U.S. Department of Justice

Federal Bureau of Investigation

RADIOLOGICAL/NUCLEAR

LAW ENFORCEMENT AND PUBLIC HEALTH INVESTIGATION HANDBOOK

September 2011 Edition

U.S. Department of Health & Human Services

Centers for Disease Control and Prevention

CDC
Centers for Disease Control and Prevention

To identify community and regional response agencies' point of contact (use the list below as a starting point on which to build)

Resource	*Contact*	*Phone Number*
FBI WMD Coordinator		
Local FBI		
FBI Hotline		
Local JTTF		
City LE Agency		
County LE Agency		
State LE Agency		
City PH Agency		
County PH Agency		
State PH Agency		
CDC Emer Ops Center		770-488-7100
FEMA Ops Center		800-634-7084
EPA Emer Ops Center		202-564-3850
EPA National Response Center		800-424-8802
NRC Ops Center		301-816-5100
DOE Ops Center		202-586-8100
FBI HQ SIOC, 24/7		202-323-3300
DHS National Ops Center		202-282-8000
DHS National Ops Center Senior Watch Officer		202-282-8101
FDA Emer Ops Center		866-300-4374

INTRODUCTION

> *"The greatest threat before humanity today is the possibility of a secret and sudden attack with chemical or biological or radiological or nuclear weapons."*
>
> **Former President George W. Bush**
> **February 11, 2004**
>
> *"...the greatest threat to United States and global security is no longer a nuclear exchange between nations, but nuclear terrorism by violent extremists..."*
>
> **President Barack H. Obama**
> **April 6, 2010**

Current information indicates that, regardless of location, American assets and citizens will continue to be targets of terrorist activities. Terrorists have demonstrated their willingness to employ nontraditional weapons to achieve their ends. One such class of nontraditional weapons is radiological/nuclear (RN) devices. RN devices pose new challenges to both law enforcement (LE) and public health (PH) officials in their efforts to minimize the effects of a RN attack, prevent or stop additional attacks, attribute the attack to the perpetrators, and apprehend those responsible for it.

In the past, it was not uncommon for LE and PH officials to conduct separate and independent investigations. However, a RN attack requires a high level of cooperation between these two disciplines to achieve their respective objectives of minimizing public panic and radiation exposure, preventing the spread of radioactive contamination, identifying the perpetrators, and apprehending/prosecuting those responsible for the attack. The lack of mutual awareness and understanding, as well as the absence of established communication procedures, could hinder the effectiveness of separate, but often overlapping, LE and PH investigations. The effective use of all resources will be critical to an efficient and appropriate response to any terrorist RN attack.

PURPOSE

This handbook serves several purposes:

- Provide an introduction to RN LE and PH investigations so personnel have a better understanding of each other's information requirements and investigative procedures.
- Identify potential barriers LE and PH personnel will encounter during their respective RN incident investigations and provide potential solutions that can be adapted to meet the needs of the various jurisdictions and agencies throughout the United States (US).
- Enhance the appreciation and understanding by all parties of each discipline's expertise.

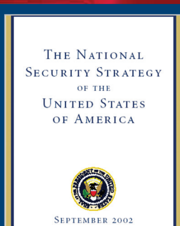
► *Common LE and PH Goals*

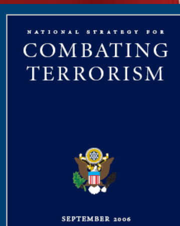
- Protect public health and safety.
- Prevent or stop the spread of contamination and avoid unnecessary radiation exposure.
- Identify those responsible for a threat or an attack.
- Protect their respective employees during their responses and investigations.
- Prevent or stop another attack.

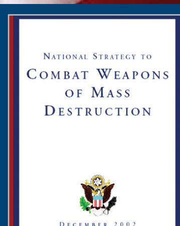
This handbook has been developed to maximize resources and facilitate communication and interaction among LE and PH officials. Additionally, it seeks to foster a greater understanding among LE and PH personnel to minimize potential barriers to communication and information sharing during an actual RN incident. LE and PH officials are encouraged to read the entire handbook and not limit their review to just their respective sections. This shared understanding is critical because LE and PH communities have two common concerns: early identification of the criminal act or PH emergency and time sensitivity associated with obtaining information.

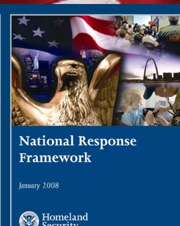
Even with common concerns, each group may be hesitant to provide specific types of information to the other because of actual or perceived information sharing limitations. Identifying and resolving the potential barriers to a free flow of information in advance will facilitate the timely exchange of critical information when dealing with an actual RN incident.

NATIONAL POLICY









HOMELAND SECURITY PRESIDENTIAL DIRECTIVE-5

On February 28, 2003, President George W. Bush issued Homeland Security Presidential Directive-5 (HSPD-5), *Management of Domestic Incidents*, which directs the Secretary of Homeland Security (Secretary) to develop and administer the National Incident Management System (NIMS). In consultation with other departments/agencies, the National Response Framework (NRF), which integrates the Federal government domestic prevention, preparedness, response, and recovery plans into a single, all-discipline, all-hazard plan was developed. The objective is to ensure that all levels of government across the nation have the capability to work effectively together by using a national approach to domestic incident management. In these efforts, with regard to domestic incidents, crisis and consequence management are treated as a single, integrated function, rather than two separate functions.

According to HSPD-5, the Secretary is the Principal Federal Official for domestic incident management. Pursuant to the Homeland Security Act of 2002, the Secretary is responsible for coordinating Federal operations within the US to prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies. The Secretary shall coordinate the Federal government's resources used in response to or recovery from terrorist attacks, major disasters, or other emergencies if and when any one of the following four conditions applies: (1) a Federal department or agency acting under its own authority has requested the assistance of the Secretary, (2) the resources of state and local authorities are overwhelmed and Federal assistance has been requested by the appropriate state and local authorities, (3) more than one Federal department or agency has become substantially involved in responding to the incident, or (4) the Secretary has been directed to assume responsibility for managing the domestic incident by the President.

Per HSPD-5, the Attorney General (AG) has lead responsibility for criminal investigations of terrorist acts or terrorist threats by individuals or groups inside the US or directed at US citizens or institutions abroad, where such acts are within the Federal criminal jurisdiction of the US, as well as for related intelligence collection activities within the US, subject to the National Security Act of 1947 and other applicable law, Executive Order 12333, and AG approved procedures pursuant to that Executive Order. Generally acting through the Federal Bureau of Investigation (FBI), the AG, in cooperation with other Federal departments and agencies engaged in activities to protect our national security, shall also coordinate the activities of other members of the LE community to detect, prevent, preempt, and disrupt terrorist attacks against the US.

Following a terrorist threat or incident that falls within the criminal jurisdiction of the US, the full capabilities of the US shall be dedicated to assisting the AG to identify the perpetrators and bring them to justice. The AG and the Secretary shall establish appropriate relationships and mechanisms for cooperation and coordination between their two departments.

NUCLEAR FORENSICS

On July 3, 2007, the President approved Annex IV to National Security Presidential Directive (NSPD)-17/HSPD-4. This annex further defined roles and responsibilities relative to RN forensics, which are referred to as "technical nuclear forensics" (TNF). The complete text of the annex is classified, but the basic roles and responsibilities assigned to the AG, normally through the FBI, can be summarized as follows: (1) conducting and directing TNF operations, (2) maintaining TNF capabilities across the government, (3) coordinating TNF developments, and (4) reporting results from any TNF investigations.

To provide further coordination for the US Government's (USG) efforts to identify the nature, source and perpetrator(s) of an attempted or actual RN attack, the US Congress passed the Nuclear Forensics and Attribution Act (Public Law 111-140) on February 16, 2010. This public law established the National Technical Nuclear Forensics Center (NTNFC) with the Department of Homeland Security's (DHS) Domestic Nuclear Detection Office (DNDO) as a mechanism to provide centralized stewardship, planning, assessment, gap analysis, exercises, improvement, and integration for all federal nuclear forensics and attribution activities.

NATIONAL INCIDENT MANAGEMENT SYSTEM

The NIMS provides a consistent nationwide template to enable Federal, state, local, and tribal governments and private sector and nongovernmental organizations to work together effectively and efficiently to prepare for, prevent, respond to, and recover from domestic incidents, regardless of cause, size, or complexity, including acts of catastrophic terrorism. The NIMS provides mechanisms for further development of supporting national standards, guidelines, protocols, systems, and technologies.

Building on the foundation provided by existing incident management and emergency response systems used by jurisdictions and functional disciplines at all levels, this system integrates best practices that have proven effective over the years into a comprehensive framework for use by incident management organizations in all-hazard context (terrorist attacks, natural disasters, and other emergencies) nationwide. It also sets in motion the mechanisms necessary to leverage new technologies and adopt new approaches that will enable continuous refinement of the NIMS over time. The NIMS was developed through a collaborative, intergovernmental partnership with significant input from the incident management functional disciplines, the private sector, and nongovernmental organizations. HSPD-5 requires all Federal departments and agencies to adopt the NIMS and use it in their individual domestic incident management and emergency prevention, preparedness, response, recovery, and mitigation programs and activities, as well as support of all actions taken to assist state, local, and tribal entities. The directive also requires Federal departments and agencies to make adoption of the NIMS by state and local organizations a condition for Federal preparedness assistance (through grants, contracts, and other activities) beginning in fiscal year 2005.

The NIMS represents a core set of doctrine, concepts, principles, terminology, and organizational processes to enable effective, efficient, and collaborative incident management at all levels. It is not an operational incident management or resource allocation plan. To this end, HSPD-5 requires the development of the NRF, which integrates Federal government domestic prevention, preparedness, response, and recovery plans into a single, all-discipline, all-hazard plan. Using the comprehensive framework provided by the NIMS, the NRF provides the structure and mechanisms for national-level policy and operational direction for Federal support to state, local, and tribal incident managers and for exercising direct Federal authorities and responsibilities as appropriate under the law.

NATIONAL RESPONSE FRAMEWORK

The NRF (or Framework) is a guide to how the US conducts all-hazards response. It is built on scalable, flexible, and adaptable coordinating structures to align key roles and responsibilities across the nation. It describes specific authorities and best practices for managing incidents that range from the serious, but purely local, to large-scale terrorist attacks or catastrophic natural disasters.

This document explains the common disciplines and structures that have been exercised and matured at the local, tribal, state, and national levels over time. It describes key lessons learned from Hurricanes Katrina and Rita, focusing particularly on how the Federal government is organized to support communities and states in catastrophic incidents. Most importantly, it builds on the NIMS, which provides a consistent template for managing incidents. The term "response" as used in the Framework includes immediate actions to save lives, protect property and the environment, and meet basic human needs. Response also includes the execution of emergency plans and actions to support short-term recovery. The Framework is always in effect, and elements can be implemented as needed on a flexible, scalable basis to improve response.

The Framework is written especially for government executives, private-sector and nongovernmental organization leaders, and emergency management practitioners. It is addressed to senior elected and appointed leaders, such as Federal department or agency heads, state governors, mayors, tribal leaders, and city or county officials—those who have responsibility to provide for effective response. For the nation to be prepared for any and all hazards, its leaders must have a baseline familiarity with the concepts and mechanics of the Framework.

The Framework also informs emergency management practitioners by explaining the operating structures and tools used routinely by first responders and emergency managers at all levels of government. For these readers, the Framework is augmented with online access to supporting documents, further training, and an evolving resource for exchanging lessons learned.

The NRF Resource Center (http://www.fema.gov/nrf) is an important online reference center that provides stakeholders at all levels of government, the private sector, and nongovernmental organizations access to the NRF and supporting documents. In particular, the NRF incident annexes address contingency or hazard situations requiring specialized application of the NRF. The incident annexes describe the missions, policies, responsibilities, and coordination processes that govern the interaction of public and private entities engaged in incident management and emergency response operations across a spectrum of potential hazards. The annexes are typically augmented by a variety of supporting plans and operational supplements. Two annexes are applicable to address our current national policy as it relates to this handbook. The Nuclear/Radiological Incident Annex and the Terrorism Incident Law Enforcement and Investigation Annex are available at http://www.fema.gov/emergency/nrf/index.htm.

NUCLEAR/RADIOLOGICAL INCIDENT ANNEX

► *Purpose*

The Nuclear/Radiological Incident Annex (NRIA) of the NRF describes the policies, situations, concepts of operations, and responsibilities of the Federal departments and agencies governing the immediate response and short-term recovery activities to address the consequences of incidents involving release of radioactive materials. These incidents may occur on Federally owned or licensed facilities, privately owned property, in urban centers, or other areas and may vary in severity from small to catastrophic. The incidents may result from inadvertent or deliberate acts. The NRIA applies to incidents where the nature and scope of the incident requires a Federal response to supplement the state, tribal, or local incident response.

The NRIA has several purposes:

- Define the roles and responsibilities of Federal agencies in responding to the unique characteristics of different categories of RN incidents
- Discuss the specific authorities, capabilities, and assets the Federal government has for responding to RN incidents that are not otherwise described in the NRF
- Discuss the integration of the concept of operations with other elements of the NRF, including the unique organization, notification, and activation processes and specialized incident-related actions
- Provide guidelines for notification, coordination, and leadership of Federal activities

Because there are several categories of potential incidents and impacted entities, this annex identifies different Federal agencies as "coordinating agencies" and "cooperating agencies" and associated strategic concepts of operations based on the authorities, responsibilities, and capabilities of those departments or agencies. In addition, this annex describes how other Federal departments and agencies support the DHS when leading a large-scale, multiagency Federal response.

► *Scope*

This annex applies to two categories of RN incidents: inadvertent or otherwise accidental releases and releases related to deliberate acts. These incidents may also include potential release of radioactive material that poses an actual or perceived hazard to public health, safety, national security, and/or the environment. The category covering inadvertent releases includes two categories of nuclear facilities (commercial or weapons production facilities), lost radioactive material sources, transportation accidents involving RN material, domestic nuclear weapons accidents, and foreign accidents involving nuclear or radioactive material that impact the US or its territories, possessions, or territorial waters. The second category includes, but is not limited to, response to the effects of deliberate attacks perpetrated with radiological dispersal devices (RDDs), radiological exposure devices (REDs), nuclear weapons, or improvised nuclear devices (INDs).

This annex applies whenever a Federal response is undertaken unilaterally pursuant to Federal authorities or when an incident exceeds or is anticipated to exceed state, local, or tribal resources. The level of Federal response to a specific incident is based on numerous factors, including, the ability of state, local, and tribal officials to respond; the type, amount, and custody of (or authority over) radioactive material involved; the extent of the impact or potential impact on the public and environment; and the size of the affected area.

