Expansion and Upgrade of the RadNet Air Monitoring Network

Volume 1 of 2

Conceptual Plan and Implementation Process

Prepared by the
Office of Radiation and Indoor Air
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DISCLAIMER

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List of Abbreviations

ANSI – American National Standards Institute
CDX – Central Data Exchange
CFR – Code of Federal Regulations
CPIC – Capital Planning & Investment Control
CRCPD – Conference of Radiation Control Program Directors
DHS – Department of Homeland Security
DOE – Department of Energy
DRL – Derived Response Level
EPA – Environmental Protection Agency
ERAMS – Environmental Radiation Ambient Monitoring System
FIPS 199 – Federal Information Processing Standards 199
FRMAC – Federal Radiological Monitoring & Assessment Center
FTP – File Transfer Protocol
GPS – Global Positioning System
IMAAC – Interagency Modeling & Atmospheric Assessment Center
IT – Integrated Technology
LAN – Local Area Network
LIMS – Laboratory Information Management System
MDA – Minimal Detectable Activity
MERL – Mobile Environmental Radiation Laboratory
NARAC – National Atmospheric Release Advisory Center
NAREL – National Air and Radiation Environmental Laboratory
NCRP - National Council on Radiation Protection & Measurements
NICT – National Incident Coordination Team
NOAA – National Oceanic and Atmospheric Administration
NRF – National Response Framework
OEI – Office of Environmental Information
OMB – Office of Management & Budget
ORIA – Office of Radiation & Indoor Air
OSCs – On-Scene Coordinators
PAG – Protective Action Guidelines
PDA – Personal Digital Assistant
QA – Quality Assurance
QAM – Quality Assurance Manual
QAPP – Quality Assurance Project Plan
QC – Quality Control
R&IE - Radiation & Indoor Environments National Laboratory
RAC – Radiation Advisory Committee
RERT – Radiological Emergency Response Team
RSC – Response Support Corps
SAB – Science Advisory Board
SCFM – Standard Cubic Feet Per Minute
SLPM – Standard Liters Per Minute
SOPs – Standard Operating Procedures
SRNL – Savannah River National Laboratory
STP - Standard Temperature & Pressure
UTC - Coordinated Universal Time

1 INTRODUCTION

1.1 Goal of the New RadNet Air Monitoring Network

This document summarizes the plan and presents the implementation process for upgrading and expanding the air monitoring component of RadNet, which is the U.S. Environmental Protection Agency's (EPA) national environmental radiation monitoring system. Although RadNet monitors multiple media, including air, precipitation, drinking water, and milk, this document addresses only the air monitoring component. After the catastrophic events of 9/11 and the subsequent national concern with homeland security, EPA decided to upgrade the air monitoring network because detection of airborne contamination provides the most useful early data in response to nuclear or radiological terrorist acts.

This plan answers the overarching question: "What changes should be made to the RadNet air monitoring component to best meet the current needs for national radiation monitoring?" Instead of targeting just nuclear or radiological accidents, the mission envisioned for RadNet includes homeland security concerns and the special problems posed by possible intentional releases of radiation to the nation's environment. The plan includes new monitoring equipment, more monitoring stations, more flexible responses to radiological and nuclear emergencies, significantly reduced response time, and much improved processing and communication of data. The ultimate goal of RadNet air monitoring is to provide timely, scientifically sound data and information to decision makers and the public.

Although the events of September 11, 2001 strongly influenced and expedited planning for RadNet, and made much needed resources available, the plan presented in this document actually began in the 1990's when EPA initiated the first self-assessments of RadNet. The following sections trace significant events and the planning and decision making process regarding RadNet (then called the Environmental Radiation Ambient Monitoring System [ERAMS]) up to the present time. The lessons learned over time and all previous planning helped inform EPA's current concept of need and proposed solutions for environmental radiation monitoring.

1.2 National Context for RadNet

Currently, RadNet is the nation's only comprehensive radiation monitoring network, with more than 200 sampling stations located throughout the United States. The network is multi-media and provides broad geographical coverage as well as coverage of many major population centers. Table 1.2.1 provides a snapshot of all of the monitoring media associated with RadNet. Appendix A provides a list of all RadNet stations operating in 2010, by city.

Table 1.2.1 Multi-media snapshot of the RadNet system in 2010 during routine operations

MEDIUM	SAMPLING FREQUENCY	ANALYSES PERFORMED
air particulates	2 per week	Gross β; If Gross β is >1 pCi/m^3 (0.037Bq/m^3), then γ scan
precipitation	as occurs	Monthly composites for γ, H-3 and Gross β
drinking water	quarterly	Quarterly H-3, Annual composites for Gross α and β, γ Sr-90 on all Oak Ridge samples and once every four years for other locations and, If Gross α > 2 pCi/L (0.074Bq/L) then Ra-226, If Ra-226 between 3-5 pCi/L then Ra-228, I-131 on one quarterly sample per year for each station, Annual composite for Pu-238, combined Pu-239 and 240 and U-234, 235 and 238 for stations with gross α > 2 pCi/L (0.074 Bq/L)
milk	quarterly	γ on individual samples, Sr-90 on one July sample per region per year

1.3 Planning Prior to 9/11

1.3.1 ORIA Assessment of RadNet in Mid-1990's

The first formal planning for upgrading RadNet began in the mid-1990's when the Office of Radiation and Indoor Air (ORIA) initiated a comprehensive assessment of RadNet to determine if the system was meeting its objectives and if the objectives were still pertinent to EPA's mission. The impetus for assessing RadNet grew from ORIA's general awareness and increasing concern that RadNet, by the 1990's, had outlasted its original objectives, which derived from RadNet's precursor systems that had been operated by the Public Health Service in the 1950's and 1960's to monitor fallout from above-ground weapons testing. Presidential Reorganization Plan No. 3 in 1970 transferred those radiation monitoring responsibilities to EPA along with the associated monitoring systems, which, in 1973, were consolidated and collectively named the Environmental Radiation Ambient Monitoring System and, in 2005, renamed RadNet. In addition to looking at major objectives, the goal of the ORIA assessment was to identify any unaddressed concerns and initiatives, potential areas for partnerships and streamlining, and ways in which national non-site directed environmental radiation monitoring could be updated.

1.3.2 RadNet RAC Advisories (1995 and 1997) and Review (2005)

The first Radiation Advisory Committee (RAC) advisory, in 1995, concentrated on an ORIA proposed preliminary design for a RadNet reconfiguration plan and development of objectives for the system. (See Appendix B for details of this advisory.) The second advisory, in 1997, examined the reconfiguration plan that was developed for RadNet, in large part based upon the guidance received in the 1995 advisory. The reconfiguration plan proposed a three-phased approach for implementation based on zero, some, and optimal additional resources. Upon receipt of the recommendations from the second RAC advisory (see Appendix C) as well as comments from EPA regional personnel and state radiation personnel, ORIA began implementing the reconfiguration plan as resources permitted.

Following the second advisory, the primary improvement to the air network was to upgrade some of the air monitors in the field. Because the existing air monitors had been fabricated at the Office of Radiation and Indoor Air's National Air and Radiation Environmental Laboratory (NAREL) years earlier and were aging and technologically out of date, a number of commercially available air samplers were purchased to replace them. The commercial air samplers could measure flow rate more accurately and had other features that improved field quality control.

In December 2005, the EPA's Science Advisory Board's (SAB) RAC reviewed the RadNet air monitoring program. The original Concept and Plan document (EPA05a) was used as the basis for the review. The RAC provided comments and recommendations to EPA in July 2007 (MOR07) and EPA responded to the RAC in September 2007 (JOH07). EPA used many of the recommendations provided by the RAC to improve the RadNet program. Those improvements are detailed throughout this document.

1.3.3 Lessons from the Tokaimura event and the DOE Fires

In 1999 and 2000, three events occurred that placed the RadNet national air monitoring network on alert status and, in the process, produced or confirmed some lessons on deficiencies and limitations in the system. First, there was the Tokaimura, Japan, criticality incident in 1999, which, because it was believed to have released noble gases, underscored the fact that the RadNet air system was not designed to detect noble gases. The other two events were uncontrolled fires in 2000: one near the Department of Energy's (DOE) Los Alamos National Laboratory and the other near DOE's Hanford Reservation. The fires underscored two limitations: the low sampling density (few samplers) in both instances and the relatively slow system response time if a mobile laboratory is not present. Because air filters had to be shipped to NAREL or the Radiation and Indoor Environments National Laboratory (R&IE) for analyses during the Hanford Reservation fire, it took several days for definitive data to reach decision makers and the public. Overall, the message from the fires was that data needed to be more timely and monitoring coverage needed to be more flexible and dynamic—that is, the system needed an effective and rapid means to put monitors where needed.

1.3.4 New Vision of A Comprehensive National Radiation Monitoring System

In early 2001, well before the events of September 11, ORIA began generating, through a series of planning activities that included management and technical staff, a new vision for national radiation monitoring. Implicit in this planning was the goal of utilizing the results from all the work that had gone into the two advisories from the RAC and from the lessons learned in the Tokaimura incident and the fires near DOE facilities. The result of the 2001 ORIA planning was the first full vision of a comprehensive, multi-component system to address radiological emergency response, which includes national monitoring.

In February of 2001, a key national monitoring system meeting was held in Montgomery, Alabama, the purpose of which was to redefine the mission and objectives of the network and to develop an initial conceptual design to guide the reconfiguration of the network into the future. A significant outcome of the meeting was the determination and agreement that support of the Agency's emergency response responsibilities was to be the primary purpose of the network's current and future radiation monitoring capability. The working mission of the system to be designed, it was agreed, would be: *To monitor radionuclides released into the environment during significant or major radiological emergencies.* Three basic objectives that would support the system's mission also were defined:

- To the extent practicable, maintain readiness to respond to emergencies by collecting information on ambient levels capable of revealing trends.
- Ensure that data generated are timely and are compatible with other sources.
- During events, provide credible information to public officials (and the public) that evaluates the immediate threat and the potential for long-term effects.

The ORIA RadNet planning team not only recognized the linkage between emergency response and the monitoring network but considered the relationship of the monitoring network to other related emergency response assets. Section 2.4 presents ORIA's view of the relationship between RadNet and the other existing EPA emergency response assets.

In August of 2001, the ORIA planning team provided a vision of the new monitoring system that was developed on the basis of four design goals:

- Better Response to Radiological Emergencies
- More Flexible Monitoring Capability
- More Integrated and Dynamic Network
- Meet Needs within Realistic Costs

These design goals would be incorporated into the planning that would soon be expedited by the events of September 11, 2001.

1.4 Impact of 9/11 on Planning the RadNet Air Network

The terrorist attacks on the United States on September 11, 2001 expedited and strongly influenced the subsequent planning for updating and expanding RadNet. In January 2002 ORIA began a self-assessment of the existing monitoring program in light of homeland security concerns, and very early on decided that the air program could best support homeland security objectives. As a result, the review of the other sampling networks in RadNet was deferred to a later time, and the air network received full scrutiny in the system assessment.

The ORIA self-assessment of the RadNet air network identified two major system weaknesses and three proposals to solve them, as shown in Table 1.4.1.

Table 1.4.1 Post-9/11 weaknesses discovered in and solutions proposed for the RadNet air monitoring network

Weakness	Proposed Solution
Decision makers need data more quickly than is currently possible.	Add real-time monitoring capabilities.
Assessing widespread impacts from an incident that might occur anywhere in the United States will require data from more locations than are currently monitored.	Significantly expand the number of locations with fixed monitors. Provide the flexibility to augment the fixed locations with "deployable" monitors that fill the void between local/first responder monitoring and the national scale monitoring provided by the fixed monitors.

Because the deployable (mobile) monitors could be purchased more quickly, the first available homeland security funding (late 2001) was committed to acquiring them. The attention then turned to updating the fixed system. Based on the findings of the post-9/11 assessment and reinforced by similar findings in the earlier 2001 assessment, ORIA turned its attention to the system of fixed monitors to determine the most appropriate equipment configuration and feasibility; to find the most acceptable plan for siting the monitors across the nation; and to design an electronic capability for delivering verified data (from fixed as well as deployable monitors) quickly to decision makers and the public. In 2002 prototype testing of fixed monitors began, which lasted over a year and resulted in the conviction that commercially available components could be assembled to meet the performance specifications needed for the RadNet air monitoring program

In 2003, the prototyping project had adequately demonstrated the technical feasibility of adding real-time gamma and beta monitoring capability to the fixed air monitoring stations. Consequently, in August of 2003 an Exhibit 300 Capital Planning and Investment Control (CPIC) proposal for upgrading and expanding the fixed air monitoring stations component of RadNet was submitted to the Office of Management and Budget (OMB) as part of the Fiscal Year 2004 EPA budget request. The Exhibit 300 document amounts to a business plan that is measured along a number of budgetary concerns, including scope of work, milestone schedule, budget, and risk assessment. In the fall of 2003, OMB evaluated EPA's proposal, including reviewing it for redundancy against the entirety of the federal government's related assets, and gave the plan high marks. As a result, it was included in the President's FY04 budget request, and subsequently was funded by Congress. In 2004, ORIA was able to begin implementation and acquisition planning, followed in 2005 with actual purchase of an initial order of upgraded fixed station radiation monitors.

The general data uses that guided the development of the RadNet air monitoring network are shown in Table 1.4.2. The objectives encompass the fixed monitoring network and the deployable monitors. The objectives are presented in sequential phases reflecting the chronological progress of an event and the parallel status of the system from routine, to emergency, and back to routine conditions. (Section 2.1 provides a more detailed discussion of the system's mission and objectives.)

Table 1.4.2 Overview of general data uses for the RadNet air monitoring network

Incident Phase	Fixed Monitor Objectives and Data Uses	Deployable Monitor Objectives and Data Uses
ONGOING OPERATIONS / PRE-INCIDENT	Establish Baseline • Information • Trends • Increases from Incidents Maintain Readiness • Continuous Operation	Maintain Readiness ▪ Routine Testing If Pre-Deployed ▪ Establish Baseline
EARLY PHASE (0-4 days)	Provide Data for Atmospheric Dispersion Modelers Who • Verify Model Output or Adjust Model Input, Especially for Longer Distance Transport • Assist Decision Makers and Scientists with the Model Outputs Provide Data to Assist in Evaluating National Impact	(Only Applicable if Deployables are Pre-Deployed or operating before the early phase ends) Provide Data for Atmospheric Dispersion Modelers Who • Verify Model Output or Adjust Model Input • Assist Decision Makers and Scientists with the Model Outputs Provide Data to Assist in Evaluating Local Impact
INTERMEDIATE PHASE (up to 1 year)	Provide Data for Atmospheric Dispersion Modelers Who • Continue to Verify Model Output or Adjust Model Input, Especially for Longer Distance Transport Provide Data to Assist in Refining National Impact • Determine Overall Data Trends • Assist in Determining Additional Sampling Needs	Provide Data for Scientists Who • Provide Recommendations to Decision Makers to Continue/Alter Protective Actions • Determine Additional Sampling Needs • Determine the Need to Move Deployables • Define / Refine Regional Impact • Provide an Established Location for Operation of a Longer Term Air Monitor
LATE PHASE (following intermediate phase)	Provide Data for Scientists Who Perform Trend Analyses to • Verify Return to Normal Levels • Establish New Baselines	Deployables are Expected to be Returned to the Laboratories

Note.—Objectives and data uses may overlap from one phase to another. Data are also available to decision-makers and the public for their use.

1.5 Summary of Proposed Improvements to RadNet Air Network

Table 1.5.1 provides a snapshot of the proposed improvements to the RadNet air monitoring network presented in this document.

Table 1.5.1 Main improvements proposed for RadNet air monitoring network

Improvement Area	New System	Old System
Number of Stations	134 fixed; 40 deployable	59 fixed; 0 deployable
Time for Data Availability	Near-real-time (4-6 hrs)	36 hours minimum (if on alert)
Criteria for National Siting	Population and Geography	Population and Fixed Nuclear Facility Proximity
Local Siting Criteria	Derived from Title 40 Code of Federal Regulations (CFR) Part 58	None
Data Dissemination	Central Database with Internet Access	Hard copy
Meteorological Data	Yes—deployables Optional—fixed monitors	None
Telemetry	Modem (land line and cell); internet; satellite link	None
Station mobility	40 deployable monitors	None
Data Security	High	None
Operator Dependency	Primarily for air filter changes; no operator action required for near-real-time data transmission to central database to support emergency response	Completely operator dependent
Gross alpha/beta data at station location	Gross alpha and beta	Gross beta only
U.S. Population Proximity (see Section 3.6)	Approximately 60%	Approximately 24%
Frequency of Data Collection	Continuous (hourly data transmission during routine conditions) and air filters for fixed lab analysis [1]	Two air filters per week for fixed lab analysis

[1] Twice weekly air filter changes are not required for the near-real-time monitoring system since there is no loss of data quality due to the hourly data transmission capability.

