. 3, 8; see also MacKinney, "Guidance for Federal Protective Actions," p. 24.
[65] U.S. EPA, "Manual of Protective Action Guides," p. 2-5.
[66] MacKinney, "Guidance for Federal Protective Actions," p. 24.
[67] "Protective Action Guides, Interim Final," p. 2.
[68] See MacKinney, "Guidance for Federal Protective Actions," p. 24. Such a comparison between cleanup from a nuclear facility accident and an RDD is highly dependent on specific characteristics of the incident. MacKinney's description of the working group's deliberations assumes an accident at a small facility, such as a radiation source manufacturer. An accident at a large nuclear power plant would likely release large quantities of relatively long-lived radioactive materials, like cesium-137, as occurred in the Chernobyl accident. Such a disaster, however, is widely considered extraordinarily unlikely in the United States given differences in design and safeguards at U.S. plants.
[69] Ibid.
[70] Health Physics Society, "Background Information on 'Guidance for Protective Actions Following a Radiological Terrorist Event,'" Health Physics Society Position Statement, January 2004, p. 3.
[71] "Protective Action Guides, Interim Final," p. 9.
[72] McKinney, "Guidance for Federal Protective Actions," p. 25, and "Protective Action Guides, Interim Final," p. 9.
[73] Ibid.
[74] Paraphrase of Buddemeier reported in Joe Fiorill, "U.S. to Issue Guidance on Nuclear Response," Global Security Newswire, September 23, 2004.
[75] MacKinney, "Guidance for Federal Protective Actions," p. 25.
[76] Ibid. and "Protective Action Guides, Interim Final," p. 10
[77] "Protective Action Guides, Interim Final," p. 10
[78] Ibid., p. 26.
[79] Ibid.
[80] For example, see Peter D. Zimmerman and Cheryl Loeb, "Dirty Bombs: The Threat Revisited," *Defense Horizons* 38 (January 2004), p. 9.
[81] Elcock, et al., "Establishing Remediation Levels," p. 2511.
[82] Hebert, "Planned Cleanup for Dirty Bombs Called Lax."
[83] GAO/RCED-00-152, p. 25. The GAO notes that "…the EPA and NRC, while disagreeing over appropriate public protection levels, are both regulating at levels where the harm of radiation and the health benefits

of radiation standards may not be clearly demonstrable. Regulating at these levels, well below the range where radiation effects have been conclusively verified, is essentially a policy judgment." GAO/RCED-00-152, p. 28.

[84] See David Willman and Michelle Munn, "Dirty Bombs' Greatest Impact Likely Would Be Psychological," *Los Angeles Times*, June 11, 2002, p. A16.

[85] For more on public reactions to radiological terrorism, see National Council on Radiation Protection and Measurement (NCRP), "Management of Terrorist Events Involving Radioactive Material," Report No. 136, October 24, 2001, pp. 55-56.

[86] R. D. Lasker, *Redefining Readiness: Terrorism Planning Through the Eyes of the Public* (New York: The New York Academy of Medicine, 2004), p. 39.

[87] Zimmerman and Loeb, "Dirty Bombs: The Threat Revisited," p. 4.

[88] D.L. Collins and A.B. de Cravalho, "Chronic stress from the Goiania 137Cs radiation accident," *Journal of Behavioral Medicine* 18 (1993), pp. 149-157, cited in NCRP, "Management of Terrorist Events Involving Radioactive Material," p. 58.

[89] Ferguson et al., *Four Faces*, p. 270.

[90] Reference to the EPA's 15 mrem "cleanup rule" for Superfund sites and the forthcoming PAG for the early phase of a radiological terrorist incident.

[91] Ferguson, et al., *Four Faces*, p. 308. On this point, see also Mark M. Hart, "Disabling Radiological Dispersal Terror," paper presented at The American Nuclear Society Winter Meeting, Technical Sessions National Meeting and Embedded Topical Meeting: Emergency Preparedness and Response, Washington, DC, November 8, 2002, p. 12.

[92] The criticism is based on an undated version of the guidance printed in the independent *Inside EPA* in November 2003; see Wald, "Pending U.S. Advice."

[93] Nuclear Information and Resource Service, Press Release, December 2, 2004, "Groups Criticize Homeland Security Plans to Relax Radiation Cleanup Standards for a 'Dirty Bomb' or Terrorist Nuclear Explosive."

[94] Weil, "Groups Object to DHS Standards."

[95] For more on the importance of educating the public about the RDD threat, see Charles Ferguson and Kaleb Redden, "Facing the Inevitable: Arm Public with Facts on Dirty Bomb Defense," *Defense Weekly*, February 9, 2004, p. 53.

[96] Lasker, *Redefining Readiness,* p. 45.

[97] Harry C. Vantine and Thomas R. Crites, "Relevance of Nuclear Weapons Clean-up Experience to Dirty Bomb Response," Lawrence Livermore National Laboratory, and Wald, "Pending U.S. Advice."

[98] EPA Office of the Inspector General, "Evaluation Report: EPA's Response to the World Trade Center Collapse: Challenges, Successes, and Areas for Improvement," Report No. 2003-P-00012, August 21, 2003, p. 7.

[99] Ibid., pp. 7-13.

[100] Ibid., p. 12.