If any agency or government entity becomes aware of an overt threat or act involving RN material/device or indications the incident is not inadvertent or otherwise accidental, the Department of Justice (DOJ) should be notified through the FBI. The AG has lead responsibility for criminal investigations of terrorist acts or terrorist threats by individuals or groups inside the US or directed at US citizens or institutions abroad, where such acts are within the Federal criminal jurisdiction of the US. The AG, in cooperation with other Federal departments and agencies engaged in activities to protect our national security, shall also coordinate the activities of the other members of the LE community to detect, prevent, preempt, and disrupt terrorist attacks against the US. For investigations pertaining to RN incidents, the coordinating and cooperating agencies perform the functions delineated in this annex and provide technical support and assistance to the FBI in the performance of its LE and criminal investigative mission. Further details regarding the FBI response are outlined in the Terrorism Incident Law Enforcement and Investigation Annex. In situations resulting from a deliberate act, NRIA response actions will be coordinated with the NRF and the Terrorism Incident Law Enforcement and Investigation Annex and the Catastrophic Incident Annex, as appropriate.

Under the NRF and the NRIA, the Department of Health and Human Services (HHS) has the major role in protecting people's health through the following:

- assessing, monitoring, and following up on people's health;
- ensuring the safety of workers involved in and responding to the incident;

- ensuring that the food supply is safe;
- providing medical and public health advice; and
- providing medicines (medical countermeasures) to treat radiation exposure or contamination with radioactive materials.

When exercising domestic incident management responsibilities, the Secretary is supported by other coordinating agencies (Table 1, page 17) and cooperating agencies. For incidents wherein the Secretary is not fulfilling domestic incident management responsibilities, the coordinating agency will be the responsible agency for domestic incident management as defined by its authorities.

Table 1. Coordinating Agencies for RN Incidents

RN Facilities or Materials Involved in Incident	Coordinating Agency
Nuclear facilities	
Owned or operated by the Department of Defense (DoD) or the Department of Energy (DOE)	DoD or DOE
Licensed by the Nuclear Regulatory Agency (NRC) or an Agreement State	NRC
Not licensed, owned, or operated by a Federal agency or an Agreement State or currently or formerly licensed facilities for which the owner/operator is not financially viable or is otherwise unable to respond	Environmental Protection Agency (EPA)
Radioactive materials being transported	
Materials shipped by or for DoD or DOE[a]	DoD or DOE
Shipment of NRC or Agreement State–licensed materials	NRC
Shipment of materials in certain areas of the coastal zone that are not licensed or owned by a Federal agency or Agreement State (see DHS/U.S. Coast Guard (USCG) list of responsibilities for further explanation of “certain areas”)	DHS/USCG
All others	EPA

RN Facilities or Materials Involved in Incident	Coordinating Agency
Radioactive materials in space vehicles impacting within the United States	
Managed by the National Aeronautics and Space Administration (NASA) or DoD	NASA or DoD
Not managed by DoD or NASA and impacting certain areas of the coastal zone	DHS/USCG
All others	EPA
Foreign, unknown, or unlicensed material[b]	
Incidents involving inadvertent import of radioactive materials	DHS Customs and Border Protection
Incidents involving foreign or unknown sources of radioactive material in certain areas of the coastal zone	DHS/USCG
All others	EPA
Nuclear weapons[a]	DoD or DOE (based on custody at time of incident)
All deliberate attacks involving RN facilities or materials, including RDDs or INDs[c,d]	DHS

a. The coordinating agency is either DoD or DOE, depending on which of these agencies has custody of the material at the time of the incident.

b. The DHS DNDO coordinates the adjudication of unresolved radiation detection alarms.

c. For deliberate attacks, DHS assumes its domestic incident management responsibilities under HSPD-5, paragraph 4, and is also the coordinating agency for implementing the activities in this annex with respect to deliberate attacks.

d. For deliberate attacks, DOJ assumes those LE coordination activities under HSPD-5, paragraph 8.

TERRORISM INCIDENT LAW ENFORCEMENT AND INVESTIGATION ANNEX

► *Purpose*

The purpose of this annex is to facilitate an effective Federal LE and investigative response to all threats or acts of terrorism within the US, regardless of whether they are deemed credible and/or whether they escalate to a major RN incident. To accomplish this aim, the annex establishes a structure for a systematic, coordinated, unified, timely, and effective national LE and investigative response to threats or acts of terrorism within the US. The FBI is the coordinating agency for the Terrorism Incident and Law Enforcement and Investigation Annex.

► *Scope*

This annex is a strategic document that:

- provides planning guidance and outlines operational concepts for the Federal LE and investigative response to a threatened or actual terrorist incident within the US; and
- acknowledges and outlines the unique nature of each threat or incident, the capabilities and responsibilities of the local jurisdictions, and the LE and investigative activities necessary to prevent or mitigate a specific threat or incident.

Under the NRF and NRIA, the LE and investigative response to terrorist threats or incidents is based on the following priorities:

- preserving life or minimizing risk to health, which constitutes the first priority of operations;
- preventing a threatened act from being carried out or an existing terrorist act from being expanded or aggravated;
- locating, accessing, rendering safe, controlling, containing, recovering, or disposing of a weapon of mass destruction (WMD) that has not yet functioned and disposing of chemical, biological, radiological, nuclear, and explosive material in coordination with appropriate departments and agencies (e.g., DoD, DOE, and EPA); and
- apprehending and successfully prosecuting perpetrators of terrorist threats or incidents.

PUBLIC HEALTH

CENTERS FOR DISEASE CONTROL AND PREVENTION ROLE

Based on the terrorist events of 2001, people have expressed concern about the possibility of a terrorist attack involving radioactive materials. During and after such incidents, the Centers for Disease Control and Prevention (CDC), in cooperation with Federal agencies, would assist state, local, and tribal authorities in protecting people's health and offer guidance on actions that people can take to reduce their exposures to radiation.

CDC is a part of HHS, which includes the National Institutes for Health (NIH), the Food and Drug Administration (FDA), and several other health and family service agencies. CDC's goal is to improve the health of the people of the US through disease control and prevention, the promotion and protection of environmental health, and health promotion and education activities. CDC would be a significant public health (PH) entity to respond to a RN incident, whether accidental or intentional, with the following specific roles and responsibilities:

- assessing the health of people affected by the incident;
- assessing the medical effects of radiological exposure on people in the community, emergency responders and other workers, and high-risk populations (such as children, pregnant women, and those with immune deficiencies);
- advising state, local, and tribal health departments (working in conjunction with other Federal agencies such as the US Department of Agriculture, FDA, and EPA) on how to protect people, animals, and food and water supplies from contamination by radioactive materials;
- providing technical assistance and consultation to state, local, and tribal health departments on exposure assessment, health risk evaluation, medical treatment, follow-up, and decontamination of victims exposed to radioactive materials;
- providing laboratory services for analysis of urine samples to assess internal contamination from radionuclides; decontamination of people contaminated with or exposed to radioactive materials; and
- supporting state, local, and tribal authorities in establishing and main-

taining a registry of people contaminated with or exposed to radioactive materials.

In the hours and days following a RN incident, CDC would assist and advise state and local health departments on recommendations for communities to:

- protect people from radioactive fallout,
- protect people from radioactive contamination in the area,
- safely use food and water supplies from the area,
- assess and explain the dangers in the area of the incident, and
- monitor people (http://www.bt.cdc.gov/radiation/population monitoring.asp) for contamination (http://www.bt.cdc.gov/radiation/contamination.asp) with RN materials and exposure to radiation.

CDC also will have representatives on the Advisory Team for Environment, Food, and Health (sometimes referred to as the A-Team), a collection of experts from a variety of Federal agencies that advise state, local, and tribal governments on ways to protect people and the environment following a RN incident. To learn more about the A-team visit: http://www.crcpd.org/ATeam/Ateam.htm.

If necessary, CDC would also deploy the Strategic National Stockpile, a Federal store of medical supplies and radiological or medical countermeasures set aside for emergency situations. Table 2 (page 24) lists some countermeasures available.

In addition, CDC's National Institute for Occupational Safety and Health, in coordination with the Occupational Safety and Health Administration, would give workers in the area information on:

- the amount of time they can safely work in an area contaminated with RN materials;
- procedures needed to protect themselves from radiation and RN materials;

- types of personal protective equipment needed to work in the contaminated area; and
- use of radiation monitoring devices.

Following an incident involving RN materials, CDC would support state, local, and tribal authorities in establishing an exposure registry to monitor people's exposure to radiation and perform dose reconstructions to determine the amount of radiation to which people were exposed. This registry would assist with long-term medical follow-up for those who were affected by the incident.

Table 2. Countermeasures in Strategic National Stockpile

Name	Symbol or Brand Name	Targeted Radionuclide(s)	Benefit to Patients
Potassium iodide	KI	Iodine-131	Blocks radioactive iodine absorption in the thyroid
Prussian blue	$Fe_7(CN)_{18}$	Cesium-137 Thallium-201	Traps radioactive cesium and thallium in the intestines, keeping them from being reabsorbed by the body so that they are excreted
Calcium and zinc diethylenetriamine-pentaacetic acid (DTPA)	Ca DTPA and Zn DTPA	Plutonium-239 Americium-241 Curium-244	Removes radioactive plutonium, americium, and curium by binding onto the materials so that they will be eliminated by the body
Cytokines	Neupogen, Neulasta, and Leukine	N/A	Stimulates growth of white blood cells to help recovery of the bone marrow

PUBLIC HEALTH GOALS

The radiation PH community investigations have the following basic goals:

- **Protect public safety.** PH professionals use radiological and medical information, surveys, surveillance, and evaluation of trends to guide investigations for protecting PH. Disease surveillance will play a definitive role in protecting PH in a RN incident. Additionally, education, both before and after the incident, will affect the public response to a RN emergency and thus a substantial impact on human health.

  An essential aspect of PH is prevention of radiation contamination and/or exposure of the population. PH professionals will use survey instruments and data analysis to determine the source and the extent of environmental contamination. Additionally, members of the population will be given instructions on how to remove physical contamination to prevent further exposure and spread of contamination.

  The PH community will also be responsible for determining the extent of the exposure to the population through epidemiology, surveillance, laboratory analysis, risk and/or exposure assessment, and a long-term exposure registry. Medical intervention may be necessary in some cases, depending on the radionuclide(s) involved and the extent of exposure and/or contamination.

- **Protect PH personnel.** One major consideration during these investigations is the protection of PH personnel. Since interviewers could potentially come in contact with radioactively contaminated individuals, it is important that the proper protective protocol is provided for these individuals during their investigation.

PUBLIC HEALTH INVESTIGATIONS

Successful investigations require the thorough accumulation of information in the field. The field investigation will resemble LE investigations because of the types of information collected and the means that it is collected. The basic elements of a PH investigation occur simultaneously or in a different order, depending on the availability of personnel. The following list is a synopsis of the basic elements of a PH investigation.

► *Detecting a Radiological Incident*

Radiological incidents include a RDD, a transportation accident, and a nuclear reactor accident. Only one incident—the nuclear reactor accident—would provide pre-event situational awareness for the PH and LE agencies to address radiation exposure immediately before or after the incident. Deployment of RDDs ("dirty bomb") might also provide pre-event situational awareness for the LE and PH agencies because first responders have radiation absorbed dose (RAD) detectors that would be used during investigations dealing with bombs. Therefore, the first sign that a radiological PH emergency may have occurred is an increase in people that display some of the following adverse health effects: general weakness and discomfort, nausea, and vomiting. In fact, due to the infrequency of physicians actually encountering a case of radiation exposure or acute radiation syndrome, it is easy to see how such signs and symptoms could initially be attributed to food poisoning, metal poisoning, or an infectious disease. For most radiological incidents, disease surveillance will most likely produce information of interest to LE personnel. Hospitals, ambulatory clinics, urgent care facilities and possibly community-based primary care practitioners in the area affected should be contacted to determine whether anyone is currently or was recently receiving treatment for a similar illness.

In a nuclear detonation or IND incident, PH and LE personnel will both be aware of the source of the incident. Therefore, syndromic surveillance will not be an issue for PH investigations. The investigation will move to collecting specimens for analysis, reporting, and possible medical intervention depending on the quantity and type of RN material(s) used.

► *Identify and Characterize Additional Cases*

This element of the PH investigation has many similarities to a LE investigation. At this stage sources for cases are analyzed, and additional cases are identified. Individuals may be contacted multiple times as investigators collect additional information. Information collected by PH investigators can include the following:

- pertinent demographic data (name and contact information);

- clinical data (signs and symptoms, duration, onset, etc.);
- exposure history (travel, meals, and significant incidents, all based on the type of illness suspected); and
- case contacts and knowledge of other cases.

In addition to interviewing personal contacts of the cases, PH officials will attempt to identify all the cases of exposure to treat the victims with medical countermeasures and to initiate long-term tracking. This step will be accomplished through soliciting media assistance to notify everyone with the symptoms of the time, date, and location of the incident and to decontaminate themselves through CDC-provided instructions. Affected individuals should go to a population monitoring welcome center for further assistance. Population monitoring welcome centers will be essential in triaging cases and post-incident tracking of individuals.

► *Confirm Diagnosis Through Collection of Specimens*

Due to its noninvasive nature, collecting urine specimens will be one of the primary methods for diagnosis of exposure to radionuclides. Other materials that may be collected to support the investigation include food, water, environmental samples (air filters, soil, vegetation, etc.), and other biological samples (nasal swabs). The Division of Laboratory Sciences within the National Center for Environmental Health at CDC will be responsible for testing the clinical samples, while EPA, DOE, and others will test environmental samples.

► *Reporting*

The time necessary for a confirmatory diagnosis can range from hours to days, depending on the radionuclide(s) involved in the incident. PH officials may develop a potential scenario about the source of the radiological incident as they accumulate additional clinical laboratory results and receive intelligence information from their LE partners. Senior officials may wait for the results of the confirmatory tests prior to confirming the diagnosis if RN terrorism is suspected; however, implementation of the intervention plan may require action prior to this confirmation based on the available information.

► *Implement Intervention Plans*

The ultimate objective of the above procedures is to identify the radionuclide(s) used in the incident and protect the public's health through medical intervention, depending on the dosage and the type of radionuclide used. Implementation of the intervention plan should be executed as soon as it is known that radiation is involved. Thus, the spread of contamination can be reduced significantly and PH can be addressed. An intervention plan developed by CDC is outlined in the document entitled "*Population Monitoring in Radiation Emergencies: A Guide for State and Local Health Planners*", which can be downloaded at http://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf. The guide focuses on planning a PH response to RN terrorism incidents.

Population monitoring is an essential element that is often overlooked in emergency response planning for RN terrorism incidents. Many critical components of population monitoring should be put in place in the first few hours after the incident, before the arrival of Federal assets that might be used to assist in the monitoring efforts. The planners' guide described above, focuses on the significant effort required to identify, screen, measure, and monitor populations (people and possibly even their pets) for exposure to or contamination from RN materials. The guide also presents the concept of a community "reception" center (monitoring and decontamination facility) for a large-scale RN incident. The community reception centers would be established to assess people for exposure, contamination, and the need for decontamination and to register people for follow-up monitoring or medical assessment.