1.6 Strategy and Process for Developing This Plan

ORIA's strategy for developing the plan to upgrade and expand the air network of RadNet was based on the following strategic guidelines:

- Emergency response as the overarching, designated mission
- Full exposure to and input from stakeholders to assure that EPA will be doing what is needed
- Inclusion of all of EPA's national radiation monitoring responsibilities, with special emphasis upon homeland security needs
- High levels of technical and professional expertise incorporated at all levels of planning
- Continuing self-assessment and incorporation of results
- Utilization of all appropriate previous planning

- Survey, research, and incorporate up-to-date relevant information across the technical, professional, and government communities
- Operation within limits of known and anticipated available resources

The inclusion of stakeholders throughout the planning process has been a high priority. The EPA Regions' (see http://www.epa.gov/aboutepa/index.html#regional) direct involvement has been important, particularly in helping to identify site locations and provide for the operation and maintenance of monitors. Similarly, the contributions of the Conference of Radiation Control Program Directors (CRCPD—see http://www.crcpd.org) have provided state input and assistance via needs surveys and regular dialogue with ORIA (through a specifically established CRCPD committee to address RadNet issues) on system goals and objectives, scenario assessments, location of monitors, identification of station operators, and so forth. The existing RadNet station operators have also provided very useful information and commentary.

The RadNet team sought information and guidance from sources inside and outside the Agency on issues that could benefit from special expertise. EPA's Office of Air Quality Planning and Standards was consulted through discussion and documentation on broad issues regarding environmental monitoring that could benefit the design and implementation of RadNet, e.g., best models for developing local siting criteria for the fixed monitors. Since the RadNet air program includes a central database receiving real-time data and eventually providing public information, the Office of Environmental Information (OEI) has provided essential guidance on developing and incorporating the RadNet information technology assets into EPA's overall Integrated Technology (IT) architecture. A specially constructed ORIA Technical Evaluation Panel has also offered commentary and constructive advice on key issues in the RadNet air project, particularly upon the matter of where to best site the fixed monitors.

External sources of expertise were important too. For example, the National Atmospheric Release Advisory Center (NARAC) and the Savannah River National Laboratory (SRNL) have made substantive contributions. NARAC provided useful modeling support and ran computer scenarios to help assess the ORIA RadNet siting plan. SRNL provided guidance on siting as well, developed an independent siting methodology, and performed equipment testing of the RadNet fixed monitor prototype. Conversations with the Nuclear Regulatory Commission and Health Canada enabled other means of coordinating the development of RadNet. Through contract support, ORIA secured expertise on a number of specific technical issues, including practices for quality assurance/control pertaining to near-real-time data; particle size issues in monitoring radiation; surveys of radiation monitoring planned or ongoing by other entities; and local siting criteria (ICF05a, LRR05, ICF05b, and ICF05c).

1.7 Current Implementation Status of the Project

Currently, 124 fixed monitors have been installed, with a total of 134 planned to be installed by the end of Calendar Year 2012. At this time, there are no plans to purchase additional monitors.

1.8 Implementation Focus Points Ahead

The focus in the future is the transformation of the network to fully operational mode. During the acquisition and implementation phases of the project, improvements were made to the monitors, telecommunications, and databases. Actual operation of the monitors has demonstrated the air system's ability to detect environmental radiation abnormalities and has provided the opportunity to develop strong data review procedures and to establish baseline radiation levels and trends at each operating location.

EPA continues to look for improvements to the RadNet network. The focus remains on the air monitoring program, but will also include evaluation of the sampling programs for the other RadNet media.

1.9 Lessons from the Fukushima Nuclear Reactor Accidents

The final draft of this plan had been made ready for final review in February of 2011. Prior to finalizing the reviewers and review charge, the 9.0 magnitude Tohoku earthquake occurred on March 11, 2011. Critical nuclear reactors at the nearby Fukushima Daiichi plant were shutdown by procedure following the earthquake. However, the resulting tsunami flooded critical emergency cooling equipment, eventually resulting in the release of radioactive contamination.

Although not completely implemented and operational, fixed and deployable RadNet air monitoring systems became one of the primary response systems for the United States. Both of these monitoring systems successfully monitored contamination from the nuclear reactors. Once the contamination levels dropped below detectable levels, this document was released for review.

As with any incident, there were issues identified in the EPA's response to the Fukushima nuclear incident. Some of these issues involved topics discussed in this report. Many of the issues were solved during the incident, but many will also require time to evaluate and implement corrective actions. Section 8 of this document discusses the major issues identified with the topics in this report (fixed and deployable monitors, as well as data transmission and availability), and the actions taken to correct them or the plan for correction at a later time.

2 THE EXPANDED AND UPGRADED AIR NETWORK

2.1 Mission and Objectives of the RadNet Air Network

The mission of the RadNet Air Network is based upon fulfilling, or providing the data necessary to fulfill, responsibilities assigned by the Department of Homeland Security (DHS) to EPA in the National Response Framework, Nuclear/Radiological Incident Annex (DHS08). Specifically, the Annex gives EPA the following responsibilities:

- Provide nationwide environmental monitoring data from the RadNet air network for assessing the national impact of the incident.
- Estimate effects of radioactive releases on human health and the environment.
- Recommend acceptable emergency levels of radioactivity and radiation in the environment.

To fulfill these responsibilities, EPA developed the following mission for the RadNet Air network:

- Provide data for radiological emergency response assessments in support of homeland security and other responders to radiological accidents and incidents.
- Inform public officials and the general public of the impacts resulting from major radiological incidents/accidents and on ambient levels of radiation in the environment.
- Provide data on baseline levels of radiation in the environment.

The system was designed to fulfill its mission, but it was recognized early that resource constraints would not allow a "do it all" system. Consequently, the fixed monitoring system is designed to do the following:

- Measure large-scale atmospheric releases of radiation impacting large parts of the country and major population centers due to:
    - nuclear weapon detonations
    - radiological dispersion devices resulting in widely impacted areas (e.g., multi-county or larger)
    - large nuclear facility incidents/accidents
    - large foreign radiological incidents/accidents
- Measure ambient levels of radiation in the environment

However, the system is not designed to:

- Measure the impact to the immediate locality ("ground zero") of a major incident/accident
- Measure releases of radiation resulting in a limited impacted area

- Monitor individual sources (nuclear facilities, storage facilities, etc.)
- Serve as an early warning/first detection system

The deployable monitoring system was designed to do the following:

- Fill the void between local/first responder monitoring and the national scale monitoring provided by the fixed monitors following atmospheric releases of radiation due to :
    - nuclear weapon detonations
    - radiological dispersion devices
    - nuclear facility incidents/accidents

However, the deployable system is not designed to:

- Measure the impact to the immediate locality ("ground zero") of a major incident/accident
- Monitor baseline radioactivity levels
- Monitor individual sources (nuclear facilities, storage facilities, etc.)
- Serve as an early warning/first detection system
- Operate for a long time following a radiological accident (should be replaced by a different monitoring system)

2.2 Data Collection

The near-real-time data produced by the fixed and deployable monitors are dissimilar. Fixed monitors are designed to obtain continuous gamma and beta spectrometric emissions from particulates collected on an air filter using a high volume air sampler. The filter can also be removed and screened by an operator for gross alpha and beta emissions, and it can be shipped to NAREL for more sensitive analysis and for radionuclide specific analyses that cannot be performed in real time or by an operator in the field.

The deployable monitors have two air samplers, one low volume and one high volume. The low volume sampler collects vapor, using a special cartridge, and particulates while the high volume sampler collects particulates only. Both filters must be removed and shipped to a fixed or mobile laboratory for analysis, but the filters may also be field screened for gross alpha and beta emissions. The deployable monitors also have a gamma exposure rate monitor that provides continuous gamma radiation level measurements. Both the fixed and deployable monitors can provide air flow data, which allows personnel at NAREL to ensure that the monitors are operating correctly. Table 2.2.1 summarizes the data available from each monitor type and the time/actions required before the data are useable.

Table 2.2.1 Summary of data and availability

MONITOR TYPE	DATA TYPE	AVAILABILITY TIMEFRAME [1]	OPERATOR ACTIONS FOR DATA TO BECOME AVAILABLE
Fixed	Gamma Spectrometry	Hourly [2]	None
	Gross Beta	Hourly [2]	None
	Alpha/Beta Screening	5 Hours	Operator removes and screens filter
	Filter Analysis	> 2 Days	Operator removes filter, ships to NAREL, and radioanalysis is performed
Deployable	Gamma Exposure Rate	Hourly to daily as directed [3]	None
	Filter and Cartridge Analysis	> 2 Days [3]	Operator removes filter, ships to fixed or mobile lab, and radioanalysis is performed

[1] Time is measured from the beginning of the collection period and is based on when data are available for retrieval by EPA. Dissemination times may vary.
[2] Remote connectivity to the fixed monitors provides EPA immediate access to data.
[3] Shipping and monitor setup times, approximately 24 hours, need to be added to obtain total time from the beginning of the event until the time data are available. Transport of filters to a mobile laboratory may reduce this time.

2.2.1 Routine Data Uses

Data from the fixed monitors are used to provide general information on radiological conditions, perform trend analyses, and establish a baseline for comparison of data in the spectrometric regions of interest to determine if abnormalities exist. The fixed system operates continuously to ensure that baselines are up-to-date, that the system is operational and ready to detect contamination, and that operator skills remain current. Baseline data provide local as well as national scale data that may be used by the public, scientists, decision makers and other customers or stakeholders. Although RadNet is not designed to be an early warning system, there is a small probability, because the monitors in the fixed network operate continuously, that they may detect airborne contamination before notifications occur.

If the deployable monitors are pre-deployed at the request of an agency with interdiction authority (e.g., the Federal Bureau of Investigation), they provide baseline data of environmental gamma radiation levels as well as low and high volume air samples for analysis at a fixed or mobile laboratory. If they are not pre-deployed at the request of an agency with interdiction authority, they are maintained ready for deployment or may be stored in remote locations when elevated potential for a radiological event may exist. The storage of deployables at remote locations should be minimized to ensure they receive appropriate maintenance by trained personnel at the laboratories.

The discussion of the data uses for both the fixed and deployable monitors considers the near-real-time data primarily. In this case, it is assumed that contaminant concentrations are high enough for detection using the respective onboard gamma detector systems. However, it should be noted that levels of contaminants that are not discernable from background are also useful. Throughout this section the terms “unaffected area” or “non-impacted" area are frequently used. These areas may or may not have contamination, but the contamination is at such low levels that it is below detection levels that are orders of magnitude below levels that would warrant action.

2.2.2 Data Uses in the Early Phase of a Radiological Event

In the early phase (nominally up to four days, see EPA's Protective Action Guidance (PAG) manual (EPA92) for information on the early phase) of an incident, the fixed monitor network is designed to accomplish the following objectives:

- Provide radionuclide data quickly to atmospheric dispersion modelers without the need for the operator to go to the monitor. The data may be used to assist in modification of model assumptions or input parameters or to assist in validation of model output, which will most likely be used for initial protective action recommendations.
- Provide data to determine the impact of an event on cities across the nation that may not monitor for contamination. This is especially important when projections of contamination spread do not indicate widespread potential impact.
- Assist in identifying non-impacted areas by providing modelers and decision makers with "zeros" for areas where contamination is not present or is present below the detection levels, which are designed to be significantly below protective action guidance levels for most nuclides.
- Provide data quickly to decision makers and the public to assure citizens and decision makers in unaffected areas that the airborne radionuclide concentrations are normal.
- Provide data to decision makers to help prioritize follow-up monitoring requirements and response resource allocation.

The deployable monitors are not expected to provide data during the early phase of an incident unless they are pre-deployed or if the early phase is long enough that the deployable monitors are able to be set up and operating. If they are operational before the end of the early phase, they achieve the following objectives:

- Provide gamma exposure rate data to modelers to help validate model output or adjust input parameters.
- Provide data to decision makers and the public to assure citizens and decision makers in unaffected areas that the airborne radionuclide concentrations are normal.
- Assist decision makers in determining follow-up monitoring requirements and response resource allocation.
- Serve as an early warning system.

2.2.3 Data Uses in the Intermediate Phase of a Radiological Event

In the intermediate phase (nominally the first year, see EPA's PAG manual for information on the intermediate phase), the fixed monitors:

- Provide radionuclide data to atmospheric dispersion modelers to continue to verify long-distance dispersion models.
- Determine if/when levels return to pre-incident values. The data also assist in determining if temporary or long-term baseline changes have resulted from an event.
- Provide data for multi-pass global transport from nuclear weapon detonations and/or from a continuous release of contamination, such as a fire.
- Provide data to help assess the national impact (i.e., population dose reconstruction).
- Assure citizens and decision makers in unaffected areas that the airborne radionuclide concentrations are normal.

In the intermediate phase, the deployable monitors provide:

- Data for potential of delayed contamination transport from resuspension, multi-pass global transport from nuclear weapon detonations and/or from a continuous release of contamination, such as a fire.
- Assurance to citizens and decision makers in unaffected areas that the airborne radionuclide concentrations are not elevated.
- Data to help assess the regional impact (i.e., population dose reconstruction)
- Data to assist decision makers concerning reducing or relaxing protective actions that may have been taken in the early phase.
- Data to help determine follow-up sampling needs.
- An established location for monitoring such that logistical needs (operator, power, etc.) are available for a more permanent monitoring system.

2.2.4 Data Uses in the Late Phase of a Radiological Event

In the late phase (nominally after the first year, see EPA's PAG manual for information on the late phase), the fixed monitors provide:

- Data to verify that radionuclide concentrations have returned to previous baseline or to establish a new baseline.
- Assurance to citizens and decision makers in unaffected areas that the airborne radionuclide concentrations remained normal.

In the late phase, the deployable monitors are likely to be returned to the laboratories, though they may continue to monitor in the region of the event. If the deployables are returned to the laboratories, they will be serviced as necessary and made ready for the next response. In the late phase, it is likely that substitute monitoring systems, which are more appropriate for long-term monitoring needs, will replace the deployable monitors. That is, there would be no need for additional gamma exposure rate monitoring or low volume air sampling. This would allow the more specialized RadNet deployable monitors to be readied for another emergency event.

2.3 How the Upgraded Air Network Meets Its Objectives

Upgrading the RadNet air network had three major emphases: adding near-real-time data transmission capabilities; significantly expanding the number of fixed monitor locations; and adding 40 new deployable monitors to the system. These upgrades addressed the weaknesses identified in the post-9/11 reassessment of the system – that decision makers need information more quickly, additional monitoring locations are needed, and that a monitoring system is needed to bridge the local scale monitoring and the national scale monitoring performed by the fixed network.

Scientists need accurate, complete, and timely information concerning radioactive contamination in the environment in order to provide atmospheric dispersion modelers and decision makers with the best possible information. The RadNet fixed monitors provide data quickly by continuously monitoring the filter for gamma and beta radiation and by providing a means to transmit the data to a central location for evaluation, assessment, and dissemination.

Many potential protective action decisions are based initially upon computer model projections of dose, especially when little or no monitoring data exist early in an incident. The fixed system provides continuously operating monitors that may detect radioactive contamination as it travels through the atmosphere. The data collected can be used to provide a rough estimate of or refine source-term activity as well as to define the radionuclide(s) released. This can be a critical issue in surprise events, such as a dirty bomb scenario, where the nuclides and source terms are initially unknown. Data from the fixed monitoring system may also help atmospheric dispersion modelers estimate or evaluate the particle size distribution of the contamination released into the atmosphere. Particle size distribution is one of the hardest parameters to predict, but the distribution is a major factor in determining the long-distance contamination footprint.

Placing numerous detectors across the nation increases the chances of detecting contamination as it spreads, and the data can be used to validate long-distance transport of contamination. Increasing the number of fixed monitors throughout the country improves the system's ability to meet its objectives in a very tangible way.

The deployable component of the air network also helps RadNet meet its objectives. Primarily, the deployables enable higher density monitoring of the area surrounding an incident. Some areas are likely to be too large for the high density monitoring performed by emergency response personnel. The deployable monitors are stored in a state of readiness and can be deployed to monitor radioactivity after the initial contamination footprint is established.

The deployables complement the fixed air monitor network by monitoring more on the regional level while the fixed monitors maintain the national picture of the status of environmental radiation. RadNet monitoring on the national and regional scale frees up emergency response personnel and equipment that monitor in the more highly contaminated, on-site areas. Although the fixed and deployable monitors have different components, provide different near-real-time data that cannot be directly compared, and are designed to be used in different ways, both types of monitors provide critical information about radiological material in the environment.

2.4 EPA's Role in National Radiological Emergency Response

Following a radiological incident, monitoring is performed near the event (local monitoring), at an intermediate distance (regional monitoring) and at long distances (national monitoring). The local monitoring is performed by emergency responders from EPA and other federal, state, and local organizations. These responders are needed in the local area of the incident, where contamination levels are likely to be highest and the need for data to support timely protective action decisions is greatest. Intermediate distances from the incident will be monitored by deployable RadNet monitors. These monitors are introduced as the need for them is determined at the time of the incident. National monitoring is the job of the in-place, continuously operating fixed RadNet monitors. The primary use of the data from the fixed system is to provide data on the long-distance spread of contamination.

The National Response Framework (NRF) (DHS08) provides the overall framework for response to hazardous materials incidents. Under the NRF and its Nuclear/Radiological Incident Annex: state, tribal, and local governments are primarily responsible for determining and implementing measures to protect life, property, and the environment in impacted areas. Toward that end, many urban areas have developed local hazardous materials incident response teams that include radiological/nuclear emergency response resources. In addition, state governments maintain radiological emergency response personnel and equipment that will be deployed to the scene of an incident following notification. These resources will be supplemented at the federal level by radiological response resources such as the following:

- DHS' Interagency Modeling and Atmospheric Assessment Center (IMAAC), which is responsible for production, coordination, and dissemination of consequence predictions for an airborne hazardous material release.
- The Federal Radiological Monitoring and Assessment Center (FRMAC), which will be established by DOE at or near the scene of an incident to coordinate radiological assessment and monitoring.
- The Advisory Team for Environment, Food, and Health (known as "the Advisory Team"), which provides expert recommendations on protective action guidance.

EPA supports each of these federal assets during the immediate response to an emergency, and takes over leadership of the FRMAC for the longer-term response. Data from RadNet will be coordinated with all three of these assets to ensure that state and local decision makers receive the full suite of information available to help them protect the public following a nuclear or radiological emergency.

In support of the overall federal, state, and local response effort, EPA deploys personnel to work in the immediate impact zone and to investigate the potential impact of the incident in the areas immediately surrounding the impact area. EPA assets include the following:

- A Radiological Emergency Response Team (RERT), a group of trained personnel who perform field measurements, collect samples, and perform limited analyses in mobile laboratories. RERT personnel can also provide other responders with advice and technical assistance on issues ranging from protective measures to containment and cleanup following an incident.
- On-Scene Coordinators (OSCs) from EPA's Superfund program who respond at the scene of biological, chemical, or radiological emergencies under the National Oil and Hazardous Substances Pollution Contingency Plan and the National Response Framework. EPA's OSCs are trained to conduct, direct, or coordinate emergency response actions to ensure that human health and the environment are protected.
- An EPA Environmental Response Team that supports the On-Scene Coordinators in their activities, providing specialized equipment and technical assistance that includes hazard evaluation, risk assessment, multimedia sampling, and analysis.
- The EPA National Decontamination Team, a team of emergency responders, engineers, and scientists available to provide technical decontamination advice and assistance at the scene of an incident.
- A large EPA fixed-laboratory capability for both radiological and mixed chemical/radiological sample analysis. Samples can be shipped from a site to the laboratories for more thorough analyses and longer counting times to improve detection capability.
- The Response Support Corp (RSC) is a group of EPA Regional personnel who volunteer to respond to major environmental incidents. RSC staff are available to respond to a radiological incident outside of the impacted area. This makes them good candidates to operate a RadNet deployable monitor. Many RSC staff have been trained on the set up, operation, and take down of the RadNet deployable units.
- Regional radiation program staff may respond to a radiological emergency in many ways. In each of the Regions, these staff are available to provide radiation technical assistance, including placement and operation of the deployable units. They may also be the operator of the fixed RadNet unit in their city. The radiation staff lead the placement of fixed units in their Region and are the lead

contact for radiation issues in the Region including providing explanations of RadNet results to Regional Management.

- The RadNet fixed and deployable monitor networks. RadNet's data will be used to supplement data that will be collected by local, state, and federal responders working in the immediately impacted area following a nuclear or radiological emergency.

These components work together and with the other federal, state, and local responders to provide information concerning radiological contamination of the environment both near and far from an incident site. In the event of a radiological emergency, the RERT and other EPA assets described above will proceed to the impacted areas to integrate into the on-site response and the FRMAC. EPA's RERT and other Federal, state, and local response assets will primarily respond from the highly impacted area(s) (the distance will depend on the magnitude and area of the contamination spread). RadNet will help to augment these emergency response assets by providing data from the extended area not being monitoring by on-site response personnel, where more long-term health impacts may be the concern. The RERT also brings mobile laboratories with the capability to perform rapid gamma spectrometry and alpha/beta analyses on samples collected by the RERT or other monitoring groups.

ORIA's two laboratories, the National Air and Radiation Environmental Laboratory (NAREL) located in Montgomery, Alabama, and the Radiation and Indoor Environments National Laboratory (R&IE), located in Las Vegas, Nevada, maintain the ability to process and analyze samples collected in the field. The fixed laboratories also process air filters collected and sent from both the fixed and the deployable monitors. In addition, DOE and other Federal, state, and local agencies may contract with independent commercial laboratories to analyze the considerable number of samples that will be generated by a significant radiological or nuclear incident. In such instances, NAREL will likely serve as a quality assurance laboratory to ensure the accuracy of the analyses being obtained. All data will be coordinated through the FRMAC, to develop a single common operating picture, as required by the NRF.

3 FIXED MONITOR NETWORK

One of the weaknesses identified in the post-9/11 reassessment of the RadNet air network was that decision makers were not receiving data quickly enough. The solution proposed was to augment the capabilities of the fixed air stations with real time monitoring. The first step in determining functional requirements for real time measurements was to establish measurement objectives, beginning with an assessment of threats posed by potential terrorist activities, decisions that might need to be made to protect human health and the environment, and data that would be needed to make those decisions.

Although the events of 9/11 created a heightened sense of urgency, the potential radiological health and safety issues related to the threat of terrorist activities involving radioactive material had been recognized and studied for 20 or more years. The National Council on Radiation Protection and Measurements (NCRP) completed Report No. 138, *Management of Terrorist Events Involving Radioactive Material* (NCR01), just prior to 9/11. This report was used to assess the capability needs for upgrading the RadNet air network. However, in evaluating the likelihood of the various postulated scenarios, the NCRP committee generally discounted those involving lethal radiation exposures to the perpetrators. The events of 9/11 made it clear that some terrorist groups may be unconcerned about their own safety. For this reason, EPA considered the full range of postulated scenarios rather than discarding those deemed likely to be lethal to the perpetrator.

While it is not possible to predict all of the ways in which data from the RadNet fixed air monitoring network might be used in responding to a radiological event, the one that would be limiting for design purposes was identified as recommending protective actions for the public. As stated in NCRP Report 138, available immediate actions for areas downwind from an incident site are temporary shelter in place or evacuation. These recommendations must be based on a projection of the radiation dose that can be averted by taking the action, which in turn requires estimates of the time available before cloud arrival, the duration of exposure, and the concentration in air of each radionuclide in the cloud. It is this last item of data that can be provided by the fixed air monitoring network.

It is unlikely that the data from a RadNet fixed air monitoring station would be used, by itself, to recommend a protective action. A more likely use would be to provide data to atmospheric dispersion modelers for model output verification and to reassure people in population centers that are not expected to be impacted by an event that no protective action is warranted. However, the required sensitivity, quality, and timeliness of data are the same for those potential uses. Providing data suitable for making protective action decisions was therefore established as a design objective. Meeting this objective will ensure that the data are also suitable for any other potential uses in responding to a radiological event.

After it was determined that the objective was to measure the concentrations of radionuclides in air at levels suitable for making protective action decisions, the next step was to determine the radionuclides and sensitivities that should be measured. Radionuclides likely to be encountered were identified by considering the categories of events described in NCRP Report 138, which included both radiological dispersal events and detonation of nuclear weapons. For dispersal events, the categories evaluated included both sabotage of a fixed nuclear facility or transport vehicle and fabrication of a weapon using radioactive materials obtained either legally or illegally. EPA supplemented the information in NCRP Report 138 with discussions with others in the radiological community, primarily at the national laboratories, who also were involved in re-assessing terrorist threats.

The conclusion was that gamma spectrometry can measure every available source of radioactive material of sufficient size and sufficiently long radioactive half-life to cause large-scale public health impacts, except for the following sources:

- Transuranic alpha emitters which are available in large quantities and mainly emit only alpha particles.
- Sr-90, which emits only beta particles, and is available in large quantities.

Individual gamma-emitting radionuclides that might need to be measured because they are readily available in large quantities include Am-241, Cs-137, Co-60, and Ir-192. The conclusion was that the ability to measure gamma radiation and beta particles in real time was needed, but that detection of alpha particles could be best addressed by laboratory analysis of the filters.

EPA periodically revisited this radionuclide list as additional threat assessment information became available, up to the time when bid specifications for the monitoring equipment were finalized in early 2004. The most recent publicly available report consulted at that time was *Individual Preparedness and Response to Chemical, Radiological, Nuclear, and Biological Terrorist Attacks* (DAV03), published by the Rand Corporation in 2003. Appendix A in that report contains a list of radionuclides identical to that derived by EPA in 2002.

An objective for measurement sensitivity was established based on the need to reach a protective action recommendation while time is available to implement the action. Therefore, the initial measurement sensitivity goal was set at the concentration in air that would result in a Committed Effective Dose Equivalent of one rem (the lower guideline value for implementing a protective action from the EPA Protective Action Guides, (EPA92) if inhaled continuously for four days). Four days was the period chosen to provide adequate time for confirmation and verification of a measurement, followed by a deliberative decision making process, and the subsequent worst-case (in terms of time required to fully implement) potential protective action, which was assumed to be the controlled evacuation of a large city.

When development of bid specifications for procuring monitors began, there were discussions of revising the Protective Action Guidance (PAG) Manual to replace the dose-based approach with a risk-based approach. In order to ensure that the monitors purchased would continue to meet measurement sensitivity objectives if risk-based PAGs were to be adopted, corresponding air concentrations were re-calculated based on the inhalation risk factors and average breathing rate given in Federal Guidance Report 13, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides* (EPA99). A sample collection rate of 2120 cubic feet per hour (60 m^3 per hour, the programmed flow rate for fixed monitors), a target lifetime mortality risk factor of 2/10,000, and 100 hours of exposure were assumed for these calculations. Values for the detection limits listed in Section 3.3.1 were then selected based on the more conservative value derived using the two different approaches. The final bid specifications were based on a fraction of the sensitivity goals calculated from the protective action guide.

Detailed specifications for the fixed monitors were developed based on experience gained from a project that began in 2002. Four prototype monitors were assembled by integrating commercially available components and software from multiple vendors. The prototypes were installed at four locations in the United States and field-tested for at least one year. The prototyping project concluded that none of the detectors tested was capable, by itself, of meeting the measurement objectives for both gamma radiation and beta particles. However, it was also concluded that it was feasible to implement the conceptual design with currently available technologies and components, if an appropriate combination of detectors was used and the detectors properly integrated. Based on this conclusion, and to allow for the broadest possible competition and to encourage potential bidders to propose innovative approaches, the specifications prepared for procurement of the monitors were performance based rather than specifying which detector technology to use.

3.1 Major Components of a Fixed Air Monitor

Each of the fixed air monitoring stations consists of the following components:

- A high-volume air sampler that draws air through a fixed sample collection filter, with instrumentation for measuring sample air volumetric flow rate and total flow
- Instruments for measuring ambient air temperature and barometric pressure
- Instruments for measuring gamma radiation and beta particles emanating from particles collected on the air filter media
- A real-time clock/timer/controller subsystem
- An operator interface and control subsystem
- A computational unit capable of performing limited calculations and unit conversions on instrument outputs
- A data logger that continuously records and stores data from the instrumentation and air sampler
- A telemetry system with redundant telecommunications capabilities

- An environmental enclosure that houses and distributes electrical power for all of the equipment
- A telescoping mast that attaches externally to the environmental enclosure, with provisions for mounting telecommunications antennas and optional wind speed and direction instruments
- Optional instrumentation for measuring wind velocity and direction

All of these components are fully integrated to complement and inter-operate with the other components, without unnecessary redundancy. Fig. 3.1.1 shows a fixed air monitor.

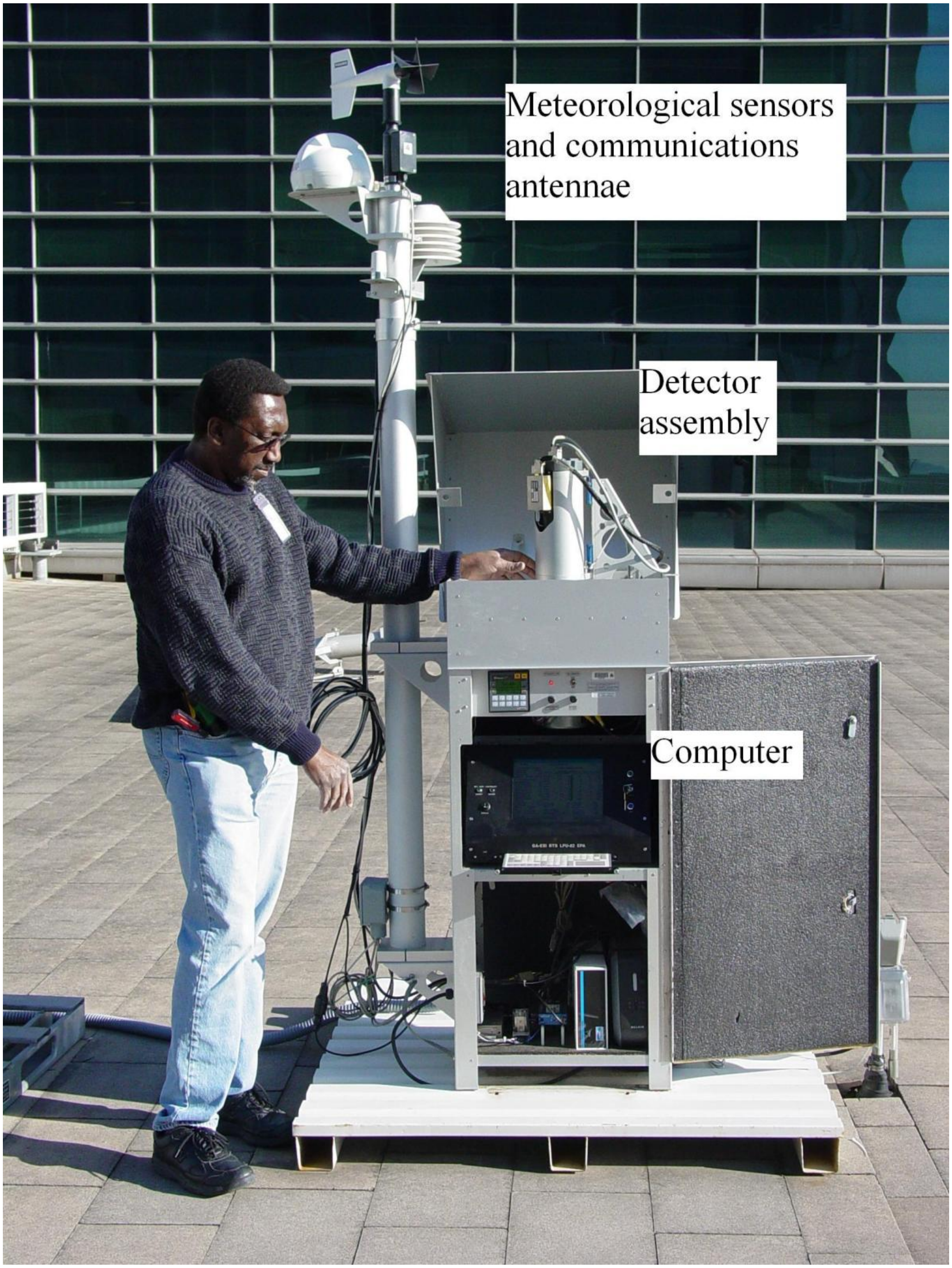

Fig. 3.1.1. Fixed air monitor.

3.2 Air Sampler

The air sampler consists of a sample air inlet, filter holder assembly, air pump and flow rate control system, and flow rate measurement device. It uses a 4 inch (10 cm) diameter round, polyester fiber filter, positioned between 3.28 and 3.77 feet (1.0 and 1.15 m) above the floor or other horizontal supporting surface.

The sampler has a sample air flow rate control system capable of providing an adjustable volumetric flow rate between 1230 and 2650 cubic feet per hour (35 and 75 cubic meters per hour). The flow rate is specified to be regulated to within ±5 percent of the programmed rate, at a pressure filter drop that ranges from 0.59 inches Hg (15 mm Hg) for a clean filter at 1230 cubic feet per hour (35 cubic meters per hour) to 1.97 inches Hg (50 mm Hg) for a fully loaded filter at 2650 cubic feet per hour (75 cubic meters per hour). It also has instrumentation to measure volumetric flow rate, corrected to standard temperature and pressure (STP) using on-board ambient air temperature and barometric pressure sensors.

3.2.1 Evaluation of Potential Sampling Biases in the Fixed Air Monitor

The U.S. EPA Science Advisory Board (MOR07) suggested during their 2005 review that a wind tunnel “would be a good place to conduct” tests of the monitor’s “collection efficiency of airborne particulates as a function of the wind speed and direction at which they arrive at the monitor” as well as the “relationship between sampling efficiency and particle size.” The Board also stated that the impact of the geometrical arrangement of detectors above the filter media should be evaluated. In response to these suggestions, a production monitor was tested in a wind tunnel at EPA’s National Exposure Research Laboratory.

The testing evaluated overall air sampler collection efficiency (under standard operating conditions using standard sampling medium) as a function of wind speed, wind direction relative to the monitor, particle size and detector position relative to the filter. The monitor was tested at two orientations, one with the front of the monitor facing the wind, the other with the meteorological mast facing the wind. Tests were performed at wind speeds of 2, 8, and 24 km/hr (1.3, 5, and 15 mph). Five particle sizes (2.5, 5, 7.5, 10, and 15 microns) were tested for each monitor orientation and wind speed. Procedures and results are fully described in “Aerosol Sampling Efficiency Test of the RadNet Monitor, Final Report.” (DRA09) Major results and conclusions are summarized below.