LAW ENFORCEMENT

FEDERAL BUREAU OF INVESTIGATION ROLE

As affirmed by HSPD-5 and the NRF, the FBI is the lead agency for criminal investigations of terrorist acts or terrorist threats and intelligence collection activities within the US. All Federal, state, local, and tribal departments and agencies must notify their local FBI WMD Coordinator (WMDC) and/or the Joint Terrorism Task Force (JTTF), through the FBI field office, regarding information associated with the threat of terrorism or an actual terrorist incident. In many cases, the WMDC is a member of the JTTF, which is operational in every FBI field office. The JTTF consists of representatives from Federal, state, local, and tribal LE/response agencies. The institution of the JTTFs improves real-time information sharing, analysis, and investigations/prevention activities.

WMDCs are located in each of the 56 field offices of the FBI. Their purpose is to act as a conduit to FBI Headquarters (FBIHQ) for investigative expertise, technical information, advice, and assistance. The WMDC is contacted by state, local, and tribal emergency responders in the event of a threat or incident potentially involving WMD. In addition, the WMDCs liaise with Federal regional counterparts such as the EPA, the FDA, the Drug Enforcement Administration, and PH and representatives of state, local, and tribal organizations.

In the event of a threat or an incident potentially involving WMD, the local WMDC will contact FBI Headquarters (FBIHQ) WMD Operations Unit (WMDOU) for operational response direction. WMDOU initiates a Threat Credibility Evaluation (TCE) conference call - the forum for addressing WMD threat and incident response protocols. The TCE process consists of evaluating the plausibility of the threat based on three major factors: behavioral resolve, operational practicality, and technical feasibility. Through the course of the threat analysis, WMDOU will involve, as needed, other Federal, state and local partners having relevant subject matter expertise. During the conference call, the evaluation of the situation is developed and conveyed to the WMDCs in support of their response and investigation. TCEs can be conducted throughout the investigative process as determined necessary and additional information is acquired to determine the credibility of the threat.

The two primary sections at FBIHQ assisting the WMDC are the Investigations and Operations Section (IOS) and the Countermeasures and Preparedness Section (CPS). IOS' mission is to identify, prevent, mitigate, investigate, and resolve the use or threatened use of WMD as a means of terrorism directed against the US, its citizens, or its interests. CPS' mission is to understand the scientific aspects of current and anticipated WMD threats encountered by the FBI, as it pursues its goals in the prevention of WMD terrorism, and develop countermeasures against them.

The FBI has multiple response resources or assets to provide assistance in the event of a terrorist incident involving WMD including the Hazardous Materials Response Team Unit (HMRTU), Hazardous Materials Response Teams (HMRT), Hazardous Materials Operations Unit (HMOU), Hazardous Materials Science Response Unit (HMSRU), Evidence Response Teams (ERT), and the Chemical Biological Radiological and Nuclear Sciences Unit (CBRNSU).

The HMRTU's mission is to provide investigative, forensic, and incident command system expertise to FBI field offices and Legal Attache offices (LEGAT) involving CBRN/WMD suspicions, threats, and/or crime scenes. HMRTs are comprised of FBI Special Agents, FBI support personnel and JTTF Officers specially trained in the collection and preservation of forensic evidence in a CBRN environment including WMD. The HMRTs are located at select FBI field offices within the US to regionally respond to hazardous material crime scenes and investigations.

HMOU's mission is to provide advanced hazardous materials and technological response services/capabilities to the FBI and Interagency partners to support crime scene operations. HMSRU's mission is to provide scientific, technical and forensic support to FBI criminal and intelligence investigations. Every FBI field office has an ERT whose mission is to conduct crime scene investigations and to collect physical evidence using the techniques of forensic science. CBRNSU's mission is to develop and maintain the FBI's ability to conduct and/or direct high-quality forensic examinations of hazardous chemical, biological, and RN materials and all related evidence.

LAW ENFORCEMENT INVESTIGATION GOALS

The LE community has the following set of goals during a RN attack:

- **Prevent a criminal act.** The role of LE begins with steps to prevent a terrorist from successfully executing an attack. Through investigations and intelligence, LE personnel seek to obtain information to identify terrorists, their targets, and methods of attack before a criminal act can be executed. It is necessary to safeguard against disclosure of intelligence information and the means by which it was gathered, especially during ongoing productive operations. Inadvertent release of sensitive information may compromise not only the specific threat being investigated, but also other/future investigations.
- **Protect public safety.** The overriding goal of LE is to protect the public from terrorist threats or attacks. Ideally, this goal includes preventing the terrorist attacks or alternatively apprehending the terrorist after the incidents to prevent additional attacks.
- **Protect LE personnel.** LE personnel are likely to encounter radioactive contamination (on the ground, suspended in air, and/or in all surrounding objects, structures, etc.) and/or be exposed to radiation. LE personnel must take precautions and wear appropriate personal protective equipment to avoid radioactive contamination or inhaling any suspended radioactive material. Additionally, LE personnel must be knowledgeable on radiation exposure limits/guidance and wear appropriate dosimeters (to measure cumulative exposure) to avoid exceeding safety limits. There may not be sufficient information about all the radiological hazards at the incident site. Thus, LE personnel are encouraged to contact the local FBI WMDC or HMRT Team Leader who will coordinate consultation with experts at the HMTRU, HMSRU and HMOU prior to entering the site.
- **Support the US attribution process.** The US attribution goal is to identify the nature, source, and perpetrator(s) of an attempted or actual RN attack. This includes rapid and comprehensive coordination of intelligence reporting, LE information, technical forensic information, and other relevant data streams to evaluate adversaries' capabilities, resources, supporters, and modi operandi in the context of a recent, completed or attempted RN attack(s).

- **Identify, apprehend, and prosecute the perpetrators.** LE personnel seek to obtain sufficient evidence and information to identify and to apprehend the individual(s) responsible for the attack. A criminal investigation into a RN attack is not complete until there is a successful prosecution and conviction of those responsible for the attack. Collection of evidence includes interviewing victims and witnesses, as well as obtaining and preserving physical evidence. In a RN attack, individuals and evidence may be contaminated with RN materials, requiring special decontamination and handling procedures. LE personnel must follow strict evidence collection procedures to obtain sufficient admissible evidence needed to achieve conviction. Any abnormalities, such as a break in chain of custody in the collection or maintenance of evidence, may prevent the use of potentially incriminating evidence at the trial. LE personnel will coordinate closely with the agencies and their personnel responsible for the collection of contaminated evidence to ensure proper procedures are followed.

LAW ENFORCEMENT CRIMINAL INVESTIGATIONS

► *Preventing a RN Attack*

Preventing a RN attack is the first line of defense and is the ultimate goal of LE. The first step in preventing and preparing for a RN attack is to attempt to identify potential terrorists or terrorist organizations likely and capable of executing a RN attack. This information allows LE officials to identify potential targets and possible modes of attack. Detecting a potential terrorist during planning, procurement, or development of a RN device is a second investigative avenue that LE must explore to prevent a RN attack. In reality, not every RN attack can be prevented; therefore, appropriate Federal, state, local, and tribal agencies must be prepared to respond to a RN incident.

► *Criminal Investigation Process*

Individuals conducting criminal investigations must operate within the applicable laws governing the investigations and the ensuing prosecution. As information is compiled, a thorough understanding of the elements necessary to prove each pursued offense will help guide the investigators to identify any missing or weak evidence. A brief summary of the criminal investigation process is provided below. While the steps are presented sequentially, some aspects of the investigation may occur simultaneously.

► *Threat Evaluation—Real or Hoax*

LE personnel may be confronted with a noncredible threat (hoax), threatened RN attack, announcement that a RN attack has occurred (overt), or an unannounced RN attack (covert). When a claim that a RN device has been or will be used is received, the FBI, in consultation with recognized experts, will conduct a threat evaluation to determine whether the threat is credible. If the threat is credible, LE in conjunction with PH, must take action to prevent or minimize the effect of a RN attack. Whether or not the threat is deemed credible, LE personnel will initiate an investigation to identify and prosecute those responsible for the threat. Under Federal law, a threat involving RN material or device is a criminal act whether or not the perpetrator actually possesses the RN material or device.

In an unannounced or covert RN attack, the PH community will most likely see the effects of radiation and/or contamination on patients seeking medical attention from their private practitioners and hospital emergency rooms. In a covert RN attack, the PH surveillance system will be the key to identifying unexplained illnesses across the population or similar symptoms being reported by community-based primary care practitioners and hospitals. As soon as the PH community suspects radiation exposure or contamination to be the result of an intentional act, LE personnel should be contacted to initiate a preliminary criminal investigation. If PH officials and LE have forged a working relationship prior to a RN attack, it is more likely that the PH officials will feel more comfortable contacting LE early in their radiological investigation, allowing for prompt initiation of the criminal investigation.

► *Gather Evidence*

The process of gathering evidence during the investigation of a RN incident involves collection of physical evidence, such as contaminated evidence or samples of RN materials, parts of the device, human body specimens, clothing of both victims and suspects, documents, as well as photographs and witness statements. LE personnel must consider a variety of issues to ensure that the evidence they gather can ultimately be used in a criminal prosecution. The list below provides a summary of some of the key issues LE personnel must consider.

- **Chain of custody.** Chain of custody is the method used to track and maintain control and accountability of all evidentiary items. This encompasses initial collection of the evidence through final disposition of the contaminated evidence or RN materials. Both LE and PH personnel must provide accountability at each stage of collecting, handling, testing, storing, and transporting the evidentiary items and reporting any test results. Failure to properly maintain the chain of custody may prevent the evidence in question from being introduced at trial. In some instances, there may be an overriding need by authorities to identify the RN materials as soon as possible to ensure the proper response is implemented and steps can be taken to protect the responders and the public. In this instance, the need for rapid collection and testing of evidence to save lives outweighs the normal evidence collection procedures. PH officials should be aware that specimens collected for PH investigations could become evidence for criminal prosecutions.
- **Delivery of contaminated evidence to appropriate laboratories.** Forensic laboratories that process traditional criminal evidence are not equipped to test for the presence of RN materials or handle contaminated evidence. The FBI has partnered with DOE and DoD to create a network of laboratories across the country with appropriate facilities and expertise to conduct appropriate analyses with approved equipment, qualified personnel, and accepted practices.
- **Documents.** Original documents should be obtained by LE when possible. Issues of authenticity and admissibility arise if copies are relied upon when original documents are available. Potentially contaminated documents should be stored and examined using appropriate procedures and personal protective equipment to protect both the individuals handling the evidence and the evidence itself.

- **Witness statements.** Witness descriptions of dissemination devices, vehicles, suspects, sounds, flashes, and other specific information must be obtained as soon as possible after a RN incident. The information a witness has to provide is "time sensitive," and the sooner the information can be obtained, evaluated, and disseminated, the more value it has to investigators. The potential for errors in witness statements increases proportionally with time since the incident occurred. This can occur as witnesses hear others describe their experiences. The accuracy of a witness' recollection can be greatly eroded by the influence of others' comments and by fading memories.

► *Evaluate Evidence*

The FBI is responsible for the collection of contaminated evidence for traditional and technical nuclear forensics. As evidence is gathered and collected, an ongoing evaluation of the evidence must be part of the investigative process. An understanding of the types of evidence and the rules governing the admissibility of the evidence will lead to better evaluations of the evidence as the investigation progresses. While not intended to be all inclusive, Table 3 (page 37) identifies and briefly explains some of the types of evidence collected during the investigative process.

Table 3. Types of Evidence Collected During an Investigative Process

Type of Evidence	Explanation	Examples
Circumstantial	Facts, if proven, allow the fact-finder to draw conclusions. In most jurisdictions, circumstantial evidence has probative value.	Suspect has radiation burns or exhibits symptoms of radiation sickness. Suspect is contaminated with radioactive materials.
Direct	Documents, records, physical evidence, notes, computer data, videotapes, or other types of information that directly relate to the case.	Vehicle rental agreements, purchase receipts, phone records, eyewitness statements.
Trace	Minute particles of matter which can be examined through microscopic, physical, chemical, or radiological analysis.	Traditional RN material residue, fibers, hair.
Hearsay	A statement, other than one made by the declarant while testifying at the trial or hearing, offered in evidence to prove the truth of the matter asserted.	A person who did not personally witness a suspect engaging in a particular manner but is reporting the observation based upon what someone else told him or her, and the person who actually made the observation is not testifying or available for the opposing party to cross examine.
Eyewitness	Observation or sensation personally seen, smelled, heard, felt, or tasted.	Witness reporting seeing a blinding flash or hearing a specific explosion sound or seeing someone.

► *Protection of Evidence*

It should be noted that evidence collected in a potentially contaminated environment must be assumed to be contaminated, significantly complicating the evidence review and evaluation process. The evidence can be tested to rule out contamination, reviewed in a facility designated to handle contaminated evidence, photographed to allow review of the contents in a safe environment, or when possible decontaminated prior to review. To properly focus their investigation in a terrorist incident, LE personnel need the results of any analyses or tests on evidence as quickly as possible. During major criminal investigations, LE officers expect a quick turnaround on laboratory results. In a RN terrorism attack, the time required to positively identify RN material(s) or device(s) may be considerably longer.

Like other investigations, during a RN incident, the investigators never know what nuance or piece of information will be the crucial break needed to identify, arrest, convict, and attribute those responsible for the terrorist attack. From the beginning of a criminal investigation into a RN attack until the case is submitted to a jury for a verdict, all facts collected during the investigation must be verified, and inconsistencies resolved and submitted to the prosecutor. Documents must be carefully analyzed to ensure they have been thoroughly reviewed and the information contained in the documents is interpreted correctly. Sometimes information contained in statements or reports is subject to differing interpretations. Investigators must examine the evidence for conflicting interpretations and resolve these issues as soon as possible or be prepared to explain the contradictions.

It is equally important to develop a mechanism to submit all information, statements, laboratory reports, documents, photos, and other evidentiary items to the prosecutor in an organized manner to ensure all of the facts are identified prior to trial. Additionally, sufficient time should be allowed to permit the prosecutor to meet with the investigators and witnesses to review all reports, evidence, and anticipated testimony.

► *Apprehend Suspects*

Once a RN threat has been prevented or a RN attack occurs and the threat to the public is either reduced or eliminated, identifying and supporting the US attribution process and building a prosecutable case against those responsible for the attack are the top priorities for LE personnel. Suspecting or even knowing who is responsible for a RN attack is different from having sufficient evidence to attribute or charge and prosecute the perpetrators. Especially when human lives are lost in a RN attack, there is tremendous pressure on LE personnel to identify, locate, and arrest the perpetrator(s).

During the apprehension of a suspect or group of suspects, LE personnel involved in the arrest need to take precautions against possible injury from the perpetrator(s). By the time LE personnel are prepared to make an arrest, the perpetrator(s) have already demonstrated or professed the willingness to kill or injure large numbers of innocent citizens. It is also possible that the arresting officers will be confronted with a radioactively contaminated environment, contaminated evidence, or even one or more contaminated suspects. While apprehending the suspects is a major phase of the investigative process, safety of the arresting team and innocent bystanders is paramount. Appropriate personal protective equipment and strict protocols for working in contaminated areas or high-radiation fields must be followed to avoid radioactive contamination or radiation exposure.