Fig. 3.2.1 summarizes monitor collection efficiency measurements versus particle size and wind speed and orientation. This graph illustrates that evaluated particle sizes 7.5 microns and smaller are collected with an efficiency of close to or above 90% for wind into the monitor “face” and with an efficiency of approximately 65% or above for wind into the monitor “met” (meteorological instrument) mast. The study was designed to evaluate wind into the mast as a worst-case orientation; therefore the 65% collection efficiency of 7.5 micron particles is interpreted as a worst-case value for particles of this size range. Lower collection efficiencies (about 50% or lower) are restricted to particles that are 10 microns and larger in winds at or above 24 km/hr.

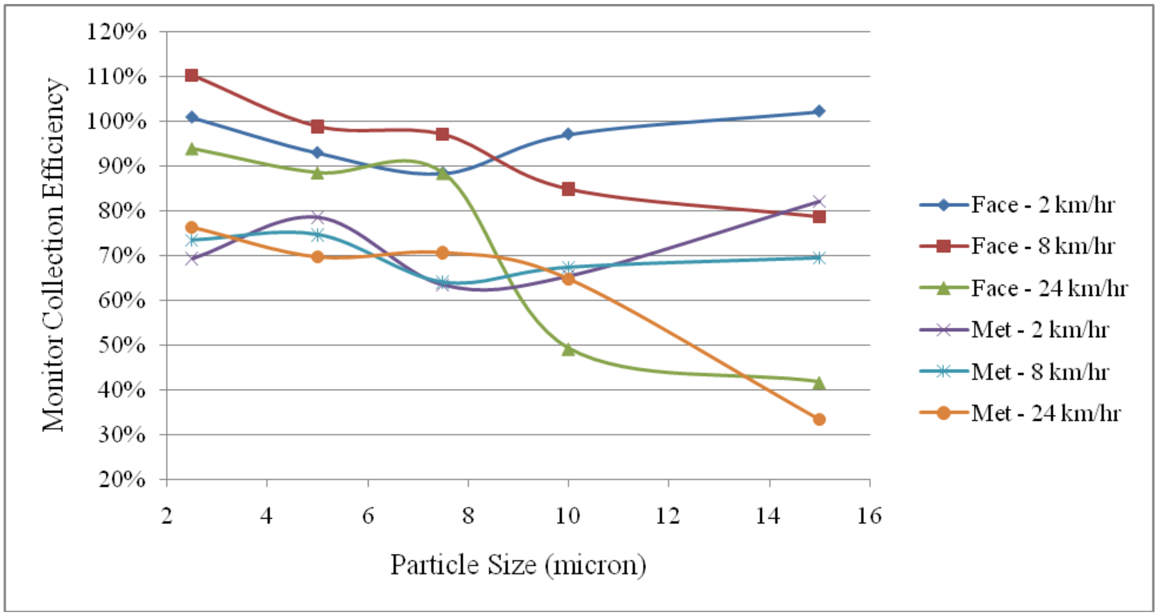

Fig. 3.2.1. Collection efficiency versus particle size for RadNet fixed monitors.

In addition to evaluating the effects of varying particle size, wind speed and wind direction, the wind tunnel testing also evaluated the effect of the geometrical arrangement of detectors on the deposition of airborne particles. Specifically, impact of the closer proximity between the beta detector and filter (compared to the gamma detector and filter) was investigated. The average ratio of material collected beneath the beta detector versus the material collected beneath the gamma detector is 90%, meaning there is not a significant amount of material lost beneath the beta detector. The report concludes that "only a small loss of material under the beta head" was measured. The investigators state this result is "surprising" because of a visible ring of material beneath the edge of the beta detector, but the report suggests that "the particles are deposited in a graduated ring" as they turn under the beta head. The report suggests that further studies could possibly model the "airflow around the cylindrical assembly" to better quantify precision and accuracy of the beta detector. Given that only a small loss of material has been measured beneath the beta detector, better quantification will not be noticeable or necessary given numerous other uncertainties associated with standard air particulate sampling and real-time radiological counting.

The referenced report concludes that the sampler collects particles up to 15 microns at low and elevated wind speeds. In addition, the report finds that the monitor collects the fine fraction (2.5 microns and below) "with reasonably high efficiency." The report also concludes that inherent errors in precision are not great enough "for the sampler to fail to see a major nuclear incident that would raise the levels of radiation across a wide area" and that "even a small elevation in the radiation level should be detectable."

3.2.2 Evaluation of Air Filters Used by RadNet Monitors

A study was performed by Lovelace Respiratory Research Institute, "Testing of Polyester Fiber Filters for the Collection Efficiency" (LRR05) to quantify the collection efficiency of the filter used by the RadNet fixed monitors. Twenty filters were tested at the fixed monitor nominal flow rate of 60 m^3/hr and particle size range of 0.2 to 10 microns. Filters were held in place with a filter holder that was connected on both sides by PVC pipes. The pipe downstream of the filter was connected to a vacuum pump. The study documents that filters show collection efficiencies higher than 99.8% for particles 5 microns and above and 97.6% collection efficiencies for 0.2 micron particles. For reference, the manufacturer of the filter that is used on the deployable monitor states the efficiency is 98% or greater (F&J11).

By design, the Lovelace filter efficiency test quantified efficiency of the filter without consideration of the entire sampling system (hooded enclosure, filter holder and detector assembly). The efficiency from the Lovelace study is higher than the overall sampler efficiency determined in the wind tunnel testing described in Section 3.2.1 because the former testing was designed to measure the filter in isolation, whereas the latter testing was designed to measure the entire sampling system.

EPA also evaluated fixed monitor operability using the above-described polyester filter and the glass filter used with the deployable RadNet monitors. Using the polyester filter, the study documents that the fixed monitor air sampler can operate at 60 m^3 per hour for a week or more with flow rate regulated to within ±5 percent of the programmed flow rate. This conclusion is consistent with observations made during initial testing of the prototype fixed monitor, subsequent routine operation of installed monitors, and specifications required of the manufacturer. Fixed monitors tested with the deployable monitor glass filter showed significant flow degradation (in excess of 5 percent) as soon as one day into a sampling event. Operation of installed fixed monitors continues with use of the polyester filters at 60 m^3 per hour.

3.3 Radiation Instruments

The RadNet fixed monitoring stations are equipped with instruments for continuously measuring beta and gamma radiation emitted from particulate matter that has collected on the sampler's filter. The detectors are mounted as close as possible to the filter media to maximize detection of radioactivity, but in a manner designed to not significantly disrupt air flow, particle distribution homogeneity, or filter changing. The U.S. EPA Science Advisory Board stated that "the impact of this geometrical arrangement on the deposition of airborne particles should be evaluated.…" (MOR07). This arrangement was evaluated as part of the monitor's wind tunnel testing, described in Section 3.2.1. The detectors and the filter are pictured in Fig. 3.3.1.

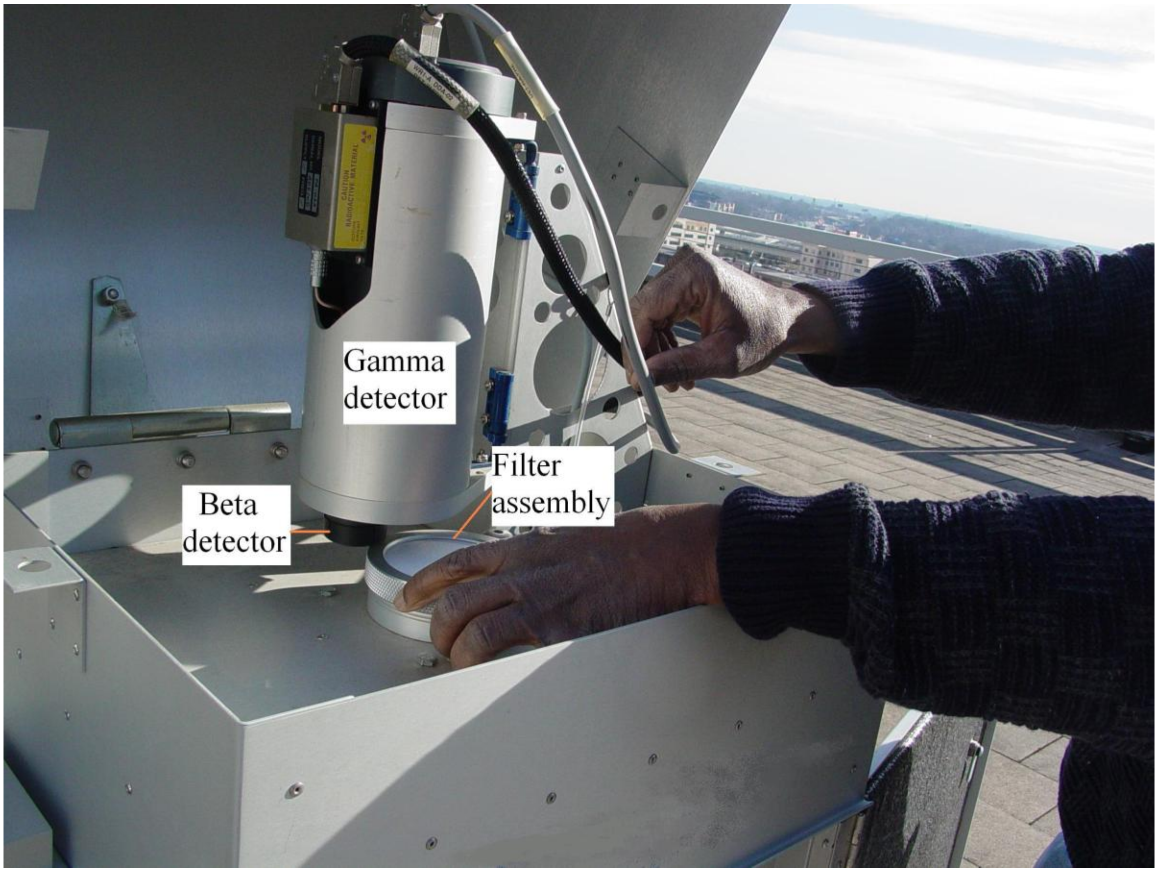

Fig. 3.3.1. Fixed monitor radiation detectors and filter.

3.3.1 Gamma Radiation Detector

The gamma radiation detector is a NaI(Tl) scintillation crystal with integral temperature sensor and heater. The heater is designed to maintain a constant temperature above freezing to prevent cracking of the crystal and to aid in gain stabilization. A small Am-241 light pulser with a gamma-equivalent energy of approximately 3 MeV is used for fine gain stabilization, leaving a useful gamma energy range of at least 100 to 2,000 keV. The detector is coupled to a 1,024-channel multi-channel analyzer and local processing unit.

Each gamma spectrum is stored locally in a separate digital file. The information stored in each file includes:

- spectrum file name
- number of channels
- acquisition start date and time (Coordinated Universal Time, or UTC)
- acquisition stop date and time (UTC)
- real time in seconds
- live time in seconds
- coefficients for the energy calibration equation
- a 64-character field for comments entered by the operator
- accumulated counts in each memory channel

The detector is arranged to optimize efficiency for measuring radiation emitted from particles collected on the filter. Although it was not a design objective, the detector can also qualitatively measure noble gas radionuclides present in the air in which the detector is immersed.

The initial Concept and Plan (EPA05a) proposed a means for evaluating static (e.g., gammas from soil and building materials) and dynamic (e.g., radon progeny) ambient background. Subsequent experience has shown that the spectra are typically very similar over time, and thus compensation for background changes is typically not necessary. When necessary, compensation for background is evaluated by graphical comparison of temporally contiguous spectra.

In the presence of background Pb-214 and Bi-214 particles on the filter media at levels varying from 300-30,000 pCi (11 Bq to 1100 Bq) and with the radioactive particles uniformly distributed over the active collection area of the filter media, specifications require the following minimum detectable activities at the 95% confidence level with a counting data acquisition time of no greater than one hour. The range of radon progeny background concentrations was based on data published in the National Council on Radiation Protection and Measurements (NCRP) Report No. 45, *Natural Background Radiation in the United States* (NCR76). The radionuclides were selected to be representative of the variation in efficiency over the desired gamma energy range of the gamma detectors that might be used in this application, with consideration of their likelihood of being used in a radiological dispersion device. Table 3.3.1 shows the Minimal Detectable Activities (MDA) in the detector specifications for the selected radionuclides.

Table 3.3.1 MDAs Specified in the Fixed Monitor Bid Package

Radionuclide	MDA at 95% Critical Level (nCi)	MDA at 95% Critical Level (Bq)
Am-241	5	185
Co-60	810	30,000
Cs-134	2,000	74,000
Cs-137	3,000	111,000
Eu-152	300	11,000
Eu-154	200	7,400
Ir-192	1,000	37,000

3.3.2 Beta Particle Detector

The beta particle instrument uses a silicon detector with an entrance window thick enough to stop 8 MeV alpha particles and is designed to minimize response to gamma radiation. In the presence of background Pb-214 and Bi-214 particles on the filter media at levels varying from 300 – 30,000 pCi (11 Bq to 1100 Bq) and with the radioactive particles uniformly distributed over the active collection area of the filter media, the instrument is designed to have sufficient sensitivity to quantitatively measure 85 nCi (3 kBq) of Sr-90 (in equilibrium with Y-90) at the 95% confidence level with a counting data acquisition time of no greater than one hour. Verification of the detector's ability to meet this 85 nCi measurement requirement is described in Section 3.3.4.

Installation and routine operation of the first production monitor in April 2006 showed potential interference of radio-frequency waves on the beta detector. To attempt to minimize this interference, the monitor’s coaxial cable was replaced with a cable that had heavier shielding and the circuitry and enclosure of the pre-amplifier were completely redesigned. The heavier shielded cables and redesigned pre-amplifier now are used on all fixed monitors.

Severe spiking of beta count rates, to the point of “locking up” the monitors, has been subsequently noted on some monitors. An investigation at various sites by the manufacturer concluded that ambient radio-frequency interference is one likely cause. A change in the operational software for the fixed monitors now prevents spiking from locking up the monitor, but does not prevent the spiking. While these changes seem to have worked well for some detectors, it has not worked well in all of them. EPA and the vendor continue to look for other causes of erratic beta measurements and ways to correct them.

3.3.3 Alpha Particle Detector

Although only gamma and beta detection were required in EPA’s specifications for the fixed monitor, the vendor proposed an algorithm for measuring both alpha and beta particles using the monitor's silicon detector. The proposed silicon detector’s window was too thin to stop 8 MeV alpha particles (based on preventing interference with the beta measurement by radon progeny that emit high energy alphas, of which Po-214 with an alpha energy of 7.7 MeV is limiting), as required by EPA’s specifications. The vendor responded with a proposal to provide a removable plastic cap for the silicon detector. Placement of this cap would conform to EPA’s specifications for beta detection without interference from 8 MeV alpha particles; removal of this cap would permit EPA to evaluate the vendor’s proposed alpha measurement algorithm.

All of the monitors produced are provided with this removable plastic cap. The cap was removed on several of the initially installed monitors to collect data for evaluating the vendor's proposed alpha measurement technique. Subsequently, EPA determined that the vendor’s algorithm for detecting alpha particles does not work. Therefore, EPA decided to keep the caps on all of the beta detectors to ensure the monitors meet the intended goal of measuring beta particles while blocking 8 MeV alpha particles. Because the cap prevents any alpha particles from reaching the detector, the monitor does not have the ability to measure alpha particles. EPA will continue to look for detectors that can measure both alpha and beta simultaneously. Meanwhile, alpha measurements continue to be made by the operator five hours after filter collection.

3.3.4 Measurement Sensitivity

3.3.4.1 Tested Measurement Sensitivity for the Prototype Monitor

The Savannah River National Laboratory tested the fixed monitor prototype at their facilities in 2005. As part of this testing, actual minimum detectable activities (MDA) were determined to ensure that the monitor was able to meet EPA's specifications. The results of the MDA determinations are available in the SRNL 2005 report "Minimum Detectable Activity for the EPA's Fixed RadNet Air Monitors." (SAL05)

A summary of the MDAs from the specifications and as determined by SRNL are shown in Table 3.3.2 below. Derived Response Levels (DRL) for protective action guidance are also shown to illustrate how the fixed monitor is more sensitive than would be required to detect contamination exceeding the early phase protective action guidelines. As documented in Table 3.3.2, the calculated MDA values are significantly lower than the MDA values specified in the request for quotes for the monitors, which were far lower than levels needed to exceed the early phase Protective Action Guideline.

Table 3.3.2 Comparison of fixed monitor specified and calculated MDAs to DRLs

Nuclide	DRL from Table 5.1 of PAG Manual (EPA92) (nCi)	MDA in Specifications (nCi)	Calculated MDA from SRNL (nCi)
Am-241	114	5	13.2 [1, 2]
Co-60	222,000	810	2.0
Cs-134	960,000	2,000	1.1
Cs-137	1,440,000	3,000	1.2
Eu-152	228,000	300	12.3
Eu-154	174,000	200	5.4
Ir-192	1,620,000	1,000	1.6
Sr-90	38,400	85	N/A

[1] This value is different than the one published in Table 4 of "Minimum Detectable Activity for the EPA's Fixed RadNet Air Monitors," Savannah River National Laboratory, October 30, 2005 as noted in Appendix D.

[2] The MDA for Am-241 was determined experimentally by EPA to be 3.8 nCi (R. Lowry, personal communication).

SRNL did not perform the MDA determination for Sr-90. However, the 50 nCi Sr-90 sources used to calibrate the beta detector are easily detectable above background beta levels, as demonstrated at the Montgomery fixed monitor.

Several minor errors were noted in SRNL's report (SAL05) during evaluation by EPA. These errors, detailed in Appendix D, do not significantly impact the results.

3.3.4.2 Measurement Sensitivity for the Selected Installed Monitors

A summary of MDAs calculated for installed monitors is presented in Table 3.3.3, along with correlative manufacturer-required MDAs and SRNL-calculated MDAs. To account for varying climatic and ambient conditions, ten monitors (one from each EPA Region) were selected for this summary. For each monitor, a representative one hour background acquisition was used to determine MDAs as described by SRNLs algorithm. The ten monitors used for this summary are:

Providence, RI
New York, NY
Baltimore, MD
Memphis, TN
Duluth, MN
Carlsbad, NM
Jefferson City, MO
Salt Lake City, UT
Eureka, CA
Seattle, WA

The MDAs calculated using data from installed monitors are similar to the MDAs calculated by SRNL. The similarities of these MDAs indicate that installed monitors acquire data with similar sensitivity to the prototype monitor evaluated by SRNL. The slightly higher MDAs calculated by SRNL are likely a result of shorter acquisition times (600 seconds) than used for routine operation of installed monitors (3,600 seconds). The significantly higher MDA for Eu-152 calculated by SRNL may reflect higher concentrations of background K-40 in the spectrum evaluated by SRNL. The 1461 keV gamma emitted by K-40 has a similar energy to one of the prominent gammas emitted by Eu-152 (1408 keV), and K-40 is ubiquitous. Interference with K-40 will increase background counts at Eu-152's energy and increases calculated MDA. The single background spectrum evaluated by SRNL was acquired indoors, without shielding, which suggests K-40 may have been present from cinder block (a common and known source of K-40).

Table 3.3.3 Summary of MDA's calculated from data collected by selected installed fixed monitors and the impact of this MDA

Nuclide	MDA in Specifications (nCi)	Calculated MDA from SRNL (nCi)	Calculated MDA from Installed Monitors (nCi)	Airborne Concentration (pCi/m^3) [3]	Projected Dose for the First 4 Days (mrem) [4]
Am-241	5	13.2 [1, 2]	4.9	82	27
Ba-140	N/A	N/A	3.1	52	0.002
Ce-144	N/A	N/A	8.0	133	0.024
Co-60	810	2.0	1.2	20	0.002
Cs-134	2,000	1.1	0.8	13	0.001
Cs-136	N/A	N/A	1.1	18	0.0003
Cs-137	3,000	1.2	0.8	13	0.002
Eu-152	300	12.3	1.5	25	0.008
Eu-154	200	5.4	1.1	18	0.007
I-131	N/A	N/A	0.7	12	0.0003
Ir-192	1,000	1.6	0.7	12	0.0003
La-140	N/A	N/A	2.0	33	0.0003
Ru-103	N/A	N/A	1.0	17	0.0002
Ru-106	N/A	N/A	0.9	15	0.003
Te-132	N/A	N/A	0.6	10	0.0002
Zr-95	N/A	N/A	2.1	35	0.0008

[1] This value is different than the one published in Table 4 of "Minimum Detectable Activity for the EPA's Fixed RadNet Air Monitors," Savannah River National Laboratory, October 30, 2005 as noted in Appendix D.
[2] The MDA for Am-241 was determined experimentally by EPA to be 3.8 nCi (R. Lowry, personal communication).
[3] Airborne concentration is determined from the Calculated MDA from Installed Monitors data for a one hour detection period.
[4] Dose is projected for the 4 day period during and after a one hour detection of air contaminated at the airborne concentration level, which is based on the activity collected at the MDA.

3.4 Data Processing and Storage

The monitoring stations have the capability to perform calculations, unit conversions, etc., on raw inputs in order to provide output in the desired formats:

- Absolute barometric pressure and ambient temperature are used to correct the measured volumetric flow rate to STP. Sample flow rates and integrated total flow for the sample period are displayed locally, stored in the data logger, and transmitted in units corrected to STP.
- Flow rate measurements are integrated to determine the total sample flow for each sampling event and for each interval of radiation instrument data acquisition.

- For each gamma radiation spectrum, the counts are accumulated in ten separate user-definable channel ranges. These ranges are integrated, and then divided by either the live time or real time (user-definable) to determine the count rate in counts per minute for each channel range.
- For each completed counting interval for the beta particle detector, the count rate in counts per minute is determined.

Data are stored in non-volatile memory. After 60 days, the data are stored in archive folders on the monitor. Data include the following:

- Date and time (UTC) that acquisition began and ended
- Real time and live time for data acquisition in seconds
- Beta count rate
- Count rate for each gamma channel range
- Total volume of air that has passed through the filter since the last filter change
- Complete gamma spectrum file
- Ambient air temperature and pressure, and wind speed and direction, averaged over the data acquisition interval

In addition, the following data are stored for the current (if a sample is in progress) and at least the most recent two sample collection intervals:

- Date and time (UTC) that sample collection began (and ended, if applicable)
- Total sample volume (corrected to STP) collected (or collected thus far, if sampling is in progress)
- Average, minimum, and maximum sample flow rate (corrected to STP)
- Total number and duration of any power interruptions lasting more than one minute

3.5 Data Telemetry

The fixed monitoring stations have a telemetry system with multiple redundant telecommunications capabilities. The system includes the necessary hardware, firmware, and software to both send and receive data, using point-to-point protocol, by all of the following methods:

- V.92 hardware modem via analog connection to a local telephone service provider (software modems are unacceptable)
- 1xRTT cellular telephone data modem
- 10/100 Base-TX Ethernet, IEEE 802.3 compliant

- LandSat satellite transceiver

Antennae for the cellular telephone and satellite transceivers are mounted on an external mast.

The telemetry system is capable of automatically transmitting data at user-programmable intervals between 10 minutes and 7 days without operator intervention. It automatically polls communication resources for availability, and automatically switches to an alternate communications method if the primary method is unavailable. The designation of primary and alternate methods, and their order of preference, is user-programmable.

Data encryption is used for all of the telemetry methods, and the telemetry system is capable of accepting and connecting with incoming transmissions to allow for remote user interface and control.

3.6 Implementation of the Fixed Monitor Siting Plan

EPA presented its national fixed monitor siting methodology in the Concept and Plan document in October 2005 (EPA05a). The process presented in that document was used to develop the list of target monitor locations. This section presents the implementation strategy used by EPA to implement this list as well as the results of a comparative study of EPA's siting plan to one developed by the Savannah River National Laboratory.

Section 3.6.1 presents a summary of the siting methodology. Section 3.6.2 outlines a siting plan developed by SRNL using computer modeling of atmospheric contamination transport which was compared to the EPA plan using an independent set of plumes generated at NAREL. The comparison was performed to determine if there were significant differences between a plan based on atmospheric dispersion modeling and the EPA plan, which was based on population, geographical coverage, and practicalities. *The conclusions were that the EPA plan produced very similar contamination detection capability results, and that the EPA plan slightly favors the area west of the Mississippi River while the SRNL plan favors the area east of the Mississippi River.*

The implementation of the EPA siting plan is discussed in Section 3.6.3. The plan was implemented by releasing selected locations from the siting list in sets rather than releasing them all at once. The strategy was to address sequentially population and geographical coverage goals.

Finally, Section 3.6.4 discusses the practicalities of location changes. Prospective operators and EPA Regions requested several changes in the siting plan due to inability to find a suitable location or operator, or to meet other objectives. These changes were considered against the primary objectives of the system as a national network to ensure there would not be an adverse impact from allowing the changes. Most changes were approved and implemented.

3.6.1 Siting Methodology Summary

The selected siting methodology (referred hereafter as the EPA siting plan) has three basic steps. It begins with population as the primary criterion, identifies and removes monitors in close proximity, and re-distributes these monitors to fill gaps. The basic approach is as follows:

- Step 1: Select the highest population cities for the number of monitors to be placed.
- Step 2: Remove cities that are in close proximity to each other.
- Step 3: Fill in the gaps.

The first step was to select the most populated U.S. cities, regardless of location. This selection resulted in several instances where locations were grouped or "clustered," mainly in the large metropolitan areas. Since the siting objectives required the system to spread across the nation, those locations were "de-clustered" as the second step of the process. The declustering process began by determining if a city was within 25 miles (40 km) of a larger city. If so, the smaller city was removed from the further consideration to receive a monitor. The locations that were removed from consideration were replaced with locations based on filling the largest gaps using an iterative process of selecting new locations as far away from previously selected ones as possible.

3.6.2 Computer Atmospheric Dispersion Modeling

Through an Interagency Agreement, the Department of Energy's Savannah River National Laboratory (SRNL) developed a siting plan based upon atmospheric dispersion modeling (KUR09). The SRNL's independently developed siting plan was compared to EPA's siting plan to determine if there was a significant difference between a theoretical plan based on atmospheric dispersion and one that was not based on dispersion patterns. *EPA found that the results of the SRNL atmospheric dispersion study were similar to the siting strategy summarized in Section 3.6.1.* A summary of the study and the comparisons of SRNL's siting versus EPA's siting are provided below.

3.6.2.1 SRNL Methodology

3.6.2.1.1 Contaminant Plume Generation

SRNL used the National Oceanic and Atmospheric Administration's (NOAA) HYSPLIT atmospheric dispersion model to simulate contaminated plumes released at four different times of day for seven days during each of the four seasons. The releases originated from the 50 largest metropolitan areas in the continental United States, producing a total of 5,600 modeled releases. Averaging the plumes every six hours for one week produced a total of 156,800 plumes. These plumes were then analyzed at locations defined by a 0.5 degree grid of the continental United States. The analyses (described below) were performed to determine monitor placement schemes based upon the modeled atmospheric transport of contamination.

3.6.2.1.2 Data Analysis Methods

SRNL used two techniques to analyze the data from the plume modeling to predict theoretical monitor placement. The first was termed the "Detection Method," which was designed to maximize the number of plumes detected by the system. The second was termed the "Summed Plume Minimization," which was designed to minimize interpolation error in population dose based on the plumes generated.

SRNL noted that the Detection Method is best when it is supplementing other data (e.g., supplementing computer modeled atmospheric plume projections) whereas the Summed Plume Minimization technique is of less value when used in conjunction with a model. Also, they noted that monitors placed using the Summed Plume Minimization method will have a significantly lower detection probability of a plume than if the monitors are placed using the Detection Method. *EPA selected the Detection Method as the appropriate analysis technique to compare to the EPA siting plan since one of the primary objectives of the RadNet fixed monitoring system is to work in conjunction with other data sources (primarily atmospheric dispersion models) and maximizing probability of detection is an important aspect of providing at least one non-zero data point for the modelers to use.*

3.6.2.1.3 Detection Method Analysis Technique

The basic philosophy of the Detection Method is to maximize the total number of plumes detected by a network of monitors. The general approach is to determine which grid point has the largest number of plumes passing over it, select that grid point as a monitor location, and then remove from further consideration those plumes that passed over that grid point. For example, assume the grid point at 35N, 95W has the 10,000 plumes passing over it and that is the most of any of the grid points. The point 35N, 95W would be selected as the first location for a monitor, and then those 10,000 plumes would be removed from the 156,800 plumes developed, leaving 146,800 plumes to be considered for the next grid point to be selected. This process continues until all 180 grid points are selected. Since EPA had already decided upon the initial 59 locations (see Section 3.6.3), those locations were automatically placed by SRNL.

The basic Detection Method described above used no weighting factors in determining monitor location. SRNL ran two alternative variations of the basic Detection Method. The first alternative used relative contaminant concentration as a weighting factor, thus placing more importance on measuring higher concentrations. The other alternative used relative contaminant concentration and population density as weighting factors, essentially evaluating potential population dose. A review of the results from both of the alternative methods indicates that there is little difference between the two and that the resulting grid points found by either alternative method center highly on release points, which were large cities.

SRNL noted that the alternative methods would provide better data for dose determination from RadNet monitors, while the basic method provides a more complete sampling of the continental United States. SRNL also noted that the alternative methods would have a better chance of detecting a plume originating from one of the locations modeled in their study. With these in mind, EPA selected the basic Detection Method as appropriate for comparison to the original siting plan because:

- the fixed monitors are not expected to provide dose determination solely from their data;
- a primary objective of the system is to provide data for long-distance transport assessment, not localized; and
- concentrating monitors in population areas would not be as effective for foreign source incidents or incidents originating from locations other than the SRNL incident locations.

3.6.2.2 Comparison of EPA's Siting Plan to the SRNL's Detection Method

For comparison purposes, EPA selected two goals to compare the EPA and SRNL siting plans. Goal number one was to minimize the number of releases where contamination does not pass over a monitor. Goal number two was to maximize the number of monitors over which contamination passes. Throughout the remainder of this section, the word "detect" is used as a convenient way of indicating that a plume passed over a particular location/monitor. In this context, "detect" makes no reference as to whether a monitor would have actually detected contamination because of the numerous variables associated with detection of contamination.

The first goal minimizes the number of releases that are not potentially detected. Stated differently, the goal maximizes the possibility that at least one data point from RadNet would be available following a radiological release. While "non-detects" are still an important aspect in defining potential contamination boundaries, a detection provides more information for atmospheric dispersion modelers to use in validating their model, so it is important that a siting plan maximize the probability of a release being detected.

The second goal maximizes the number of potential detections. Maximizing the number of potential detections provides more data points for atmospheric dispersion modelers to validate their models or to adjust input parameters. Therefore, maximizing the number of detections for each release is an important aspect of a siting plan.

If the two goals described above are considered individually, they would likely lead to two different siting plans. Minimizing the number of releases not detected would likely lead to having monitors spread more across the nation to maximize the probability that releases that occur in relatively unpopulated areas are detected. On the other hand, maximizing the number of detections would likely lead to clustered monitors in areas most likely to be the source of a release (generally assumed to be near population centers), or would favor more monitors toward the eastern half of the nation due to the general west to east wind pattern in the contiguous United States. Thus, these criteria parallel the two goals of the EPA siting plan, which strives to cover large population areas regardless of clustering while still providing significant geographical coverage, which strives to minimize large areas where there are no monitors.

3.6.2.3 NAREL's Computer Simulated Atmospheric Dispersion Study

To compare siting implementation plans, NAREL performed an atmospheric dispersion study using the HYSPLIT model (DRA03). NAREL simulated 12 releases from each of 100 locations. About two thirds of these 100 locations were major U.S. metropolitan areas. The remaining release locations were determined by ensuring there were releases from each contiguous state in the United States, releases from ten major Canadian cities and two major Mexican cities, and from nine randomly selected remote locations in the United States.

To account for varying seasonal weather patterns, NAREL ran a simulation from each location beginning in a randomly determined hour during the first half of each month of 2008. The first half of the month was selected to prevent similar plumes from being developed for a particular location (e.g., releases from New York simulated on October 31, 2008 at 2300 and November 1, 2008 at 0100 would likely duplicate dispersion patterns). A map of the source locations is shown in Fig. 3.6.1.

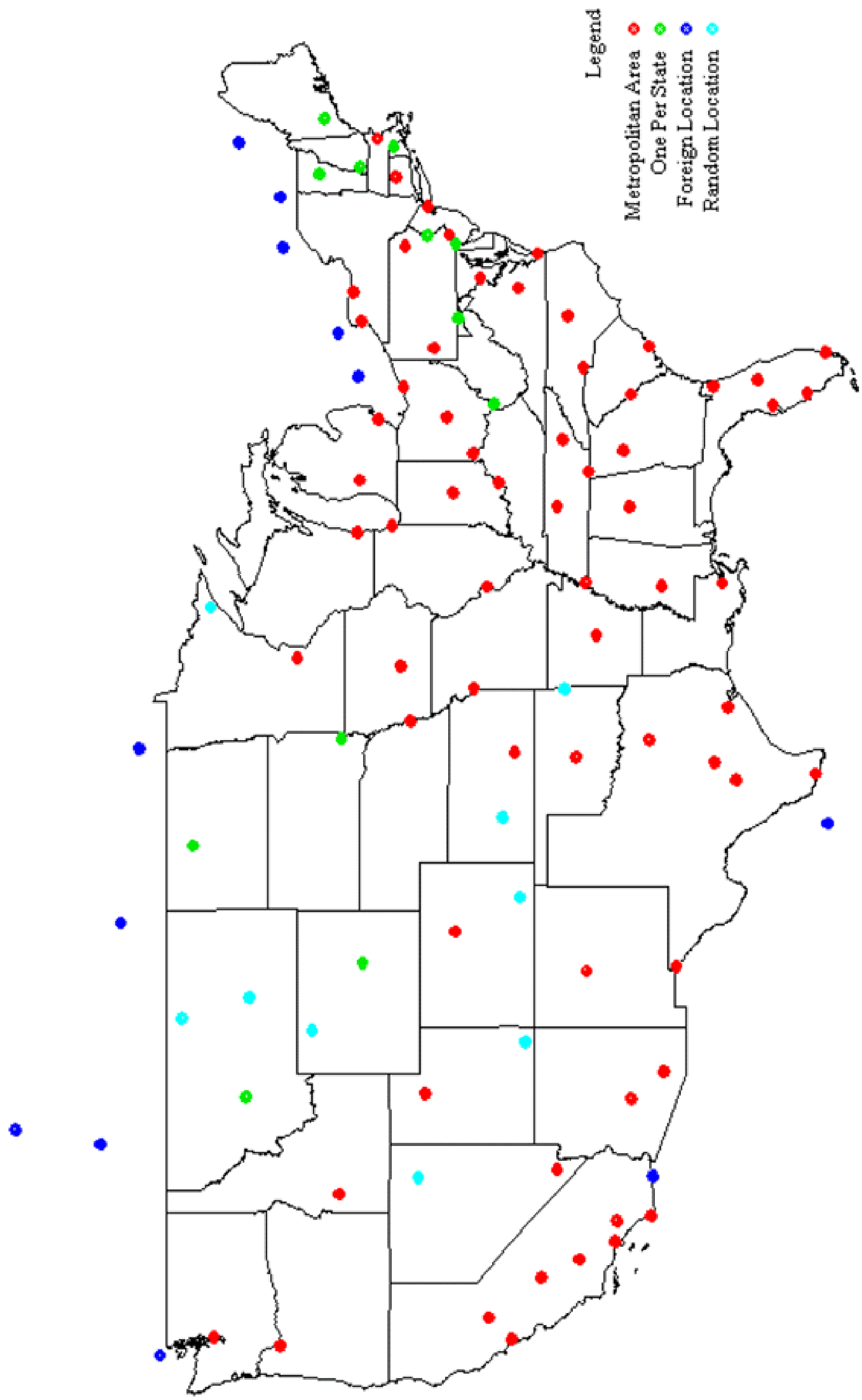

Fig. 3.6.1. Source locations for NAREL atmospheric dispersion study.