► *Render Testimony*

Prior to testifying at trial, each potential government witness should be available to meet with the prosecutor. It is important for the prosecutor to have the opportunity to evaluate how each witness may appear to the jury. Additionally, any issues, problems, discrepancies, or gaps in the evidence or testimony can be discussed and resolved. To avoid lost evidence or rulings of inadmissibility, LE officers must know and have access to all sources of information and evidence so inconsistencies or discrepancies can be investigated and addressed.

JOINT OPERATIONS

JOINT INVESTIGATIVE INFORMATION

The successful execution of LE and PH investigations during a RN incident will depend on the efficient use of all available resources. When possible, LE and PH personnel should work in teams and jointly conduct interviews with victims and witnesses. Prior to the actual interview with a witness or victim, the joint investigation team should decide which person will lead the interview and how they will work together during the interview. It is recommended that the epidemiological interview proceed first during a joint interview; however, the order of the interviews must be decided on a case-by-case basis.

When joint interviews are not possible, the separate investigative communities should be aware of the types of information their counterpart is seeking. PH personnel should obtain and provide information from their epidemiological investigation to LE personnel that would benefit a criminal investigation. Conversely, the LE community should provide data to PH personnel that would benefit an epidemiological investigation. The objective of the joint investigation and joint interviews of victims and witnesses is to maximize the efficiency of both LE and PH investigators through the exchange of real-time information.

EFFECTIVE INFORMATION EXCHANGE

One of the goals of this handbook is to encourage LE and PH officials to notify and involve each other early in an investigation, even if it turns out to be a noncriminal act (Table 4, page 43). It is essential to establish key communication mechanisms between the LE and the PH communities. These mechanisms are especially important for the expeditious exchange of information in an actual RN incident. This exchange of information requires LE and PH personnel to be familiar with one another and to know which people in each agency need to receive the information.

Table 4. How to Recognize RN Incidents

Radiological	Nuclear
• Does not involve a nuclear explosion • Victim can have contamination and/or exposure • Examples: ◦ RDD ◦ RED ◦ Nuclear reactor accident ◦ Transportation accident	• Involves a nuclear explosion (fusion/fission) • Victims can have contamination and/or exposure • Examples: ◦ Nuclear weapon ◦ IND
Not Obvious in Real Time	**Obvious in Real Time**
• Hazardous materials professionals detect radiation on scene of explosion • Monitoring of water, soil, food, and/or air for unexpected radiation • Requires clinical recognition of cluster of unusual clinical signs and symptoms of victims • Environmental detectors locate hidden sources outside of expected places (e.g., subway, sports facilities) • Examples: ◦ Explosive dispersal ◦ Nonexplosive dispersion into environment, water, food, and/or air ◦ Hidden radiological source ◦ Malicious industrial, nuclear reactor, and/or medical facility sabotage ◦ Transportation accident	• Information from Federal, state, local, and/or tribal authorities • News report • Routine radiation monitoring of ◦ Industrial radiation sources ◦ Planned transport of radiation sources ◦ Medical facility radiation sources • Personal observation • Examples: ◦ Nuclear explosion ◦ Transport accident ◦ Medical facility accident or lost source ◦ Nuclear reactor accident or sabotage ◦ Industrial radiation source accident

POTENTIAL BARRIERS

► *PH Barriers*

The first potential barrier is that the PH community is concerned it will be held legally liable for the release of patient information without consent. Some legal issues associated with confidentiality are listed below:

- PH officials normally obtain patient information from medical practitioners. The issue of whether or not this information is confidential and legally "privileged" must conform with Federal and state laws, including the Health Insurance Portability and Accountability Act (HIPAA). PH officials should consult their agency legal counsel regarding the applicability of the HIPAA exception.
- PH officials may take clinical samples from patients to aid in their RN investigation, suggest the most effective treatment, and assist in assessing the potential impact on public safety. LE officials may require access to these clinical samples and/or sample results (as potential evidence) of a criminal investigation. PH officials and LE personnel must properly maintain chain of custody for evidentiary purposes. A review of applicable Federal and state statutes should be conducted to determine protocols to address limitations and challenges while meeting both organizations' needs to obtain these samples.
- LE officials may want to obtain specific information from health records at hospitals, health maintenance organizations, or the Centers for Medicare and Medicaid Services. HIPAA protects the confidentiality of health information and governs the release of this information by medical providers to LE officials. Generally, LE officials will require patient consent or legal process, such as a subpoena or court order, to obtain patient medical information. HIPAA does contain some exceptions to this general rule for LE request for protected health information under 45 Code of Federal Regulations 164.512. One exception is "to avert a serious threat to health or safety" if the health care provider, in good faith, believes that disclosure is necessary to prevent or lessen a serious or imminent threat to the health and safety of a person or the public. The disclosure must be made only to a person or persons who are reasonably able to prevent or lessen the threat. There are other LE

exceptions that may be used in the absence of consent or legal process to obtain these records. LE officials should consult their agency's legal counsel regarding these exceptions. LE officials should also be aware that psychotherapy notes and patient substance abuse medical records are afforded additional special protections under the law.

A second potential barrier to the exchange of patient information is based on issues of ethics and trust. Patients provide detailed information to the medical community with the tacit understanding that physicians and PH professionals will retain that information in confidence. The PH community has expressed concern that providing confidential patient information to the LE community, regardless of reason or intent, may jeopardize their future ability to obtain data that are critical to identify and treat patients. Additionally, protecting the confidentiality of information is one of the elements of the code of conduct for medical and PH professionals.

The doctor-patient privilege is a statutory privilege that varies from state to state, but generally can be waived by the patient. In some jurisdictions and cases, the physician may assert the privilege on behalf of the patient. In general, the three elements listed below must be present for the privilege to exist:

- The information must be given with the expectation that it will not be disclosed and must be given in the usual context of a professional relationship;
- The purpose of the professional relationship is to maintain confidentiality; and
- The possible injury to the professional relationship from the disclosure must be greater than the expected benefit to justice or the public in obtaining the information.

It should be noted that neither Federal common law nor the Federal rule of evidence recognize the physician-patient privilege. However, Federal law does recognize the psychotherapist-patient privilege. Patient consent, a subpoena, or a court order are typical methods for obtaining patient medical information and records. As noted earlier, however, information that is provided by physicians to PH authorities can be provided to LE authorities for the purposes of protecting public health and safety. There are no specific barriers to the sharing of this information between PH and LE officials, but it is widely recognized that recipients should be limited to those working an investigation or public safety response. Efforts should be made by LE to ensure the protection of sensitive identifying information associated with medical data and limit its use for the purpose of investigating instances of disease and preventing illness.

► *LE Barriers*

The LE community also has two primary concerns regarding the exchange of investigative information. First, they may be reluctant to provide information that could jeopardize the safety of confidential informants or the security of classified sources. Information that LE personnel obtain from informants is frequently so sensitive that, if the information were exposed, the suspects would be able to determine exactly who had provided the information to LE officials. As a result, the more people who have access to the sensitive information, the greater the possibility that the information source will be exposed. While not discounting the need for closely held, informant-provided information, PH officials would like to receive an alert from LE of the need for heightened awareness and/or preparedness. This alert may or may not require the disclosure of sensitive information, but it would notify PH officials of unusual or unexplained symptoms and to monitor what may otherwise initially be overlooked as a signal that a radiation exposure and/or contamination has occurred.

Second, the LE community is concerned that the suspects may avoid detection as a result of the exchange of sensitive information. For example, should LE personnel inform the PH community to look for a specific individual or group, the number of individuals who know the specifics of the case will obviously increase. As in any investigation, the more people who have access to sensitive information, the more opportunities exist for inadvertent disclosure of the information. As a result, there is a greater opportunity for sensitive information to inadvertently leak back to the suspected perpetrators, thus giving them the advanced warning needed to facilitate the destruction of evidence, possibly avoiding detection, and potentially affecting a successful prosecution of the perpetrator(s).

► *Joint Interviews*

Collaboration between LE and PH officials has not always been recognized as beneficial. There are concerns that the presence of LE officers would compromise the collection by PH of sensitive medical information (e.g., a person uses illegal drugs). Indeed, some degree of separation from LE may be advantageous for obtaining complete and accurate data during PH investigations. However, LE investigation of potential RN incidents requires interviewing all potential witnesses and victims. Separate questioning by LE and PH investigators may lead to conflicting statements by the interviewee, jeopardizing the admissibility of those statements in subsequent judicial proceedings. Despite these challenges, joint interviews are recommended in certain situations.

When there are benefits from doing joint LE and PH interviews, a process should be established that allows for confidential LE communications with PH officials regarding specific health-related issues that interviewees may be unwilling to share when LE personnel are present. Both LE and PH must recognize that the sharing of information can be crucial for identifying persons who have been contaminated or exposed and may be in need of medical services. Conducting joint interviews affords the opportunity to examine relevant facts based on the unique perspectives of both investigators. It also highlights that the primary goal of both LE and PH is protecting life and safety.

Special consideration should be made to protect the identifying information of interviewees, both to preserve victim privacy as well as the integrity of a criminal investigation. Because of different training backgrounds and professional experiences, LE and PH interviewers may recognize and note different information or clues that could aid in identifying the source of illness and its perpetrator(s). Additionally, concurrent interviews reduce the number of times persons must be questioned.

► *Information Exchange Triggers*

During a RN incident, certain information or a specific event should trigger the exchange of information between the LE and the PH communities. For example, the LE community conducts criminal investigations every day, and in recent years, there have been numerous RN hoaxes. What should prompt the LE community to contact the PH community and involve them in the criminal investigation of such an incident? At what point in an epidemiological investigation should the PH community be prompted to contact LE? Both communities are legitimately concerned about overreacting and further stretching their already overburdened infrastructure and resources.

Below are lists of factors that could trigger LE or PH communities to exchange information. These lists are not all inclusive but are intended to provide a starting point to tailor or improve individual jurisdictional needs. Each jurisdiction may want to add or remove triggers to suit its individual needs. The most important aspect of this information exchange is to overcome the hesitation or reluctance to share information before all of the facts are known.

► *LE Triggers*

- Any intelligence or indication that an individual or group is unlawfully in possession of RN material and/or devices
- Seizure of any RN material, devices, and/or its specialized handling tools from an individual, group, or organization where there appears to be no legitimate use
- Seizure of any potential dissemination devices from an individual, group, or organization where there to be seems no legitimate use
- Report of a theft or loss of industrial or medical radiological source(s)
- Identification or seizure of literature pertaining to the development of RN devices and/or dissemination of RN materials where there is no discernible lawful purpose and is a perceived risk to public health
- Any assessments that indicate a credible RN threat exists
- A hazardous material response which involves the presence of RN materials

► *PH Triggers*

- Large numbers of patients with similar and unusual symptoms
- Large numbers of unexplained deaths
- Higher than expected morbidity and mortality associated with common symptoms and/or failure of patients to respond to traditional therapy
- Simultaneous clusters of similar illness in noncontiguous areas
- RN agents transmitted through aerosol, food, or water, suggestive of sabotage
- Ill persons presenting near the same time, suggestive of a point source

SHARING SENSITIVE INFORMATION

► *Information Matrices*

The timely exchange of information is critical to achieve an effective response to a RN incident. However, there are concerns within LE and PH communities about the types of information that each group will openly exchange. Both communities may determine there are circumstances that may necessitate withholding certain types of information from each other because of legal restrictions.

To help lower barriers to the free exchange of information, Table 5 (page 51) can assist members of the LE and PH communities to understand the types of information each seeks and potential means to obtain that information. The categories in the table are defined below.

- **Known information.** Information that each group has during the specific phase of the incident.
- **Needed information.** Information that each group needs to effectively conduct its investigation during the specific phase of the incident—information that the PH community needs from the LE community or vice versa.
- **Actions.** Steps that should be taken by each community to obtain the information or to identify what information can be readily obtained.

- **Presuspicion.** Both communities may be receiving unusual information, but there is nothing to raise suspicion of a criminal act or a RN incident.
- **Suspicion.** The LE community has information that leads it to believe a criminal act may be committed or has been committed, or the PH community suspects radiation illness. LE personnel would initiate measures to identify, acquire, and plan the use of resources needed to anticipate, prevent, and/or resolve an attack.
- **Incident management.** Measures to protect PH and safety, restore essential government services, and provide emergency relief to governments, businesses, and individuals affected by the consequences of terrorism.
- **Recovery.** Gradual return to normal operations.

Table 5. Information Matrix

Phase	Known Information	Needed Information	Actions
PH and Medical Information			
Pre-suspicion of a RN incident	• Unusual symptoms • Potential recognition of radiation sickness/ contamination	• Potential radioactive material available in the area • Threat: RDD, RED or IND?	• Can freely provide assessments and analyses without personal data • Medical examiner provides data on fatalities to prosecutor; no subpoena needed • Prosecutor can request post-mortem data; no subpoena needed • No specific case data released • Hospital/emergency medical service does not report to LE directly; immediately report up the chain to PH officials • Follow state laws for reporting

Phase	Known Information	Needed Information	Actions
PH and Medical Information			
Suspicion of a RN incident	• Same as above • Analysis of incident • Medical examiner findings • FBI laboratory network findings • Contact information on other potential cases via interviews	• Medical community information • Specific data: potential targets? • Any specific information on type (alpha, beta, gamma) or isotope of radiation?	• Laboratory analyses provided to all response groups • PH will take steps to ensure appropriate release of information • A subpoena ensures the release of information and legally protects PH from liability • Prosecutors can obtain medical examiner information • Information is reported to CDC • Report to local health departments • Require patient permission for additional laboratory testing
Incident management	• Same as above	• Same as above • Survey extent of the devastation and/or contamination • Approximate number of casualties	• Epidemiological investigation • Local PH personnel advised by CDC on epide-miological questions • Share epidemiological investigation results with LE officials

Phase	Known Information	Needed Information	Actions
PH and Medical Information			
Recovery	• Patient treatment • Post-incident dose calculations • Long-term registry	• Same as above • Damage to infrastructure	• Same as above
LE Information			
Pre-suspicion of a RN incident	• Data concerning potential terrorist threat(s) • Data concerning potential radiological device/material	• Information about unusual symptoms • Patient information	• LE will openly reveal general information • No specific case information will be released • Special consideration should be given regarding whether sources and methods will be compromised by information release
Suspicion of a RN incident	• Specific case data • Suspect group and/or individuals • Threat information: type of radiological device, target, and method of delivery	• Patients are potential victims of radiation exposure or contamination • Personal information • Suspect radionuclide	• Can exchange information with appropriate cleared and vetted individuals to help with investigation

Phase	Known Information	Needed Information	Actions
LE Information			
Incident management	• Specific data on the attack • Sources and methods data • Potential suspect(s) in custody	• Same as above • Location of victims • Medical assessments • Laboratory information for prosecution	• LE will alert PH officials • Share known information to minimize PH risk
Recovery	• Same as above	• All potential suspects • Ongoing victim report, list of victims and/or casualties, patient information • Any information on any criminal activity, regard-less of time frame	• Investigation and prosecution

► *Recommendations to Improve the Information Exchange*

As noted above, the LE and PH communities are more willing to exchange information once they have confirmed a criminal act. An exchange of available information in the early stages of a RN incident is critical to contain the situation (RN material, contamination, evidence, etc.) and effectively apprehend/prosecute the perpetrators. Table 5 (page 51) and Table 6 (page 57) provide some guidance on how to obtain and disseminate sensitive information. However, the steps required to obtain the information may cause both communities to lose valuable time in their investigations. Some guidance is listed below on how individual jurisdictions can improve information sharing between LE and PH officials. The recommendations are intended to be general so that any jurisdiction can tailor the recommendations based on local needs and any legal restrictions on information sharing.