Each simulated release was run for a total of 48 hours since this is when atmospheric dispersion models are the primary source of information used by most decision makers for protective actions. The plumes developed by HYSPLIT were averaged over the entire 48-hour period, as well as being averaged for each hour of that period.

The 48-hour averaged plumes were used to determine if a potential detection would occur, with one exception described in the next paragraph. If a location was within the boundary of the plume, that location was considered to have detected the release. The HYSPLIT model output consisted of three equal plume concentrations that were equal for each simulated release, allowing consistent comparisons to be performed. The three plume concentrations represent plumes where the dispersion is “widespread” (lowest concentration isopleths), “reduced” contamination spread (middle concentration isopleths), and “minimal” contamination spread (highest concentration isopleths).

In the first hours of model simulation, the generated plumes frequently surrounded the release location. Since many of the release locations were in or near potential monitor locations, these “local” monitor locations always met the criterion for detection discussed in the previous paragraph. Since it is not likely that detection by a monitor in or near the same location as the release will occur, any potential monitor location within 25 miles of the release location was automatically removed from the list of locations where plumes were detected. However, detailed study of the hourly plumes showed that there were situations where local monitors would likely have detected the release. The two primary situations where a local monitor would be likely to detect the plume include a release that begins during a very calm wind period or temperature inversion and a release where contamination travels away from the monitor, but then reverses direction and travels back over the monitor. In these cases, the monitor was considered to have detected the plume.

Fig. 3.6.2 shows an example of a widespread, 48-hour averaged plume generated from the November 2008 simulated release from North Dakota with the EPA siting plan monitor locations. The monitor locations that were within the plume boundary (i.e., detected), such as St. Louis, Missouri, are shown in green while the monitor locations that were not within the plume boundary, such as Chicago, Illinois, or that did not meet the local detection criteria, such as Minot, North Dakota, are shown in maroon. Fig. 3.6.3 shows the reduced, 48-hour average plume from the same release, and Fig. 3.6.4 shows the minimal, 48-hour average plume.

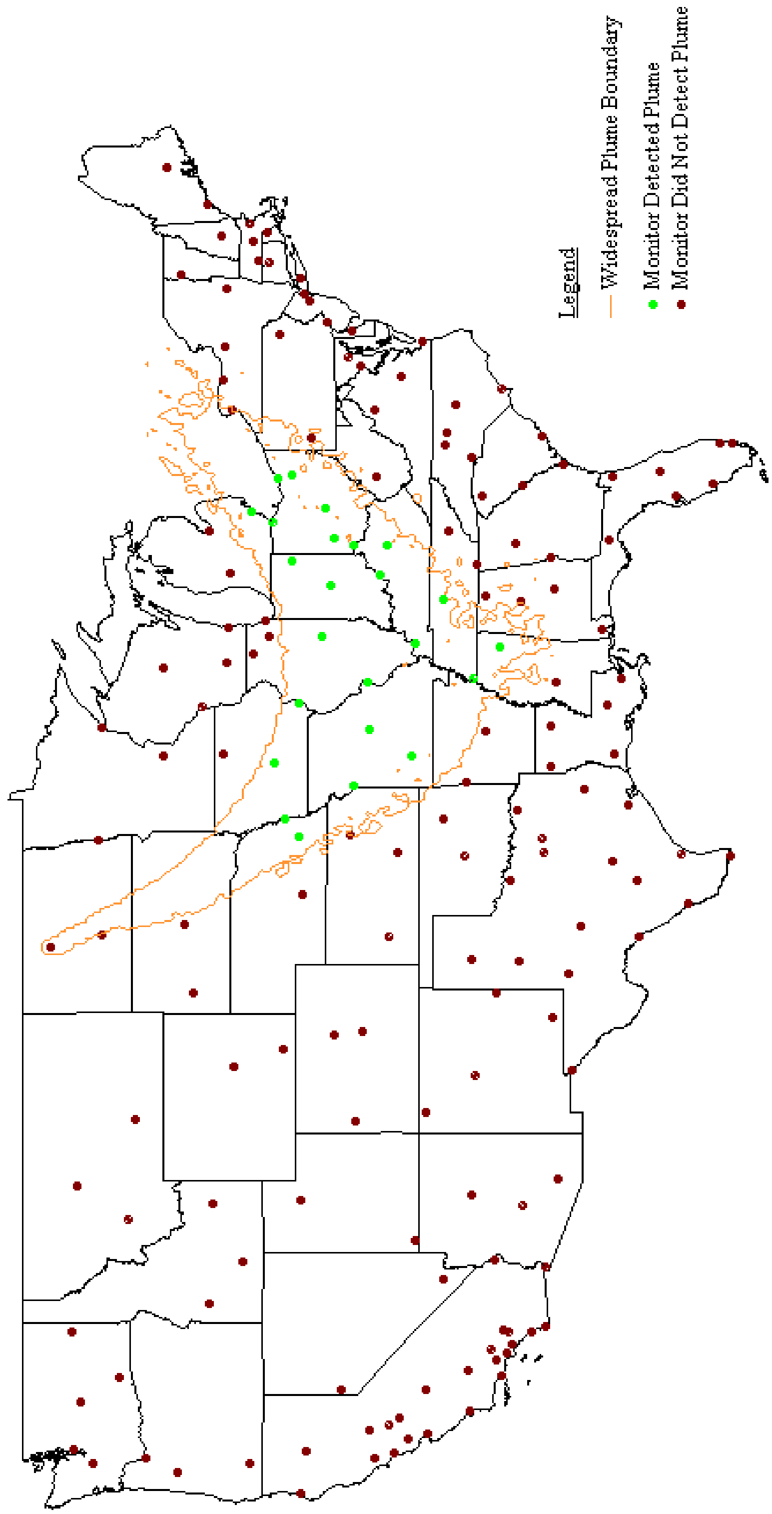

Fig. 3.6.2. Example of a widespread 48-hour averaged plume with monitor locations and detections.

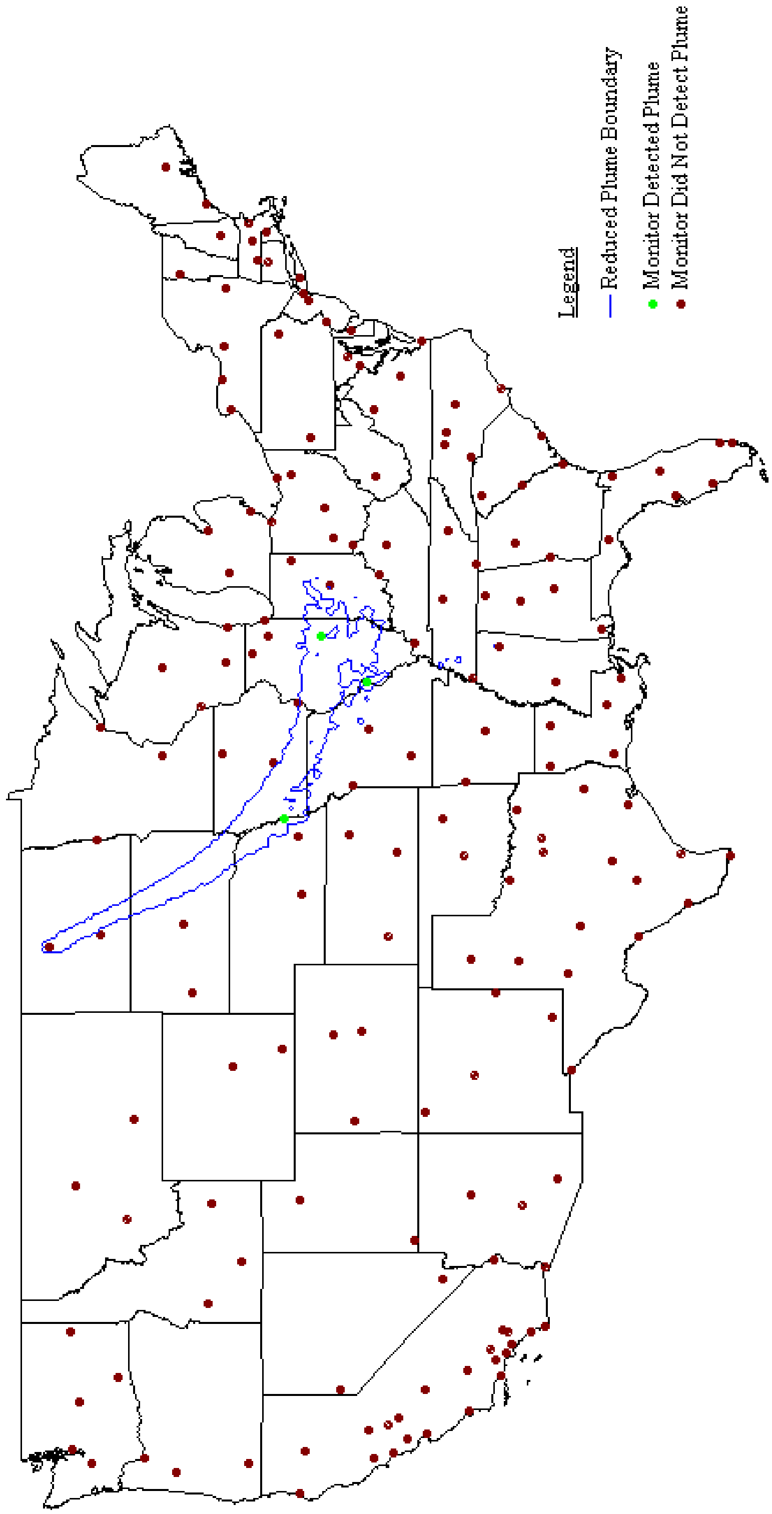

Fig. 3.6.3. Example of a reduced 48-hour averaged plume with monitor locations and detections.

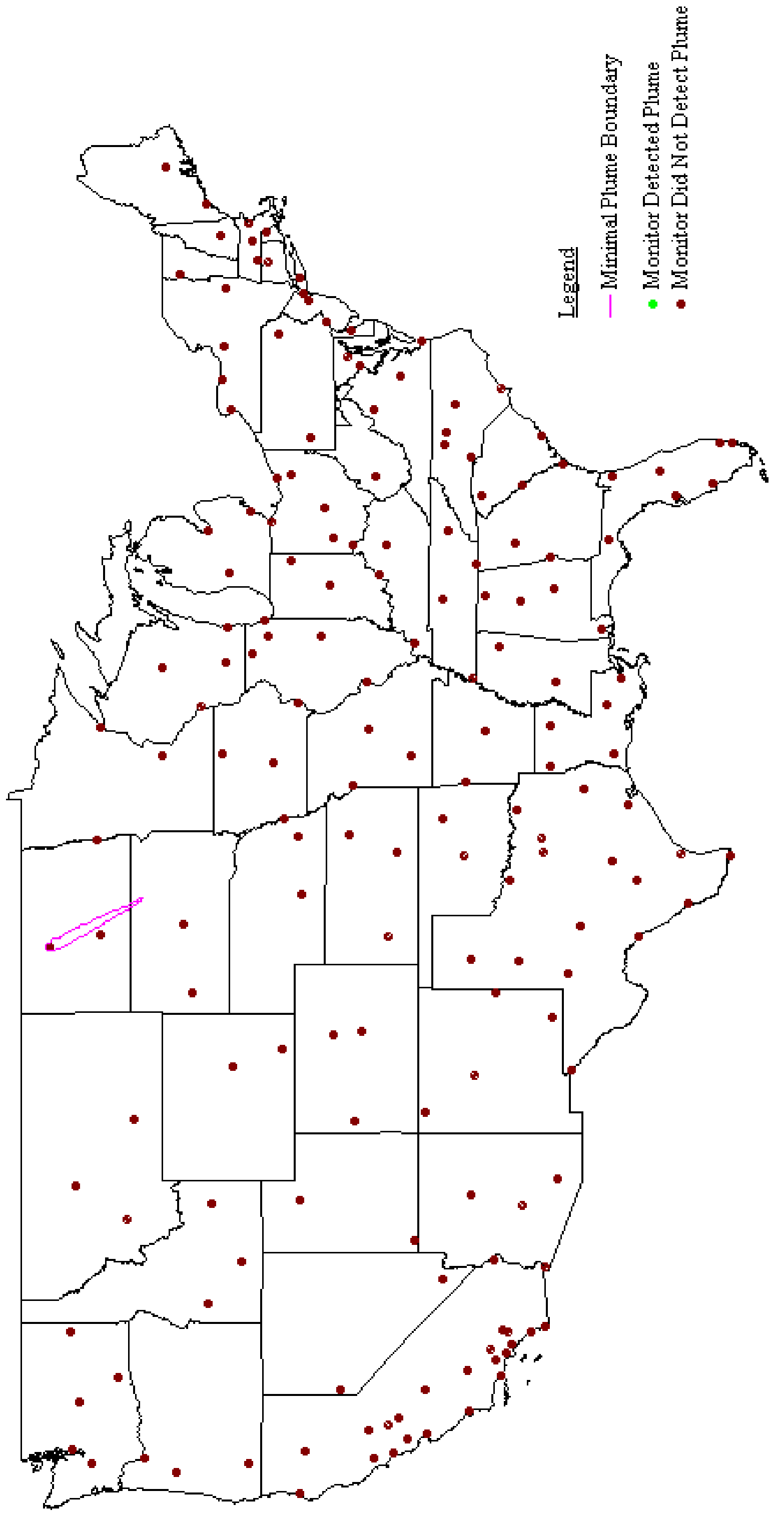

Fig. 3.6.4. Example of a minimal 48-hour averaged plume with monitor locations and detections.

Fig. 3.6.2 shows that the widespread plume was detected at 24 locations; Fig. 3.6.3 shows that the reduced plume was detected at three locations; and Fig. 3.6.4 shows that the minimal plume was not detected. The same detection analysis was preformed for the SRNL Detection Method locations to compare the plans on the basis of the two siting goals, minimizing undetected releases and maximizing number of detections. These comparisons were performed for the entire monitoring network to evaluate the overall difference in the plans and were also broken down by region to determine if there were regional biases between the two plans.

3.6.2.3.1 National Comparison of the EPA and SRNL Siting Plans

The EPA and SRNL siting plans were compared for all of the simulated releases to determine the relative effectiveness of monitor placement across the nation based on the two different siting methodologies. The results of the comparison show that the two plans provide similar capability to detect plumes and provide data to atmospheric dispersion modelers and decision makers. It should be noted that there is no specific reference standard for monitor placement, and neither the EPA nor SRNL plan should be considered as “the reference.”

The results for the two siting goals were determined for the EPA and SRNL siting plans for each of the three plume footprints. To address siting goal one, minimizing undetected releases, a “release detected” determination was performed for all 1200 releases. Once any monitor location detected the release, the release detected score for that release is one. If the release was not detected by any monitor, the release detected score for the release is zero. The total releases detected for each plume footprint is the sum of all of the individual releases detected, with a maximum of 1200.

To score the comparison of the EPA plan to the SRNL plan, the EPA plan results were divided by the SRNL plan results to obtain a ratio. The ratios were used to evaluate the effectiveness of each plan in minimizing plumes not detected. A score of 1.00 indicates the two plans are similar, while a score greater than 1.00 indicates the EPA plan is more effective and a score less than 1.00 indicates the SRNL plan is more effective. The greater the ratio above or below 1.00, the more significant the difference is. The results of the releases detected ratio determination are shown in Table 3.6.1.

For the releases detected example above, the results of the comparison would be 0.96, 0.98, and 0.94, for the widespread, reduced, and minimal plume spreads, respectively. This indicates that the SRNL plan is slightly more effective than the EPA plan, but that either plan will detect a similar number of releases.

Table 3.6.1 Releases detected by EPA and SRNL siting locations

Plume Spread	Releases Detected by the EPA Siting Plan	Releases Detected by the SRNL Siting Plan	EPA / SRNL
Widespread	1029	1067	0.96
Reduced	841	857	0.98
Minimal	239	254	0.94

Of the 1200 simulated "widespread" plumes, 99 were undetected by either siting plan. Almost all of these plumes were from source locations that were in states that border Canada, Mexico, or a major body of water; or were from foreign source locations. The SRNL siting plan detected 72 plumes that were not detected by the EPA siting plan. Of those 72 simulations that were detected by the SRNL plan, 45 were detected at only one SRNL location. Alternatively, the EPA siting plan detected 34 plumes that were not detected by the SRNL plan, with 21 of those plumes detected at only one EPA location. Table 3.6.2 shows a summary of the plumes missed by each plan for the three different plume spreads.

Table 3.6.2 Releases not detected by EPA and SRNL siting locations

Plume Spread	Releases Detected by the SRNL Siting Plan but not by the EPA Siting Plan	Releases Detected by the EPA Siting Plan but not by the SRNL Siting Plan	Releases Detected by either the EPA Siting Plan or the SRNL Siting Plan
Widespread	72	34	99
Reduced	132	116	227
Minimal	124	109	837

To evaluate siting goal two, maximizing the total number of detections, the "detections" determination was performed for all 1200 releases, using the three plume spreads (widespread, reduced, and minimal). This was performed similarly to the "releases detected" comparison, except the total number of detections was calculated instead of assigning one or zero for a detection. For example, using the November release from Minot, the widespread and reduced plumes were detected by 24 and 3 monitors respectively, while the minimal plume was detected 0 times. These scores were added to scores from the other 1199 releases to produce the total number of detections score for each siting plan and plume footprint. Ratios of EPA results to SRNL results were calculated in the same manner as for the releases detected ratios. The results are also interpreted similarly, where a score of 1.00 would indicate the two plans are similar, while a score greater than 1.00 indicates the EPA plan is more effective and a score less than 1.00 indicates the SRNL plan is more effective. Again, the greater the ratio above or below 1.00, the more significant the difference is. Table 3.6.3 shows the total detections and calculated ratios for the EPA and SRNL plans. The ratios were 0.94, 0.96, and 1.00, for the widespread, reduced, and minimal plume spreads, respectively, which indicates that the SRNL plan is again slightly more effective than the EPA plan at producing detection data, but not by a significant amount.

Table 3.6.3 Total detections by EPA and SRNL siting locations

Plume Spread	Total Detections by the EPA Siting Plan	Total Detections by the SRNL Siting Plan	EPA / SRNL
Widespread	5896	6276	0.94
Reduced	2145	2240	0.96
Minimal	321	322	1.00

Considering the national picture, the results of these comparisons were all very close to one, indicating that *the EPA siting plan and the SRNL siting plan produce similar release detection capability and similar capability to provide data to atmospheric dispersion modelers and decision makers*.

Finally, it should be noted that the results of the SRNL concluded that “180 samplers are sufficient to sample the majority of plumes at least once or to define the geographical extent of most plumes. In fact, both methods [Detection and Summed Plume] indicated that this objective could be achieved with 100-120 samplers.” Naturally, this assumes that the samplers are placed in the same order as each method selected them. Also, as stated earlier, the siting plan goals are to minimize the number of plumes not detected (same goal as the SRNL Detection Method) and to maximize the amount of data (i.e., detections) available for scientists and decision-makers (same goal as the Summed Plume Method).

3.6.2.3.2 Regional Comparison of the EPA and SRNL Siting Plans

The national comparison showed that the EPA siting plan and the siting plan developed by SRNL produce similar results when evaluated against the siting goals. However, a comparison was also performed to determine if there were regional biases. To evaluate regional biases, the 10 EPA Regions were chosen as boundaries. The two siting goals were evaluated for each region to determine relative ratios of releases detected (siting goal number one) and total detections (siting goal number two) for the EPA plan versus the SRNL plan. *The evaluation showed that the EPA plan was stronger in the western part of the nation while the SRNL plan was stronger in the eastern part.* The reasons why this occurs appear to be associated with simulation release location decisions and plume generation duration.

Two methods to evaluate regional bias were used. The first evaluated both siting goals for releases that occur in each region (regional source based). This evaluation measures the difference between the two plans for releases that occur in specific areas of the United States. For example, the Region 1 evaluation would include only releases simulated from Region 1 source locations, with all monitors from the plan being evaluated. For the ten foreign release locations, the releases were considered to be in the region closest to that location.

The second method evaluated the siting goals for locations in a region for all of the modeled releases (regional receptor based). That is, the releases detected and detections in a given region were evaluated using all 1200 simulated releases. This evaluation compares the sampling effectiveness in each region.

The results of these comparisons showed a clear trend of similar results for Regions 1 through 5, and likewise for Regions 6 through 10. For simplicity, this can be considered east and west of the Mississippi River. Therefore, east and west of the Mississippi River will be the basis for discussion through the remainder of this section.

Table 3.6.4 shows the ratios of releases detected and detections for all monitors when the simulated release is either east or west of the Mississippi River. Similarly, Table 3.6.5 shows the ratios of releases detected and detections for monitors either east or west of the Mississippi River using all simulated releases.

Table 3.6.4 Ratios (EPA / SRNL) of releases detected and total detections from simulated sources east and west of the Mississippi River

Release Locations	Widespread Plumes		Reduced Plumes		Minimal Plumes	
	Releases Detected	Total Detections	Releases Detected	Total Detections	Releases Detected	Total Detections
East	0.93	0.85	0.92	0.87	0.89	0.86
West	1.01	1.09	1.07	1.12	1.03	1.20

Table 3.6.5 Ratios (EPA / SRNL) of releases detected and total detections for monitors east and west of the Mississippi River from all simulated sources

Monitor Locations	Widespread Plumes		Reduced Plumes		Minimal Plumes	
	Releases Detected	Total Detections	Releases Detected	Total Detections	Releases Detected	Total Detections
East	0.90	0.86	0.89	0.88	0.86	0.85
West	0.98	1.12	1.04	1.12	1.05	1.22

Tables 3.6.4 and 3.6.5 show that the EPA plan is more effective for releases occurring west of the Mississippi River and the SRNL plan is more effective for releases occurring east of the Mississippi River.

In summary, the higher number of monitors that the SRNL plan places east of the Mississippi River results in higher monitoring effectiveness in that area, at the expense of the area west of the Mississippi River. There are two primary reasons why the SRNL plan favors the area east of the Mississippi River. The first reason is that unlike the EPA modeling study, the SRNL study used release locations based solely on being the largest cities. Thirty of the fifty SRNL release locations (60%) were located east of the Mississippi River. In contrast, the EPA modeling study had only 52% of the release locations east of the Mississippi River. Thus, the ratio of EPA locations to SRNL locations east of the Mississippi River is 0.87.

Additionally, the EPA modeling study was designed to measure the impact of a release in the initial stages (48 hours) because this is the time where atmospheric dispersion models are the primary source of information used by most decision makers for protective actions. The SRNL modeling study extended each release to seven days. The additional time associated with the SRNL study would eventually result in most plumes having a significantly larger footprint east of the source location due to the natural west to east weather pattern which occurs at most of the latitudes where releases were simulated. Therefore, the combination of the migration of plumes east over time, along with the higher proportion of release locations east of the Mississippi River in the SRNL study is likely to have resulted in the bias toward higher monitoring density east of the Mississippi River for the SRNL siting plan.

3.6.3 Siting Implementation

The EPA siting plan was implemented in sets of locations rather than releasing the entire list at once. This allowed flexibility in changes to the list from alternate siting plans or changes in priorities (e.g., change from population to geographical siting priorities). The sets were developed with specific goals for each one, which are discussed in the following sections.

During the implementation process, it was recommended in the SAB Review that EPA consider temporarily placing deployable monitors in fixed locations until the fixed monitors were produced and ready for shipment. EPA chose not to follow this recommendation for the reasons discussed in section 3.6.3.1.

3.6.3.1 Evaluation of Temporarily Installing Deployable Monitors at Fixed Locations

In the early phases of installing monitors, there was a suggestion to temporarily site deployable monitors at fixed monitor locations to more quickly improve the geographical coverage of the air monitoring system. As discussed below, EPA concluded that the disadvantages to using the deployable monitors in that manner outweighed the advantages, and did not implement this approach.

One major disadvantage to temporarily siting deployable monitors as fixed monitors is that the deployable monitors are not designed to operate continually for long periods of time. Another major disadvantage is that the deployable monitors provide different data and require operator action in order to measure the activity collected on the filter. As opposed to the fixed monitors, the deployable monitors do not have the sensitivity needed to detect long distance contamination transport in real time. For example, assume an event resulting in airborne Cs-137 contamination occurs. If the airborne concentration is such that a fixed RadNet station filter collects the Minimum Detectible Activity of about 1 nCi over one hour (meaning an average atmospheric concentration of about 20 pCi/m^3), the increase above ambient gamma radiation level after that hour would be less than 0.01 uR/hr. Since typical background levels range from 5 to 15 uR/hr, and naturally fluctuate by as much as 50%, the increase of 0.01 uR/hr would not be discernable from natural background fluctuations.

There are other disadvantages to temporarily using a deployable monitor in place of a fixed monitor. A deployable monitor would not be available for its intended purpose if used as a temporary fixed monitor because there would be significant logistical issues associated with relocation of the deployable monitor. The volunteer operator may not be immediately available to move the deployable monitor. If they are available, they would be required to breakdown the deployable monitor, properly pack it for shipment, and arrange for shipping since EPA's trained personnel would not be available to do this in an emergency. To do this, each volunteer operator would be required to participate in specialized training to ensure the monitor is properly packed for shipment. Furthermore, the volunteer operator may not have an appropriate storage location for the deployable monitor's shipping containers. EPA did not want to burden the volunteer operators with this specialized training and the requirement to find storage for the shipping containers. EPA also did not want to burden the volunteer operators with learning to operate a temporary system that is much different than a fixed monitor.

For these reasons, EPA concluded that the disadvantages of temporarily siting the deployable monitors at fixed locations outweighed the envisioned benefits of the short-term increase in geographical coverage.

3.6.3.2 Release of Monitor Locations

EPA released locations for monitors in stages rather than releasing the entire list at once. This allowed EPA to maintain flexibility in implementing the RadNet fixed monitor siting plan. After the initial list of locations had been distributed, the criterion by which locations were released changed from population to geographical coverage based on the recommendations of stakeholders and the Science Advisory Board. Table 3.6.6 summarizes the considerations that went into determining which locations would receive a monitor.

Table 3.6.6 Rationale for releasing locations for fixed RadNet monitors

Set	Year Released	Number of Sites Released	Rationale for Selections
1	2005	59	Largest population metropolitan areas
2	2007	36	Quick geographical coverage by ensuring each state that had a city on the siting list had at least one monitor. Population within each state was a secondary consideration.
3	2008	39	Geographical coverage while minimizing locations within 100 miles of another monitor and disallowing any monitor within 50 miles of another monitor. Population was not considered.
4	2009	9	Geographical coverage while minimizing locations within about 100 miles of another monitor. Population was not considered.

3.6.3.2.1 Initial Set of Selected Locations (2005, 59 locations)

Early in 2005, preparations were begun for placing monitors in the largest 58 metropolitan areas to quickly get large cities ready to receive a monitor to enhance readiness as soon as possible. Montgomery, AL was added to those 58 since the prototype was delivered and tested at NAREL and a monitor was needed at NAREL to ensure program managers were familiar with the system and could address operator concerns or problems. Even though there was consideration of moving these locations if clustered, EPA agreed with some stakeholders that clustering in the largest cities was desirable because it increased the amount of data in the largest cities and also provided redundancy so the probability of providing at least some data for the largest cities would be high. Fig. 3.6.5 shows the initial 59 locations.

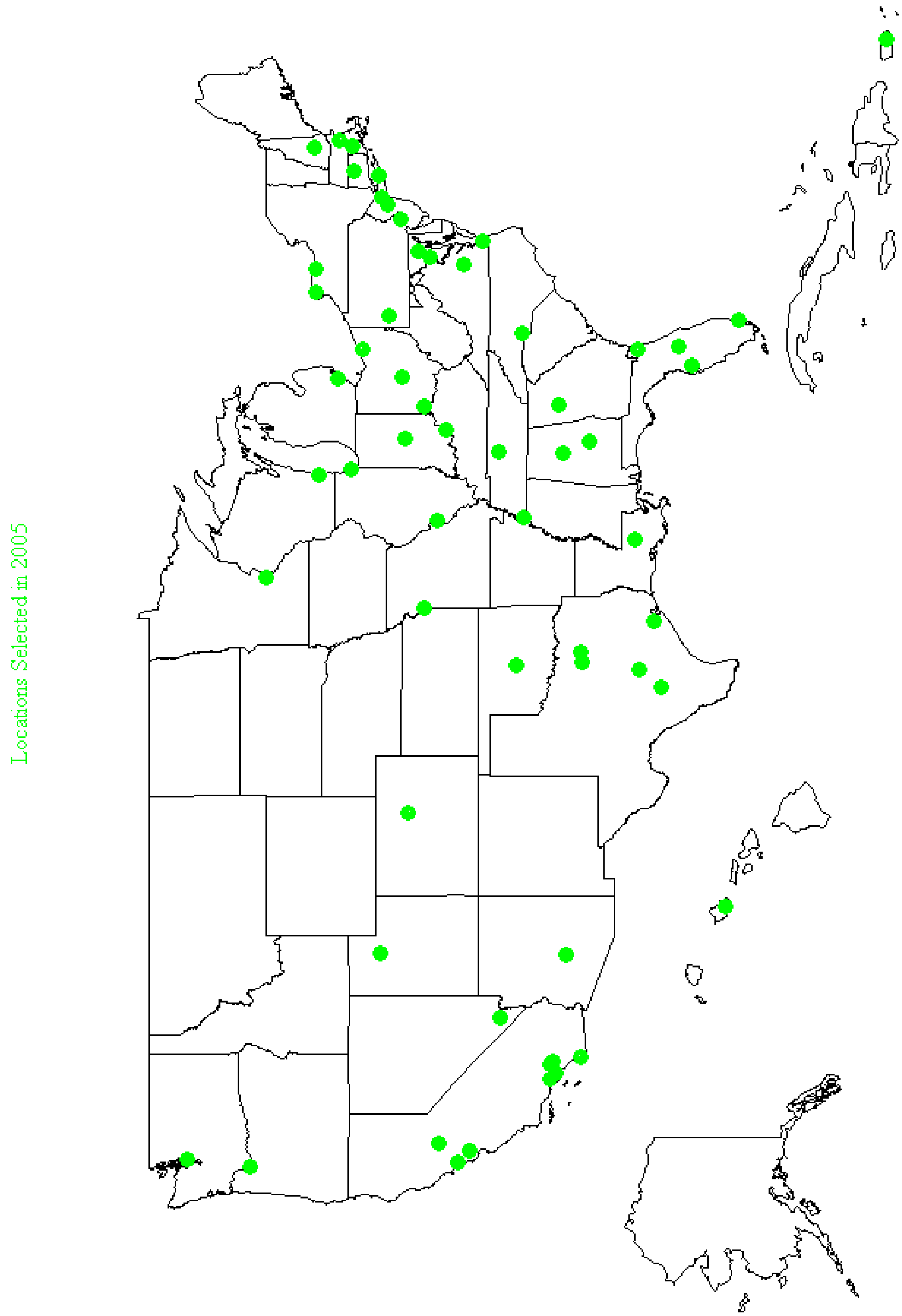

Fig. 3.6.5. Initial 59 RadNet real-time fixed air monitor locations.

3.6.3.2.2 Second Set of Selected Locations (2007, 36 locations)

While the atmospheric modeling study was being conducted by SRNL, EPA continued to purchase monitors to increase the coverage of the network as quickly as possible, as recommended by the Science Advisory Board. Purchasing more monitors meant additional locations had to be ready to operate a monitor, so additional target cities were selected. The focus of locating these monitors would not be based solely on population, as was the focus in the first phase of locations. The primary reason for this shift in focus was that most of the largest cities had a monitor, but very large areas of the nation remained unmonitored, which limited the utility of the network for atmospheric dispersion modelers. By focusing on filling gaps, the system would be much more valuable to those modelers.

Selecting cities for this second phase began by removing all cities on the initial list of selected locations. Next, states that did not already have a city selected to receive a monitor were determined. The highest populated city on the EPA siting list for each of those states was selected to receive a monitor. This allowed monitors to be more widely distributed across the nation by ensuring each state that had a location on the list received a monitor.

Once each state with a location on the list had at least one monitor, EPA focused the analysis on states that had only one monitor. The largest “unselected” city on the siting list in each state with only one monitor was added to a new list, which was then ordered by decreasing population. The largest cities on that list were selected until the total number of cities was equal to the number of monitors purchased (93). Two additional cities were added to this list because site preparation was almost complete at these locations that were not released in set 1 or 2. These locations began preparation because they were on a draft list of locations produced in 2004, prior to the final siting plan being developed. The locations were included in the final siting plan. Fig. 3.6.6 shows the additional locations selected in the second set.