- Establish information exchange group;
- Develop close working relationships between LE and PH officials;
- Include a PH official in the Joint Operations Center;
- Include a LE official in the PH Operations Center;
- Prepare the local emergency response community on the characteristics of a RN terrorist attack;
- Preestablish agreements on sensitive and laboratory results information sharing; and
- Conduct training/exercises on topics such as chain of custody, joint interviews, etc.

PUBLIC INFORMATION RELEASE

The media will have a significant impact on the response and the public reaction to a RN incident. As a result, each community should use a single representative, identified by each jurisdiction, to coordinate and disseminate the response to queries, ensuring that the appropriate information, especially sensitive information, is released to the media at the proper time. Table 6 (page 57) provides general guidance concerning a jurisdiction's interaction with the media.

MEDIA ISSUES

LE and PH officials need to develop a working relationship with the media to ensure timely and useful information is shared with the media to keep the public accurately informed, but not overly alarmed. While not intentional, the media may negatively impact the investigation by releasing information that could cause public panic or compromise LE sources. The goal of keeping the public accurately informed can be accomplished by issuing public announcements. It is paramount that LE and PH officials coordinate their media information in accordance with the NIMS. The designated spokesperson will help to ensure the accuracy of the information being disseminated to the public and should have adequate expertise to respond to technical questions specific to either LE or PH issues. The spokesperson may also help avoid the release of sensitive information. With the public fear and the psychological impact of a RN attack, the media will aggressively seek information from the investigators. Establishing a Joint Information Center (JIC) will aid both the LE and PH officials in dealing with the media and providing timely and accurate information.

Table 6. Release of Information to the Media/Public

Phase	Information for the Media	Who Releases the Information
Pre-suspicion of a RN incident	NA	NA
Upon suspicion of a RN incident	• Confirm something unusual • Need to provide rumor control • Prepare to respond to inquires • Do not release any threat assessments	• Designate a single point of contact for LE and PH agencies to coordinate information release • Points of contact work together to develop a single response to queries • Develop agreed-upon rules of public release
Incident management	• Alert media to decon-tamination procedures and other pertinent information • Confirm and announce any protective actions • Provide rumor control • Use risk/crisis communications to address the psycho-logical impact of RN terrorism	• Same as above • LE and PH agencies coordinate response; establishment of a joint information center to coordinate communications with the public; develop a joint LE and PH press release, if appropriate
Recovery	• Focus on closure issues • Media reassurance "everything is back to normal" if possible	• Emphasis on LE and PH actions in support of the community • Focus on the investigation and prosecution

SUMMARY

SUMMARY

This handbook provides recommendations for, and is intended to increase the reader's awareness of issues surrounding the effective coordination of LE and PH investigations. Individual jurisdictions should modify this guidance to accommodate their individual needs and the special characteristics of their emergency response procedures. The recommendations made in this handbook should not be viewed as policy directives from the Federal government for immediate implementation.

The primary goal of this handbook is to promote the sharing of information and to encourage LE and PH personnel to establish effective information exchange procedures to improve their LE and PH investigations. Both communities will be better prepared to save lives, avoid panic, and work together. This cooperation should lead to improved capabilities to prevent a RN attack, minimize the impact of an attack, prevent subsequent attacks, and ensure the successful prosecutions and convictions of the perpetrator(s).

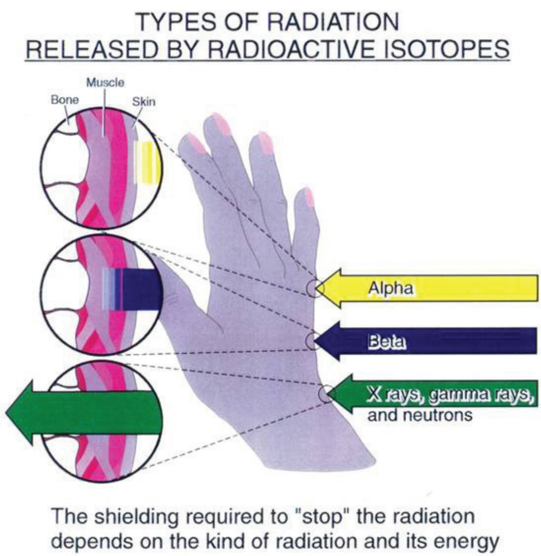
APPENDICES

Appendix A. Applicable Federal WMD Statutes

18 U.S.C. §13	Laws of states adopted for areas within Federal jurisdiction
18 U.S.C. § 35	Imparting or conveying false information
18 U.S.C. § 831	Prohibited transactions involving nuclear materials
18 U.S.C. § 832	Participation in nuclear and weapons of mass destruction threats to the United States
18 U.S.C. § 842	Unlawful acts
18 U.S.C. § 844	Penalties
18 U.S.C. § § 872–880	Extortion and threats
18 U.S.C. § 876	Mailing threatening communications
18 U.S.C. § 1038	False information and hoaxes
18 U.S.C. § 1365	Tampering with consumer products
18 U.S.C. § 1366	Destruction of an energy facility
18 U.S.C. § 1992	Terrorist attacks and other violence against railroad carriers and against mass transportation systems on land, on water, or through the air
18 U.S.C. § 2283	Transportation of explosive, biological, chemical, or radioactive or nuclear materials
18 U.S.C. § 2332a	Threatened use of a weapon of mass destruction
18 U.S.C. § 2332b	Acts of terrorism transcending national boundaries
18 U.S.C. § 2332f	Bombings of places of public use, government facilities, public transportation systems and infrastructure facilities
18 U.S.C. § 2332h	Radiological Dispersal Devices
42 U.S.C. § § 2011–2284	Atomic Energy Act
49 U.S.C. § 60123	Criminal penalties

Appendix B. Understanding Radiation and its Health Effects

Ionizing radiation is radiation capable of producing ions when passing through matter. Alpha, beta, gamma, and neutron radiation are released from a nuclear reaction, such as fission, fusion, and radioactive decay. Alpha particles are helium nuclei with a mass of 4 atomic mass units and a +2 charge. They are emitted in radioactive decay and formed in fusion. Betas are charged particles of very small mass which are emitted during decay and are identical to electrons moving at high speeds. Electrons carry a –1 charge, and positrons carry a +1 charge. Gammas, also called "photons," are small packets of energy that have no mass or charge. They are released in fission, fusion, radioactive decay, inelastic scatter, and neutron capture. Neutrons are atomic particles with no charge and a mass of 1 atomic mass unit. They are released from fission and fusion. Alphas and betas are the primary health concern internally while gamma and neutrons are for external exposure. Some of the most radiotoxic radionuclides are alpha emitters.



► *How Radiation Interacts with Matter*

Alpha particles interact strongly with atomic electrons because of their strong positive charge. Because alpha particles interact so strongly with atomic electrons, they travel a short range. They move in a straight line, deposit all of their energy quickly, and are what is known as a densely ionizing radiation.

Unlike the interaction of alpha particles with matter, the path of beta particles through matter is not in a straight line. While beta particles may penetrate only a short distance into a medium, their mean path length (the average distance that a beta particle would travel in a medium if its path were straightened out) can be quite long.

Ionizing electromagnetic radiation (gamma and X-rays) interacts with orbital atomic electrons through various processes, causing atomic electrons to be ejected from their orbits. Like beta particles, if the gamma ray or X-ray ejects an atomic electron with enough energy, the atomic electron can cause additional ionizations. Neutrons are electrically neutral and interact with matter by either collisions with or absorption by an atomic nucleus. Collisions with atomic nuclei slow down, or thermalize, a neutron so it may undergo nuclear capture.

In nuclear capture, the incident neutron is actually absorbed into the nucleus. This event can make the nucleus unstable and, therefore, radioactive. An unstable nucleus will shed its excess energy through radioactive decay and will emit particulate radiation and/or gamma rays. Nuclear capture is how objects, people, soil, etc., become radioactive after a nuclear detonation.

► *How Radiation Is Measured*

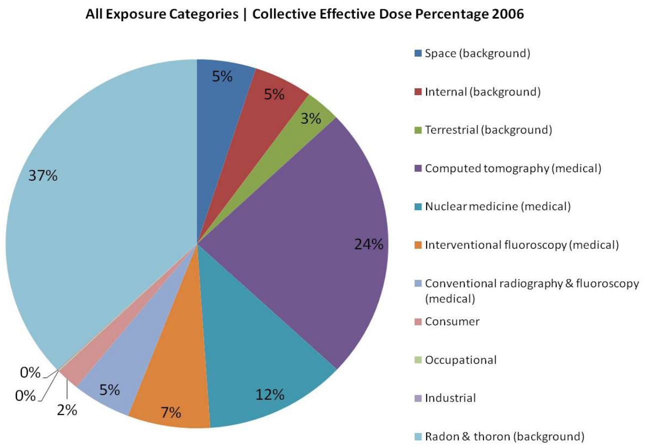
Gamma radiation is measured in **roentgens** (R), which measure the amount of ionization caused in air. One R will cause 2.08×10^9 ion pairs when it passes through 1 cm^3 of dry air at standard temperature and pressure. Since gamma rays have no mass, R is purely a measure of energy. Exposure rates are normally expressed in R/hr or mR/hr.

The **rad** is used to measure gamma energy absorption. Converting R to rad is dependent on the material absorbing the radiation. In tissue near the surface of the body, 1 R equals 1 rad. Dose rates are usually expressed in rad/hr or mrad/hr.

The **rem**, an abbreviation of "roentgen equivalent in man," measures the expected effects of radiation on body and organs. It is convertible to different types of radiation, not just gamma. To find the total rem, multiply the rad (which measures gamma absorption) by the quality factor for the type of radiation involved. The quality factor for beta radiation is 1, the quality factor for alpha radiation is 10–20, the quality factor for gamma radiation is 1, and the quality factor for neutrons is 4–10. Dose rates are usually expressed in rem/hr or mrem/hr. The metric unit is the sievert (Sv).

Every person on Earth is exposed to ionizing radiation every day. The average US resident receives a dose of about 360 mrem per year. The most significant contributor to this dose is radon, a gas created by the radioactive decay of uranium. Since uranium occurs naturally in the ground and rocks, including building materials, radon seeps into buildings, where it concentrates in enclosed spaces and is inhaled.

The exposure rates in the "Radiation Dose" chart (page 66) are for the average person. A person who does not receive a medical X-ray during the year does not get that dose. Note that the average person receives less than 1 mrem per year from nuclear power production and fallout from atmospheric weapons testing.



The annual radiation dose that each person receives also varies by geographic location. For example, the background radiation levels in Denver are higher than those at sea level. Being a mile high, Denver has less air between it and the sun than does a city at sea level. Although not dense, air still acts as a shield from cosmic rays.

► *Protecting Yourself from Radiation*

The three cardinal rules of radiation protection for external radiation exposure (not contamination) from a radiation source are time, distance, and shielding.

- **Time** — The less time spent near the radiation source, the lower the exposure will be.
- **Distance** — The greater the distance from the source, the less the exposure will be. Radiation exposure decreases with distance according to the inverse-square law. That is, if you triple your distance from the radiation source, your exposure will decrease by a factor of nine.
- **Shielding** — External exposure to radiation can be partially blocked by the use of shielding. Traditionally, shielding is made of lead or concrete. However, staying behind vehicles, buildings, or other objects will also decrease exposure.

► *Effects of Ionizing Radiation on the Body*

Ionizing radiation affects the body by damaging or killing parts of the cells. Damaged cells are not able to perform their normal functions to keep the body alive and healthy. Cells can become so damaged that they are not able to reproduce themselves as they normally would, resulting in the death of the cell and thus reduced functioning of that tissue or in cancer.

► *Biological Effects of Radiation*

Radiation has two effects on health, deterministic and stochastic. A deterministic effect is a clinically observable symptom, such as hair loss, nausea, or changes in lymphocytes in the blood. The severity of a deterministic effect is directly proportional to the dose received. Time duration from exposure to manifestation of symptoms is inversely proportional to the dose. A stochastic effect is a long-term effect that may or may not happen, like cancer. The risk of a stochastic effect is proportional to the dose, but the severity of the effect is independent of dose received.

Ionizing radiation can cause changes in our cells by breaking the bonds that hold molecules together. Ionizing radiation's principal target is deoxy-ribonucleic acid, or DNA. The damage done to DNA can cause changes that would either destroy or alter the cell's growth or function. Our cells, however, do have mechanisms to repair the damage inflicted by the ionizing radiation. The efficiency of the mechanisms depends on several factors, including the type and dose of radiation. The possibility of small radiation doses inducing a clinically significant illness or other problem is remote.

The cells most sensitive to radiation are found in the lymph tissue, bone marrow, spleen, reproductive system, and gastrointestinal tract. Moderately sensitive cells are found in the skin, lungs, and liver. The least sensitive cells are in the muscles, nerves, and adult bone. Doses of radiation which are received in a 24-hour period are referred to as "acute" doses. The same amount of radiation received over a long period of time ("chronic" dose) would be less damaging to the body due to the body's ability to repair itself.

The severity of effects from internal ionizing radiation also depends on the radioactive and biological half-lives of the elements and the type and energy of radiation emitted when they decay. Elements with a long radioactive half-life continue to emit decay gammas for longer periods of time, extending the time during which the body is exposed to radiation. Elements which the body cannot easily remove have longer biological half-lives and expose the body to ionizing radiation for longer periods. Lastly, those elements which emit alphas or high-energy gammas or betas also expose the body to more damaging types of radiation.

After entering the body, radionuclides normally found in the body concentrate in areas where their counterparts are normally found. For instance, radioiodine concentrates with nonradioactive iodine in the thyroid, contributing to incidents of thyroid cancer. Elements not normally found in the body concentrate in areas with similar elements. For instance, radioactive barium and strontium are similar to calcium and, like calcium, accumulate in the bones, contributing to incidents of leukemia.

- **Deterministic effects.** Following acute whole-body dose of ionizing radiation, the body reacts in three stages: initial, latent, and final. Clinical expression of the acute radiation syndrome is strongly modified by dose, dose rate, uniformity of exposure, the extent of treatment provided, and variations in individual susceptibility. No immediate illness is observed in acute doses up to 100 rem. Between 100 and 200 rem, nausea and vomiting occur within the first day or two. During the latent period, which can last up to two weeks, few symptoms are seen, but changes in the blood appear. During the final phase, the original symptoms may reappear mildly.

  Over 200 rem, the symptoms become increasingly more severe and life-threatening. The immune system can be degraded, creating the possibility of lethal infections, especially in burn victims. Between 200 and 1000 rem, the initial phase is marked by nausea, vomiting, diarrhea, loss of appetite, and fatigue for one to two days. The latent period lasts up to two weeks, during which blood changes occur. During the final phase, the initial symptoms recur, accompanied by a step increase in temperature and hemorrhaging under the skin and in the mouth, intestines, and kidneys. At doses over 300 rem, the final stage also includes hair loss.

At doses over 1000 rem, the victim suffers almost immediate incapacitation and organ failure. Death occurs in a few hours to a week.

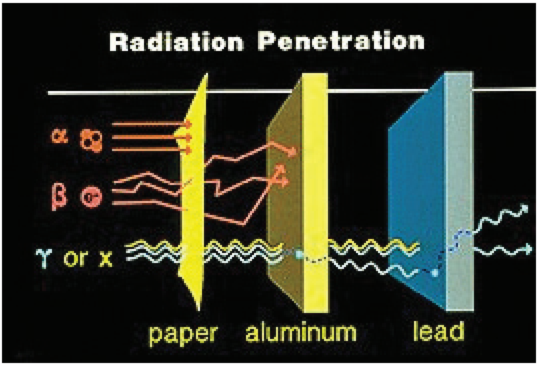
After recovery, a victim of ionizing radiation may continue to experience effects, depending on the type of radiation received, the dose received, and the person's age and gender. One of the first effects seen is cataracts. Cataracts appear within a few months to several years and are especially prevalent in patients who received more than 200 rem of radiation. The fast neutrons produced by nuclear explosions are particularly effective at causing cataracts.

- **Stochastic effects.** Long-term effects of radiation exposure are various types of cancer. One common type is leukemia, a cancer of the blood. Leukemia can appear in victims 1–20 years after exposure and affects children under 10 more often. Other common cancers seen after exposure to ionizing radiation are cancers of the thyroid, lung, gastrointestinal tract, and female breast.
- **Prenatal exposure.** When pregnant women are exposed to ionizing radiation, the children may also suffer effects. The possibility of severe health effects depends on the gestational age of the unborn baby at the time of exposure and the amount of radiation it is exposed to. Unborn babies are less sensitive during some stages of pregnancy than others. However, unborn babies are particularly sensitive to radiation during their early development, between weeks 2 and 15 of pregnancy. The health consequences can be severe, even at radiation doses too low to make the mother sick. Such consequences can include stunted growth, deformities, abnormal brain function, or cancer that may develop sometime later in life. However, since the baby is shielded by the mother's abdomen, it is protected in the womb from radioactive sources outside the mother's body. Consequently, the radiation dose to the unborn baby is lower than the dose to the mother for most radiation exposure events.
- **Biological effects specific to nuclear explosions.** Fallout is activity which is spread over areas by wind. It extends the time people are exposed to radiation as well as the area of the country in which people

are exposed. Since fallout is airborne, it can cause both internal and external effects. Externally, contact with fallout can cause burns to the skin due to beta radiation. Symptoms of beta burns include lesions, discoloration, and hair loss. Beta burns typically appear on areas of the body that are exposed. Normally, alphas and betas do not present an external danger to people because they cannot penetrate the outer layer of clothing or the external layer of skin. They do, however, pose a significant threat when inhaled, ingested, or introduced through open wounds. Early fallout drops in the first 24 hours after the detonation and poses a biological hazard. Delayed fallout drops after the first 24 hours. While the biological hazard is reduced as time passes due to the continued decay of fission products, uranium, plutonium, and activated elements in the environment, a long-term health risk still exists. The risk to health and the possibility of shifting winds can make evacuation of an area very difficult.

► *Materials Used to Shield from Ionizing Radiation*

People can be shielded from ionizing radiation by various materials. The most effective shield depends on the type and energy of the radiation. Due to their strong interactions with atomic electrons, alpha particles can be stopped by a piece of paper. On the other hand, a thicker or denser material such as aluminum is needed to stop beta particles.



Gamma rays and X-rays are even more difficult to shield against. A material with a large number of protons per atom (and thus a large number of electrons) is needed to limit the number of gamma and X-rays that penetrate the shield. Such materials are called “high

Z" materials, and a good example is lead. No matter how thick or dense a gamma- or X-ray shield is, some of the photons will get through.

Neutron shielding is a more complicated task due to the process of nuclear capture. To be effective, the shielding material must be able to slow down the neutrons. The best elements for this are "low Z" elements such as hydrogen.

In a practical situation, a 12-inch concrete wall placed between a person and the detonation will attenuate approximately 90% of fission product gammas and fast neutrons coming straight from the detonation toward the person. However, the actual dose received will be higher due to the refraction of radiation through the air that allows radiation to reach the person around the edges and top of the wall.

► *Contamination*

Contamination is radioactive material that has deposited on surfaces. Contamination can be internalized through inhalation, ingestion, or open wounds. Because the particles can be atom-sized, contamination is not visible in all cases and must be detected using radiation detectors.

► *Decontamination Is Important*

Decontamination is important because it prevents the spread of contamination. When contamination is removed from people, the total dose received is minimized, the possibility of inhalation and ingestion is reduced, and the possibility that others will be exposed is reduced. Decontaminating equipment limits activation of the equipment and reduces the possibility that others will be exposed.

► *Priorities for Decontamination*

Lifesaving efforts always take priority over preventing the spread of contamination. Do not delay urgent medical care or emergency responders for decontamination or donning protective equipment. Also, do not delay evacuation from high or potentially high exposure rate areas.

► *Personnel Decontamination*

Following emergency response to a nuclear event, a warm area—adjacent to and upwind of the hot area—should be established. The warm area should be far enough from high exposure rate areas that people waiting on the edge of the hot area are not exposed to high exposure rates. Decontamination lines should be established for emergencies, responders, and mass casualty decontamination. The number and use of these lines can vary with each incident and the stage of emergency response. The basic process in each line will be to remove the outer layer of clothing, walk through a shower, be checked for contamination, redress in uncontaminated clothing, and exit to the cool area. For responders dressed in protective equipment, the process may include only removal of protective clothing and disposing of or decontaminating equipment such as boots, gloves, and breathing equipment by wiping, rinsing, or scrubbing.

The shower area can be set up using fire hydrants or fire hoses set on low-pressure fan spray. If possible, the shower area should be curtained to provide separate lines for men and women. The water should drain back into the hot area, not forward into the cool area. People do not need to be completely free of contamination to exit to the cool area. They need only to meet the prescribed limits. Decontaminating the injured requires special precautions depending on the type of injury to avoid worsening the injury or flushing contamination into the wound. Those with life-threatening injuries do not need to be decontaminated!

Once cleared to exit the warm area, people will enter the cool area to be triaged and staged for evacuation. A monitoring and decontamination area may also be established at evacuation sites and hospitals to recheck for contamination.

CDC's intervention plan is outlined in the document entitled *Population Monitoring in Radiation Emergencies: A Guide for State and Local Health Planners*, which can be downloaded at http://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf.

Appendix C. Effects of a Nuclear Detonation

► *Overview*

There are three principal categories of primary effects resulting from a nuclear detonation: thermal radiation (35% of the energy from a nuclear detonation), blast energy (50%), and nuclear radiation (15%). Nuclear weapons effects vary significantly with the yield of the weapon detonated and the detonation's height of burst.

► *Thermal Radiation*

Thermal radiation occurs when the fireball emits intense electromagnetic radiation as a result of its very high temperature and burns objects in the surrounding area. Temperatures associated with a nuclear explosion are similar to the interior temperature of the sun, approximately tens of millions of degrees Fahrenheit. The fireball can cause damage to eyes for many miles, and combustible materials can burst into flame, creating firestorms.

Nuclear weapons detonated in the atmosphere emit thermal radiation in two distinct pulses. The first pulse emits mostly X-ray and ultraviolet radiation and very little energy of the visible thermal type. The second pulse emits mostly visible light and infrared radiation and has much more energy than the first pulse. This energy, which extends great distances, is responsible for most of the thermal damage of military significance. The total amount of thermal energy is directly proportional to the yield.

The thermal pulses can ignite wood-frame buildings and other combustible materials. Anything that casts a shadow, such as buildings, trees, and dust from the blast wave, will protect objects within its shadow from

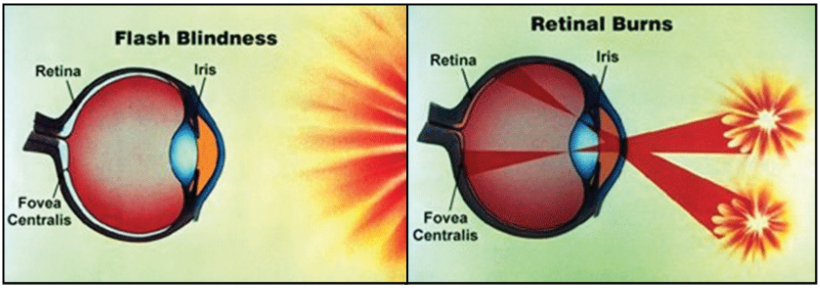
burns or ignition. Any solid or opaque material between a given object and the fireball will act as a shield and provide some protection. Transparent materials, such as glass or plastic, attenuate thermal radiation only slightly.

► *Flash Burns*

Flash burns result from absorbing high intensities of thermal radiation and are most severe close to the explosion. Flame burns are caused indirectly by the thermal energy emitted from fires. Exposed people at great distances from the burst can be burned. Third-degree burns over 25% of the body or second-degree burns over 30% of the body cause serious shock and are usually fatal unless immediate medical care is received.

► *Flash Blindness*

Looking in the direction of a nuclear detonation can result in flash blindness, which is caused by the effect on the retina of the initial brilliant flash of light produced by the explosion; temporary retinal burns may result. Flash blindness may occur even if the fireball is not in direct view. A one megaton nuclear detonation could cause flash blindness up to 11 miles away on a clear day and up to 45 miles away on a clear evening. Because pupils dilate at night, the effect of flash blindness is prolonged by as much as three times. Depending on the yield of the detonation, sufficient direct thermal radiation can result in permanent burns to the retina. Damage to the eyes can occur farther from the burst site than damage to the skin. Reflex actions



to protect the eyes, such as blinking, provide only limited protection. After viewing a nuclear detonation, a person will continue to see the afterimage of the fireball. This will not affect the central vision unless the individual was situated at or near the fireball. The afterimage may last from several seconds to several minutes. A transient dazzling effect will occur for two – three seconds as the individual's field of vision resets.

► *Blast Energy*

Blast energy is produced by X-rays heating the air surrounding the fireball; an enormous amount of energy is released in a small volume of air, producing intensely hot gases at extremely high pressures. The result is a shock wave (blast wave) that continues outward from the explosion, crushing and moving objects in the surrounding area.

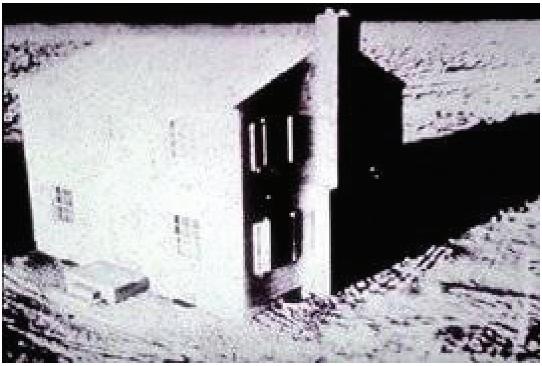
Blast effects depend on overpressure, measured in pounds per square inch (psi). The magnitude of the blast depends on the yield of the weapon, height of the burst, and distance from ground zero. Blast injuries and fatalities generally result from the indirect effects resulting from overpressure (i.e., injuries/ fatalities result when objects become missiles during motion caused by winds generated by the overpressure).

► *Overpressure*

Shock waves produce overpressure large enough to destroy virtually any structure. Overpressure is the difference between the pressure in the shock wave front and the atmospheric pressure, measured in psi. An overpressure of five psi is sufficient to destroy normal residential buildings and cause a 50% casualty rate. If the overpressure is five psi or greater; the wind velocity will be more than 150 miles per hour. The duration of the blast wave's overpressure and dynamic pressure may last from tenths of a second to seconds, depending on the yield and the distance from the burst.

► *Initial Radiation*

Initial radiation is radiation that arrives within the first 60 seconds after a nuclear detonation, generally consisting of gamma rays and neutrons, but can include alpha and beta particles and X-rays. In general, the larger the weapon's yield, the larger the dose of initial radiation. Alpha particles have an extremely limited range in the air, have little ability to penetrate the skin, and are of little significance unless they are inhaled or ingested. Beta particles are much less penetrating than gamma rays but can be extremely harmful if a beta-emitting substance is ingested or deposited on the skin. X-rays are rapidly attenuated in the air, but their effects do not dominate in the lower regions of the atmosphere. On the other hand, neutrons and gamma rays have a long range in the air, are highly penetrating, and are the main cause of casualties. Three percent of the total energy generated from a nuclear explosion is initial radiation. Gamma radiation is the most difficult to shield and is the major radiation dosage received from radioactive fallout.



Although the US no longer has neutron bombs in its arsenal, neutron bomb effects are unique. To reduce the safety distance for populated areas, designers produced the enhanced radiation weapon (the neutron bomb). This weapon produces less of its energy as blast and heat and more as nuclear radiation. On target, that radiation consists of a higher proportion of neutrons and gamma rays of higher energy than would be received from fission devices of comparable yields.

► *Residual Radiation*

Residual nuclear radiation is defined as radiation that is emitted later than one minute after the explosion. It consists chiefly of beta particles and gamma rays. The radiation is emitted mainly by fission products and other bomb residue in the fallout, and it persists for some time following a nuclear explosion. Early fallout occurs within the first 24 hours; delayed fallout occurs days to years following a nuclear explosion. Fallout patterns vary with terrain, wind speed, and direction. Residual gamma radiation, neutron, and beta effects are similar to those defined in the previous section.

► *Electromagnetic Pulse*

Electromagnetic pulse (EMP) is a sharp pulse of long-wavelength electromagnetic radiation produced when an explosion occurs in a nonsymmetrical environment, especially at or near the earth's surface or at high altitudes. EMP occurs when gamma radiation collides with atoms or objects in the air. The intense electric and magnetic fields can damage unprotected electrical and electronic equipment (i.e., communication systems, radar) over a large area.

► *Transient Radiation Effects on Electronics*

Transient radiation effects on electronics (TREE) can be temporary or permanent, depending on the type of component, its construction, the materials used, the operating state, the type of radiation, and total dose (rad) or the dose rate (rad/sec). TREE can vary widely, even among similar devices. Examples include degradation in the current amplification of transistors, temporary or permanent altering of vacuum or gas-filled tubes, and changes in capacitance and resistance. Radiation can cause a current in cables that were not exposed to a voltage. The insulation around cables and wires can also be damaged but usually recovers well. As a result, electrical service may be restored even after some physical damage to the area. Batteries, including nickel-cadmium and mercury, can withstand high levels of radiation with very few adverse affects.

► *Ground Shock and Cratering*

Ground shock is produced by two primary mechanisms: directly coupling energy to the ground in the area of the crater and pressure from the air blast as it travels over the surface. Ground shock is transmitted through the earth downward and outward. The air blast pressure at the surface, an airslap, damages surface structures and also causes a shock wave that is transmitted beneath the surface, creating most of the stress experienced by underground structures outside the crater area.

Explosions on or near the ground surface create displacement craters when soil is vaporized, displaced, or compressed. The effect varies with yield and the depth of the burst. Soil is vaporized and carried up into the fireball and eventually appears as fallout. Considerable material is displaced, or thrown out, by the air blast. Some of this material falls back into the crater, and most of the remainder forms the lip of the crater. The huge pressures from the detonation also compresses the soil.

► *Blackout*

Electromagnetic interference and complete disruption of short-wave and high-frequency radio frequency signals (radio, cell phones, and radar transmissions) are caused by an ionized region of the atmosphere (produced by a high-altitude nuclear detonation). Blackout can significantly affect military wartime operations or first responder operations after a nuclear detonation in a populated area during peacetime. Blackout can last for several hours, depending on the nuclear yield and height of burst of a nuclear weapon detonation.

Appendix D. Transportation of Radiological/Nuclear Materials

The transportation of nuclear materials is highly regulated. More than three million packages of radioactive material are shipped in the US each year, posing an environmental threat. Radioactive material is transported by highway, rail, air, and sea. During the past 40 years, more than 3000 shipments of used nuclear fuel have navigated more than 1.7 million miles of US roads and railways without any accidental release.

NRC and the Department of Transportation (DOT) are the primary Federal agencies that regulate the transportation of nuclear materials. NRC regulates users of radioactive material and the design, construction, use, and maintenance of shipping packages by establishing regulatory requirements, transportation package certification, inspections, and a system of monitoring to ensure that safety requirements are met. Additionally, NRC regulates the use of special nuclear material (SNM), which can be used in the production of nuclear weapons, through licensing and oversight of licensee operations. DOT regulates shippers and carriers of radioactive material and the conditions of transport. Regulated materials include SNM, source material, and by-product materials. Regulated activities include medical, industrial, and academic uses of nuclear materials, fuel cycle facilities, source material facilities, materials decommissioning, and materials transportation.

Nuclear waste is transported by land, rail, air, and sea. During the transportation process, global satellites monitor all materials, minimizing the likelihood of theft or disaster. The public transportation routes must meet strict safety requirements before the transporation of nuclear material is permitted. Nuclear material is transported in casks approximately 15 times thicker than a gasoline truck shell, with a three-inch-thick, stainless steel radiation shield. Typically, for every ton of fuel, more than three tons of protective packaging and shielding is provided. The casks must pass a series of four tests before they are certified to carry nuclear waste: the ability to withstand high-speed crashes, fire, water immersion and puncture. Current trends in the transportation process include reduction in the pool of available commercial carriers, routing restrictions, package validation issues, and political sensitivities. All of these trends will help to increase security and decrease the potential for disaster.

Appendix E. Indicators of Radiological Incidents

The table below illustrates indicators of potential and imminent radiological incidents.

Potential Incidents	
Indicator	**Discussion**
Reported loss/theft of commercial or medical sources in the area	In the US and most developed countries, the loss or theft of a significant source is a major event and is included in most threat reports. This is not the case in less developed countries.
Reports of impending transportation of significant quantities of radioactive materials	Radioactive materials are routinely and safely transported in most industrialized countries for medical and industrial uses. In general, the amounts shipped are limited and do not post a significant threat. This is not the case for the movement of spent fuel rods, special nuclear materials, and large sources used for radiation therapy, instrument calibration, and blood irradiation or sterilization (food and other products). These products are particularly vulnerable to theft during transportation.
Suspected illegal purchase or transfer of radiological materials or sources	The illegal purchase and transfer of radioactive materials is a clear warning of malicious intent. In developed countries, these acts are difficult and readily identified because of the controls in place. This is not the case in less developed countries.
Intelligence indicating a heightened potential for attack	Close coordination with intelligence gathering and information sharing organizations is required.

Imminent Incidents	
Indicator	**Discussion**
Reported spent, broken, or used cartridges or containers of commercial sources outside of normal commercial use areas	Radioactive materials are transported or stored in a manner that readily identifies the presence of radioactive materials. Containers for significant sources are particularly well marked, and there are clear guidelines for the disposal of containers. Finding these containers has more significance if coupled with reports of stolen sources.
Unexplained personnel or vehicle portal radiation detector readings (e.g. border crossings, airports, ports, ships boarded by Coast Guard units)	The DHS has installed monitors to detect illicit use of radioactive materials. These are the best methods to detect the presence of illicit radioactive materials because they are specifically designed for this purpose.
Unusual readings for other radiation monitoring devices (For some radioisotopes of interest, the external dose rate can be very low because they are alpha or pure beta emitters. Perpetrators may shield sources to reduce the potential for identification.)	Multiple businesses and locations use radiation monitors as a routine part of operations. Examples include nuclear reactors, facilities using radioactive materials or radiation-producing devices, radioactive waste disposal facilities, and normal waste disposal facilities, which are designed to prevent the illegal disposal of radioactive materials.
Positive results from environmental monitoring of water, soil, food, or air	Many organizations, including military installations, routinely monitor air, water, and soil for radioactive materials. Unusual or unexplained readings could indicate that a RDD incident is about to occur.
Unusual radiation readings for radiation detectors	Many organizations require personnel to wear radiation dosimeters or use radiation detection instrumentation. Unusual readings include those above normal background levels, apparently coming from a specific location not known to have radioactive materials (some materials like granite, some brick, and ceramic glazes have higher levels of radioactive material), or on a person who has not had a nuclear medicine procedure.

Imminent Incidents (continued)	
Indicator	**Discussion**
Responder radiation meters detect increasing dose rates as the area/package is approached	This is a clear indication of the presence of radioactive material.
Unexplained thermal burns reported by medical facilities	This is one of the most common ways that the presence of lost or stolen high-activity radioactive material is identified. The usual scenario is that the person picks up a lost or illegally discarded source and places it in a pocket. Radiation burns have a specific clinical presentation that distinguishes them from thermal or chemical burns. The burns are usually accompanied by acute radiation sickness (ARS) symptoms.
Clinical recognition and diagnosis of acute radiation sickness (ARS)	While ARS symptoms are well defined, multiple other illnesses have similar symptoms. ARS is likely if multiple victims present with the same illnesses, or with other signs and symptoms like radiation burns. Some radioisotopes — including plutonium-239, uranium-235, depleted uranium, and natural uranium — cannot include ARS because the external dose rate is so low.
Bomb found near nuclear or radiological facility	This is a clear indication that a radiological event is about to occur. If the bomb is placed outside the radiation area, no special precautions are required to defuse and dispose of the bomb. If it is inside the radiation area, personnel at the site can advise on any precautions required.
Fixed nuclear or radiological facility perimeter radiation alarm	This is a definite indication that an event has occurred that may or may not have originated at the facility. The outside world learned of the Chernobyl reactor accident because of alarming detectors at a Swedish nuclear power plant.
Suspicious package with radiological placards and labels	Any package with a radiation warning symbol needs to be radiologically assessed for the presence of gamma, beta, or alpha emitters or contamination.

The table below illustrates radioactive sources that could be potentially used in a WMD attack.

Radioisotopes of Concern	Uses
Americium-241	Calibration sources
Americium-241/Berylium	Well logging, research test reactor start up, static eliminators, portable gauges
Californium-252	Fixed industrial gauges, well logging, medical, portable gauges
Curium-244	Teletherapy
Cobalt-60	Irradiators, medical, calibration, radiography, gauges, well logging
Cesium-137	Irradiators, teletherapy, calibration, radiography, gauges, well logging, medical
Iridium-192	Radiography, medical
Plutonium-238	Gauges, medical
Plutonium-238/Beryllium	Calibration, medical
Radium-226	Well logging, medical, gauges
Selenium-75	Radiography
Strontium-90	Calibration, medical
Thulium-170	Radiography
Ytterbium-169	Radiography

Appendix F. Radiological/Nuclear Forensics and Attribution Following a Domestic RN Incident

In the context of RN materials, forensic processes might be divided into two broad categories. One category deals with the thorough analysis and characterization of the RN materials, the devices employing these materials, the debris resulting from detonation of a RN device, and the prompt effects from a nuclear detonation. The US government refers to this category as TNF.

A second category of forensic processes deals with the conventional forensic examinations performed on evidence known to be or suspected of being contaminated with radioactivity. This category includes the traditional forensic disciplines, such as DNA, explosives, fibers, hairs, latent fingerprints, and questioned documents.

Both categories of forensic processes require specialized infrastructure, facilities, and expertise, some of which reside outside LE current capabilities. Furthermore, both processes are relatively new. For instance, TNF draws on US Government experience gained during the nuclear weapon program, where the analysis and characterization requirements often dealt with issues related to weapon design but where the provenance of a weapon was well known. Often times this experience supported requirements of the intelligence community. Therefore, LE requirements regarding chain of custody, admissibility of methods, and defensibility of results may be novel or may be incompatible with intelligence community needs to protect sources and methods. Consequently, TNF success may require the development of new procedures that meet the needs of LE without jeopardizing the interests of the intelligence community.

TNF is expected to prove vital to answering such questions as the following: Did the RN incident involve a RDD or a nuclear device (that is, one in which a nuclear yield occurs)? If a nuclear device was involved, was the nuclear fuel uranium or plutonium? If a nuclear detonation occurred, did it result from a device that had been boosted? The answers to these questions aid in estimating the level of sophistication and state support required in assembling the device and in carrying out the RN incident. TNF may also reveal characteristics that identify the likely origin of the RN material or that allow certain nations or places to be excluded as potential suppliers. For example, TNF conducted on a recovered radioactive material may have the presence of certain trace-level impurities that are known to be uniquely associated with a geographical location, with a production or processing method, or with a nation state.

Similarly, conducting conventional forensic examinations on RN-contaminated evidence requires that protocols be revised to ensure they are compatible with the appropriate infrastructure and facilities. Once protocols are revised, they must be validated, and the laboratory examiners must document their competencies in using these revised protocols. Efforts have been underway since 2003 to ensure that LE can perform these conventional forensic exams and have a cadre of competent and qualified examiners and technicians to carry out these exams. The FBI's Hazardous Evidence Analysis Teams (HEAT) are a notable example of this effort. HEAT personnel are certified forensic examiners from the FBI Laboratory who have received additional training to perform their respective forensic specialties in infrastructure required when working with CBRN materials. The results of such conventional forensic examinations are expected to aid in identifying individuals and tradecraft involved in RN incidents and in establishing investigative leads regarding suspect individuals and groups. These results are also likely to aid in eliminating prospective suspects.

In the aftermath of any domestic RN incident, the LE and intelligence communities will engage to aid in determining whether additional incidents are imminent, likely, or planned. They will also participate in efforts at attribution, in which responsibility is assigned to the nation states, nonstate groups, or individuals responsible for the RN incident. Both TNF and conventional forensics on RN-contaminated evidence will support the process of attribution; however, forensics alone will be insufficient to permit attribution. Results from forensics will need to be combined with both other investigative information and intelligence reporting to enable responsibility to be assigned to the RN incident.

Appendix G. Acronyms

AG	Attorney General
CBRNSU	Chemical Biological Radiological and Nuclear Sciences Unit
CDC	Centers for Disease Control and Prevention
CPS	Countermeasures and Preparedness Section
DHS	Department of Homeland Security
DoD	Department of Defense
DOE	Department of Energy
DOJ	Department of Justice
DOT	Department of Transportation
DNA	deoxy-ribonucleic acid
EMP	electromagnetic pulse
E.O.	Executive Order
EPA	Environmental Protection Agency
ERT	Evidence Response Team
FBI	Federal Bureau of Investigation
FDA	Food and Drug Administration
HEAT	Hazardous Evidence Analysis Team
HIPAA	Health Insurance Portability and Accountability Act
HHS	Department of Health and Human Services
HMOU	Hazardous Materials Operations Unit
HMRTU	Hazardous Materials Response Team Unit
HMSRU	Hazardous Materials Science Response Unit
HQ	Headquarters
HSPD	Homeland Security Presidential Directive

IND	improvised nuclear device
IOS	Investigations and Operations Section
JTTF	Joint Terrorism Task Force
LD	lethal dose
LE	law enforcement
NASA	National Aeronautics and Space Administration
NIMS	National Incident Management System
NRC	Nuclear Regulatory Commission
NRF	National Response Framework
NRIA	Nuclear/Radiological Incident Annex
PH	public health
RDD	radiological dispersal device
RED	radiological exposure device
RN	radiological/nuclear
SNM	special nuclear material
TCE	Threat Credibility Evaluation
TNF	technical nuclear forensics
TREE	transient radiation effects on electronics
U.S.C.	U.S. Code
USCG	U.S. Coast Guard
WMD	Weapons of Mass Destruction

Appendix H. Glossary

Provided is an abbreviated version of the glossary that can be found in its entirety at http://emergency.cdc.gov/radiation/glossary.asp.

activity (radioactivity): the rate of decay of radioactive material expressed as the number of atoms breaking down per second measured in units called becquerels or curies.

acute radiation syndrome (ARS): a serious illness caused by receiving a dose greater than 75 rads of penetrating radiation to the body in a short time (usually minutes). The earliest symptoms are nausea, fatigue, vomiting, and diarrhea. Hair loss, bleeding, swelling of the mouth and throat, and general loss of energy may follow. If the exposure has been approximately 1,000 rads or more, death may occur within two – four weeks. For more information, see CDC's fact sheet "Acute Radiation Syndrome" at http://emergency.cdc.gov/radiation/ars.asp.

air burst: a nuclear weapon explosion that is high enough in the air to keep the fireball from touching the ground. Because the fireball does not reach the ground and does not pick up any surface material, the radioactivity in the fallout from an air burst is relatively insignificant compared with a surface burst. For more information, see Chapter Two of CDC's Fallout Report at http://www.cdc.gov/nceh/radiation/fallout/.

alpha particle: the nucleus of a helium atom, made up of two neutrons and two protons with a charge of +2. Certain radioactive nuclei emit alpha particles. Alpha particles generally carry more energy than gamma or beta particles and deposit that energy very quickly while passing through tissue. Alpha particles can be stopped by a thin layer of light material, such as a sheet of paper, and cannot penetrate the outer, dead layer of skin. Therefore, they do not damage living tissue when outside the body. When alpha-emitting atoms are inhaled or swallowed, however, they are especially damaging because they transfer relatively large amounts of ionizing energy to living cells. *See also* beta particle, gamma ray, neutron, X-ray.

americium (Am): a silvery metal, man-made element whose isotopes Am-237 through Am-246 are radioactive. Am-241 is formed spontaneously by the beta decay of plutonium-241. Trace quantities of americium are widely used in smoke detectors and as neutron sources in neutron moisture gauges.

atom: the smallest particle of an element that can enter into a chemical reaction.

background radiation: ionizing radiation from natural sources, such as terrestrial radiation due to radionuclides in the soil or cosmic radiation originating in outer space.

beta particles: electrons ejected from the nucleus of a decaying atom. Although they can be stopped by a thin sheet of aluminum, beta particles can penetrate the dead skin layer, potentially causing burns. They can pose a serious direct or external radiation threat and can be lethal depending on the amount received. They also pose a serious internal radiation threat if beta-emitting atoms are ingested or inhaled. *See also* alpha particle, gamma ray, neutron, X-ray.

cesium (Cs): one of the radioactive fission products created within a nuclear reactor during its operation. Cesium is a silvery-white, ductile material that has industrial uses in photoelectric cells as a radioisotope for encapsulated energy sources. Cs-137 is radioactive for a long period of time and can contaminate property, entailing extensive cleanup. It can also be absorbed into the food chain and is a potential cancer-causing agent. Cs-137 is used in industry for measuring the thickness or density of materials and for gamma-radiography.

chronic exposure: exposure to a substance over a long period of time, possibly resulting in adverse health effects. *See also* acute exposure.

cobalt (Co): a gray, hard, magnetic, and somewhat malleable metal. Cobalt is relatively rare and generally obtained as a by-product of other metals, such as copper. Its most common radioisotope, cobalt-60, is used in radiography and medical applications. Cobalt-60 emits beta particles and gamma rays during radioactive decay.

contamination (radioactive): the deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or people, where it may be external or internal. *See also* decontamination.

decay, radioactive: disintegration of the nucleus of an unstable atom by the release of radiation.

decontamination: the reduction or removal of radioactive contamination from a structure, object, or person.

dose (radiation): radiation absorbed by a person's body. Several different terms describe radiation dose.

dose equivalent: a quantity used in radiation protection to place all radiation on a common scale for calculating tissue damage. Dose equivalent is the absorbed dose in grays times the quality factor. The quality factor accounts for differences in radiation effects caused by different types of ionizing radiation. Some radiation, including alpha particles, causes a greater amount of damage per unit of absorbed dose than other radiation. The sievert (Sv) is the unit used to measure dose equivalent.

dose rate: the radiation dose delivered per unit of time.

dose reconstruction: a scientific study that estimates doses to people from releases of radioactivity or other pollutants. The dose is reconstructed by determining the amount of material released, the way people came in contact with it, and the amount they absorbed.

dosimeter: a small portable instrument (such as a film badge, thermoluminescent dosimeter, or pocket dosimeter) for measuring and recording the total accumulated dose of ionizing radiation a person receives.

dosimetry: assessment (by measurement or calculation) of radiation dose.
electron: an elementary particle with a negative electrical charge and a mass 1/1837 that of the proton. Electrons surround the nucleus of an atom because of the attraction between their negative charge and the positive charge of the nucleus. A stable atom will have as many electrons as it has protons. The number of electrons that orbit an atom determine its chemical properties. *See also* neutron.

element: all isotopes of an atom that contain the same number of protons. For example, the element uranium has 92 protons, and the different isotopes of this element may contain 134–148 neutrons.

exposure (radiation): a measure of ionization in air caused by X-rays or gamma rays only. The unit of exposure most often used is the roentgen. *See also* contamination.

exposure pathway: a route by which a radionuclide or other toxic material can enter the body. The main exposure routes are inhalation, ingestion, absorption through the skin, and entry through a cut or wound in the skin.

exposure rate: a measure of the ionization produced in air by X-rays or gamma rays per unit of time (frequently expressed in roentgens per hour).

external exposure: exposure to radiation outside of the body.

fallout, nuclear: minute particles of radioactive debris that descend slowly from the atmosphere after a nuclear explosion. For more information, see Chapter 2 of CDC's Fallout Report at http://www.cdc.gov/nceh/radiation/fallout/.

fissile material: any material in which neutrons can cause a fission reaction. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

fission (fissioning): the splitting of a nucleus into at least two other nuclei that releases a large amount of energy. Two or three neutrons are usually released during this transformation. *See also* fusion.

fusion: a reaction in which at least one heavier, more stable nucleus is produced from two lighter, less stable nuclei. Reactions of this type are responsible for the release of energy in stars or in thermonuclear weapons.

gamma rays: high-energy electromagnetic radiation emitted by certain radionuclides when their nuclei transition from a higher to a lower energy state. These rays have high energy and a short wavelength. All gamma rays emitted from a given isotope have the same energy, a characteristic that enables scientists to identify which gamma emitters are present in a sample. Gamma rays penetrate tissue farther than do beta or alpha particles, but leave a lower concentration of ions in their path to potentially cause cell damage. Gamma rays are very similar to X-rays. *See also* neutron.

gray (Gy): a unit of measurement for absorbed dose. It measures the amount of energy absorbed in a material. The unit Gy can be used for any type of radiation, but it does not describe the biological effects of the different radiations.

half-life: the time any substance takes to decay by half of its original amount. *See also* radioactive half-life.

ingestion: in the case of radionuclides or chemicals, swallowing by eating or drinking.

inhalation: in the case of radionuclides or chemicals, breathing in radionuclides or chemicals.

internal exposure: exposure to radioactive material taken into the body.

iodine: a nonmetallic solid element. There are both radioactive and non-radioactive isotopes of iodine. Radioactive isotopes of iodine are widely used in medical applications. Radioactive iodine is a fission product and is the largest contributor to people's radiation dose after an accident at a nuclear reactor.

ionizing radiation: any radiation capable of displacing electrons from atoms, thereby producing ions. High doses of ionizing radiation may produce severe skin or tissue damage.

isotope: a nuclide of an element having the same number of protons but a different number of neutrons.

latent period: the time between exposure to a toxic material and the appearance of a resultant health effect.

lethal dose (50/30): the dose of radiation expected to cause death within 30 days to 50% of those exposed without medical treatment. Typically, the LD 50/30 is in the range from 400 to 450 rem (4 to 5 sieverts) received over a very short period.

neutron: a small atomic particle possessing no electrical charge typically found within an atom's nucleus. Neutrons are, as the name implies, neutral in their charge. That is, they have neither a positive nor a negative charge. A neutron has about the same mass as a proton. *See also* alpha particle, beta particle, gamma ray, and X-ray.

nucleus: the central part of an atom that contains protons and neutrons. The nucleus is the heaviest part of the atom.

nuclide: a general term applicable to all atomic forms of an element. Nuclides are characterized by the number of protons and neutrons in the nucleus, as well as by the amount of energy contained within the atom.

photon: a discrete "packet" of pure electromagnetic energy. Photons have no mass and travel at the speed of light. The term "photon" was developed to describe energy when it acts like a particle (causing interactions at the molecular or atomic level), rather than a wave. Gamma rays and X-rays are photons.

plutonium (Pu): a heavy, man-made, radioactive metallic element. The most important isotope is Pu-239, which has a half-life of 24,000 years. Pu-239 can be used in reactor fuel and is the primary isotope in weapons. One kilogram is equivalent to about 22 million kilowatt-hours of heat energy. The complete detonation of a kilogram of plutonium produces an explosion equal to about 20,000 tons of chemical explosive. All isotopes of plutonium are readily absorbed by the bones and can be lethal depending on the dose and exposure time.

proton: a small atomic particle, typically found within an atom's nucleus, that possesses a positive electrical charge. Even though protons and neutrons are about 2000 times heavier than electrons, they are tiny. The number of protons is unique for each chemical element.

quality factor (Q): the factor by which the absorbed dose (rad or gray) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage (rem) to an exposed person. It is used because some types of radiation, such as alpha particles, are more biologically damaging internally than other types

rad (radiation absorbed dose): a basic unit of absorbed radiation dose. It is a measure of the amount of energy absorbed by the body. The rad is the traditional unit of absorbed dose. It is being replaced by the unit gray (Gy), which is equivalent to 100 rad. One rad equals the dose delivered to an object of 100 ergs of energy per gram of material.

radiation: energy moving in the form of particles or waves. Familiar radiations are heat, light, radio waves, and microwaves. Ionizing radiation is a very high-energy form of electromagnetic radiation.

radiation sickness: *See also* acute radiation syndrome (ARS) or the CDC fact sheet "Acute Radiation Syndrome," at http://emergency.cdc.gov/radiation/ars.asp.

radiation units: In the international system of units, the activity of a radioactive source is measured in becquerels (symbol Bq), where one becquerel is equal to one nuclear disintegration per second (an older unit is the curie). The exposure is measured in coulombs per kilogram ($C\ kg^{-1}$); the amount of ionizing radiation (X-rays or gamma rays) that produces one coulomb of charge in one kilogram of dry air (replacing the roentgen). The absorbed dose of ionizing radiation is measured in grays (symbol Gy), where one gray is equal to one joule of energy being imparted to one kilogram of matter (the rad is the previously used unit). The dose equivalent, which is a measure of the effects of radiation on living organisms, is the absorbed dose multiplied by a suitable factor that depends upon the type of radiation. It is measured in sieverts (symbol Sv), where one sievert is a dose equivalent of one joule per kilogram (an older unit is the rem). Conversion factors are: 1 curie (Ci) = 37 billion Bq, 1 rad = 0.01 Gy, and 1 Sv = 100 rem.

radioactive contamination: the deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or people. It can be airborne, external, or internal. *See also* contamination, decontamination.

radioactive decay: the spontaneous disintegration of the nucleus of an atom.

radioactive half-life: the time required for a quantity of a radioisotope to decay by half. For example, because the half-life of iodine-131 (I-131) is 8 days, a sample of I-131 that has 10 mCi of activity on January 1, will have 5 mCi of activity 8 days later, on January 9.

radioactive material: material that contains unstable (radioactive) atoms that give off radiation as they decay.

radioisotope (radioactive isotope): isotopes of an element that have an unstable nucleus. Radioactive isotopes are commonly used in science, industry, and medicine. The nucleus eventually reaches a stable number of protons and neutrons through one or more radioactive decays. Approximately 3700 natural and artificial radioisotopes have been identified.

radiological or radiologic: related to radioactive materials or radiation. The radiological sciences focus on the measurement and effects of radiation.

radiological dispersal device (RDD): a device that disperses radioactive material by conventional explosive or other mechanical means, such as a spray.

radiological exposure device (RED): also called a "hidden sealed source," a RED is a terrorist device intended to expose people to significant doses of ionizing radiation without their knowledge. Constructed from partially or fully unshielded radioactive material, a RED could be hidden from sight in a public place, exposing those close by. If the seal around the source is broken and the radioactive contents release, the device could become a RDD capable of causing radiological contamination.

radionuclide: an unstable and therefore radioactive form of a nuclide.

radium (Ra): a naturally occurring radioactive metal. Radium is a radionuclide formed by the decay of uranium and thorium in the environment. It occurs at low levels in virtually all rock, soil, water, plants, and animals. Radon (Rn) is a decay product of radium.

radon (Rn): a naturally occurring radioactive gas found in soils, rock, and water throughout the United States. Radon causes lung cancer and is a threat to health because it tends to collect in homes, sometimes to very high concentrations. As a result, radon is the largest source of exposure to people from naturally occurring radiation.

rem (roentgen equivalent, man): a unit of equivalent dose. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Rem relates the absorbed dose in human tissue to the effective biological damage of the radiation. It is determined by multiplying the number of rads by the quality factor, a number reflecting the potential damage caused by the particular type of radiation. The rem is the traditional unit of equivalent dose, but it is being replaced by the sievert (Sv), which is equal to 100 rem.

roentgen (R): a unit of exposure to X-rays or gamma rays. One roentgen is the amount of gamma or X-rays needed to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions.

shielding: the material between a radiation source and a potentially exposed person that reduces exposure.

sievert (Sv): a unit used to derive a quantity called dose equivalent. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the rem.

stable nucleus: the nucleus of an atom in which the forces among its particles are balanced. *See also* unstable nucleus.

strontium (Sr): a silvery, soft metal that rapidly turns yellow in air. Sr-90 is one of the materials created within a nuclear reactor during its operation. Strontium-90 emits beta particles during radioactive decay.

surface burst: a nuclear weapon explosion that is close enough to the ground for the radius of the fireball to vaporize surface material. Fallout from a surface burst contains very high levels of radioactivity. *See also* air burst. For more information, see Chapter 2 of CDC's Fallout Report at http://www.cdc.gov/nceh/radiation/fallout/.

thermonuclear device: a "hydrogen bomb." A device with explosive energy that comes from fusion of small nuclei, as well as fission.

thorium (Th): a naturally occurring radioactive metal found in small amounts in soil, rocks, water, plants, and animals. The most common isotopes of thorium are Th-232, Th-230, and Th-238.

unstable nucleus: a nucleus that contains an uneven number of protons and neutrons and seeks to reach equilibrium between them through radioactive decay (i.e., the nucleus of a radioactive atom). *See also* stable nucleus.

uranium (U): a naturally occurring radioactive element whose principal isotopes are U-238 and U-235. Natural uranium is a hard, silvery-white, shiny metallic ore that contains a minute amount of U-234.

whole body exposure: an exposure of the body to radiation, in which the entire body, rather than an isolated part, is irradiated by an external source.

X-ray: electromagnetic radiation caused by deflection of electrons from their original paths, or inner orbital electrons that change their orbital levels around the atomic nucleus. Like gamma rays, X-rays can travel long distances through air and most other materials and require more shielding to reduce their intensity than do beta or alpha particles. X-rays and gamma rays differ primarily in their origin: X-rays originate in the electronic shell; gamma rays originate in the nucleus. *See also* neutron.

Appendix I. References

1. Federal Emergency Management Agency
National Response Framework Resource Center

   http://www.fema.gov/emergency/nrf

2. U.S. Department of Health and Human Services
Radiation Emergency Medical Management
Guidance on Diagnosis and Treatment for Health Care Providers

   http://www.remm.nlm.gov

3. Centers for Disease Control and Prevention
Emergency Preparedness and Response
Radiation Emergencies

   http://emergency.cdc.gov/radiation

4. Uniformed Services University of the Health Sciences
Armed Forces Radiobiology Research Institute
Medical Effects of Ionizing Radiation

   http://www.afrri.usuhs.mil/outreach/meir/meir.htm

5. U.S. Environmental Protection Agency
Radiation and Radioactivity

   http://www.epa.gov/ebtpages/radiationandradioactivity.html

6. U.S. Nuclear Regulatory Commission
Radiation Protection

   http://www.nrc.gov/about-nrc/radiation.html

RADIOLOGICAL/NUCLEAR
LAW ENFORCEMENT AND PUBLIC HEALTH INVESTIGATION HANDBOOK

September 2011 Edition