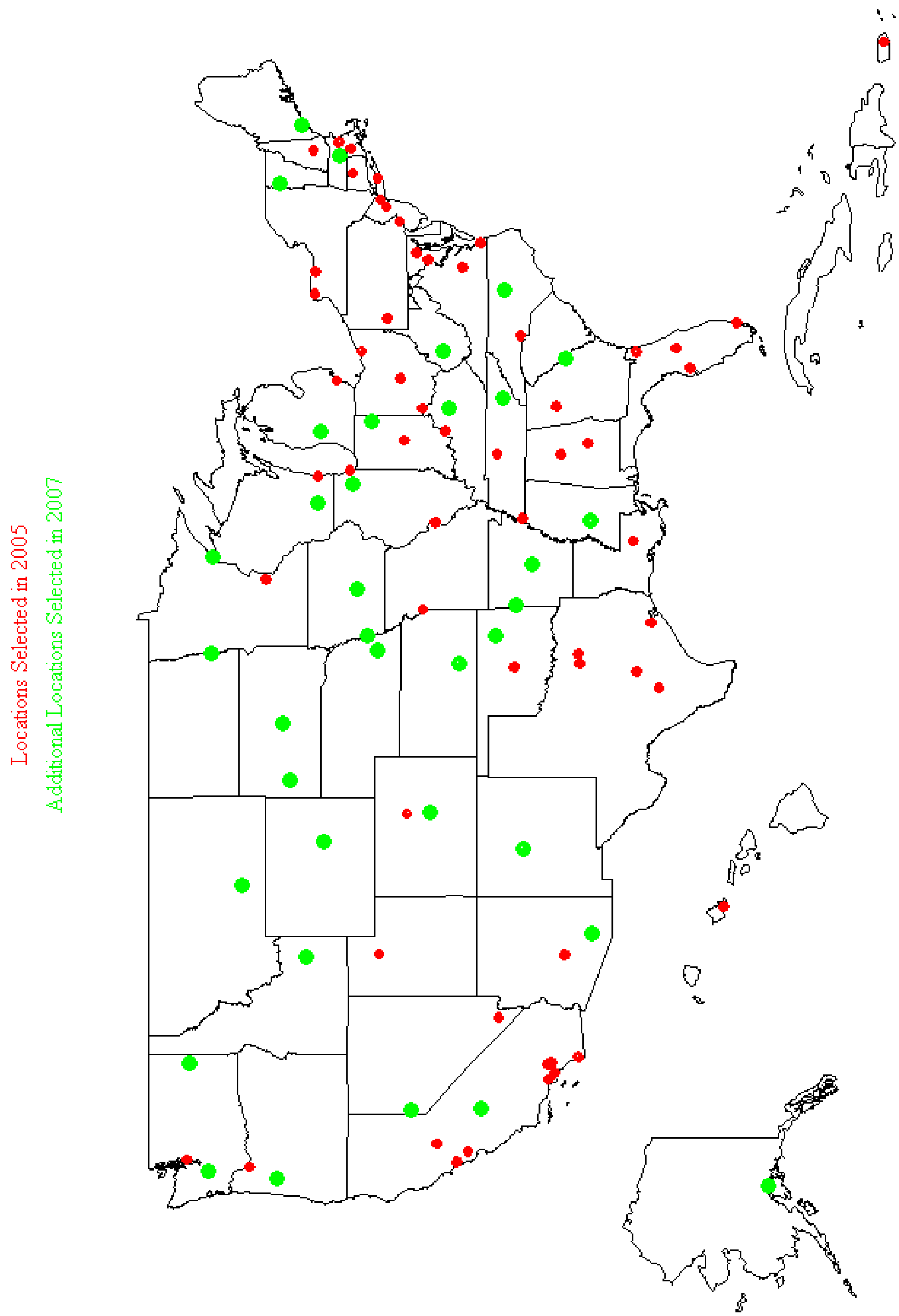

Fig. 3.6.6. Second set of RadNet fixed monitor locations (36).

3.6.3.2.3 Third Set of Selected Locations (2008, 39 locations)

In 2008, EPA emphasized selecting monitors in areas of the nation where large geographical gaps existed. EPA also decided to minimize clustering in this implementation phase by ruling out locations within 50 miles of another monitor and setting a goal of maximizing the number of new locations that were at least 100 miles from other monitors. Strict adherence to these goals would have put a significant burden on EPA Regions 6 and 8 since regional personnel were primarily responsible for finding operators and locations in the designated cities. Therefore, this phase of siting implementation emphasized large gap coverage, but included regional balance as a secondary consideration. Of the 39 locations selected in this process, only 6 were within 100 miles of another monitor. These 6 were selected for regional balancing. Fig. 3.6.7 shows the additional locations selected.

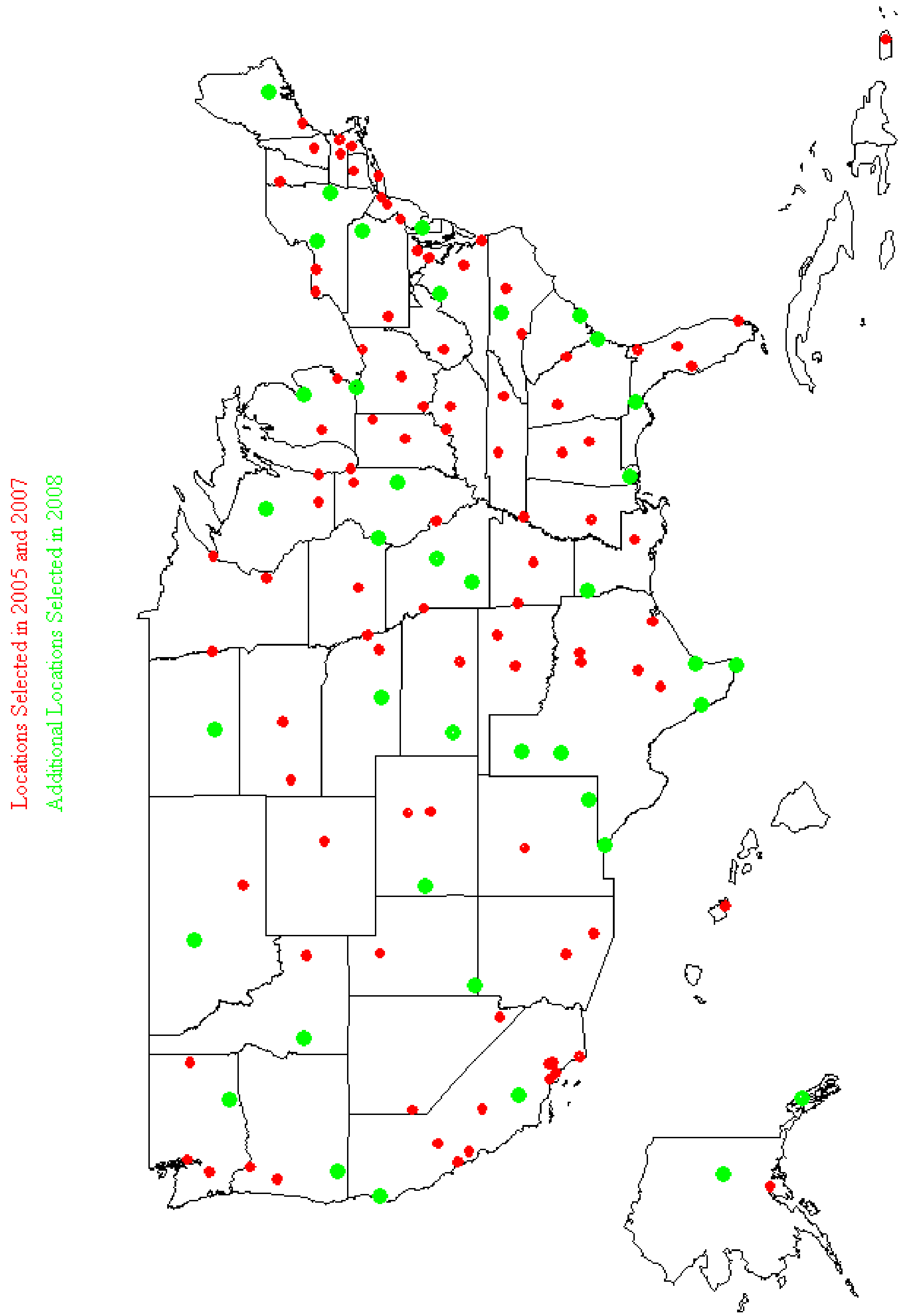

Fig. 3.6.7. Third set of RadNet fixed monitor locations (39)

3.6.3.2.4 Fourth Set of Selected Locations (2009, 9 locations)

In 2009, EPA planned to purchase 9 more monitors and locate them using the same strategy as the third set of selected locations discussed above. Of these 9 locations, only 1 location was within 100 miles of another monitor. Fig. 3.6.8 shows the additional locations selected.

Late in Fiscal Year 2009, EPA decided not to purchase the additional nine monitors due to budgetary concerns. Because EPA had released the nine locations early in 2009 to initiate site preparation work, some of those locations were ready to install a monitor before locations in the second and third sets. In those cases, EPA decided to substitute these ready locations for locations where little or no progress in preparations had been made. Fig. 3.6.9 shows the final 134 location network.

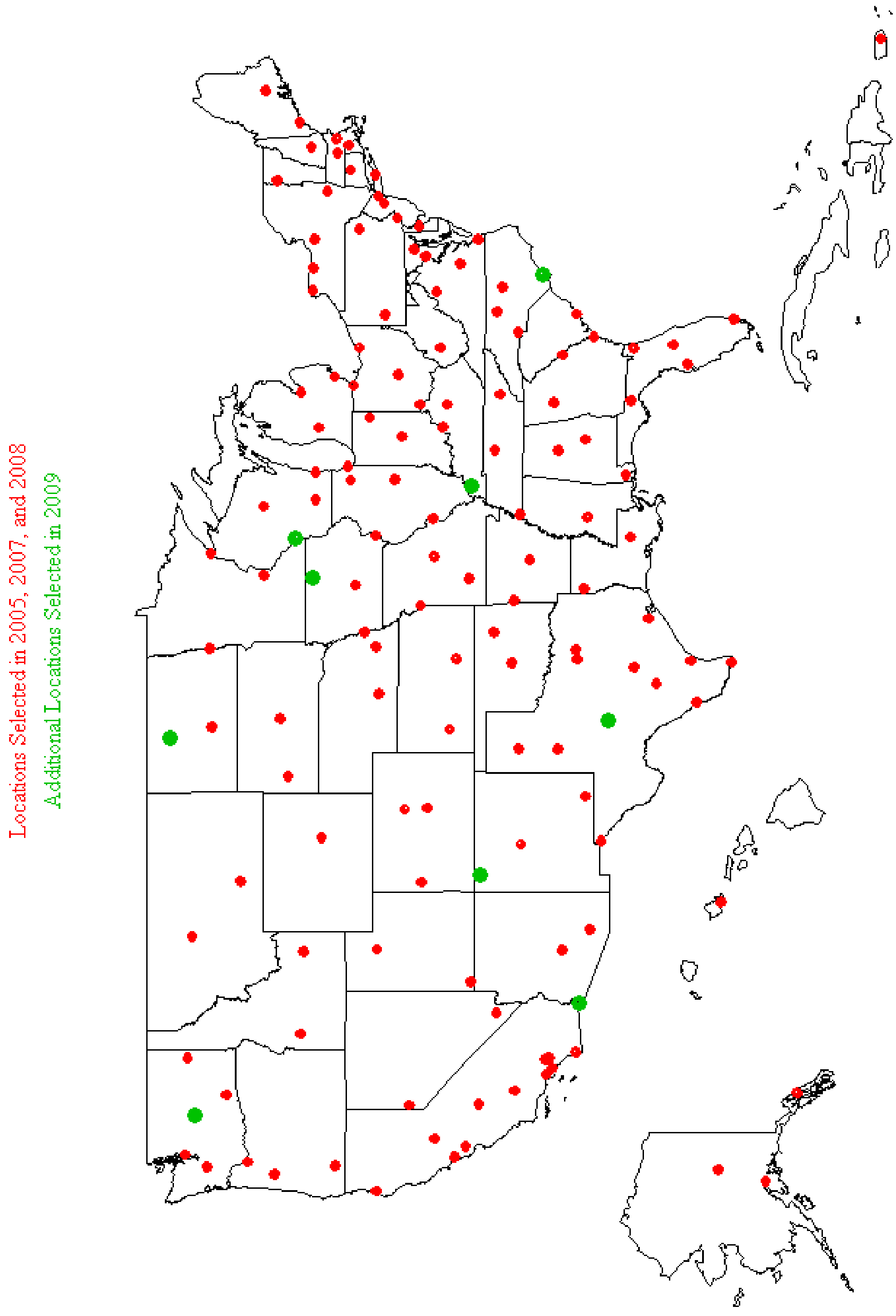

Fig. 3.6.8. Fourth set of RadNet fixed monitor locations (9).

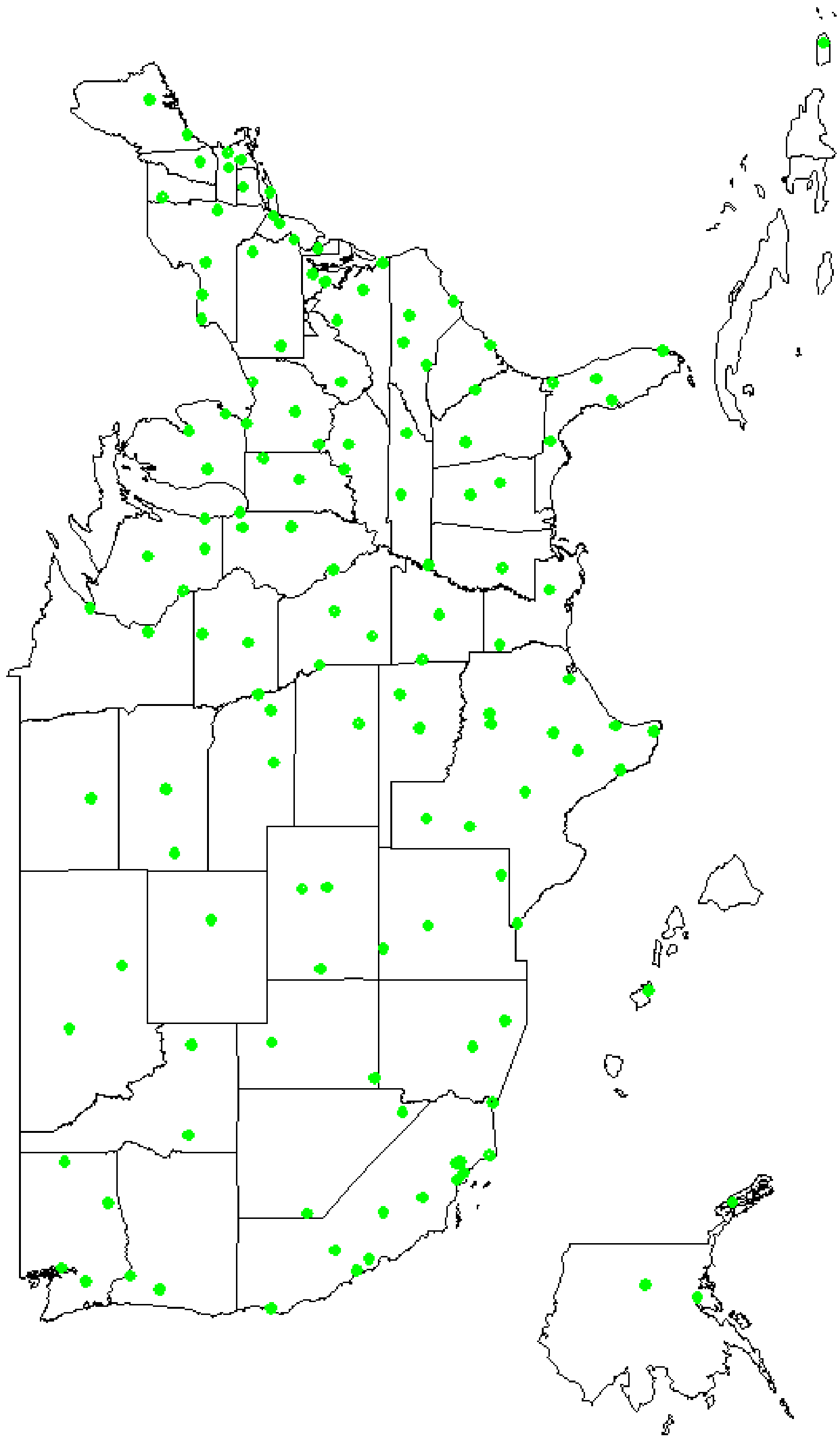

Fig. 3.6.9. Final 134 RadNet fixed monitor locations.

3.6.4 Practicalities of Siting and Changes

Although EPA established lists of target cities to receive a monitor using the siting process previously described, implementation of the plan was not completely rigid. EPA changed several locations, usually at the request of an EPA region or state. These requests were usually made when difficulty in finding a suitable operator or location in the target city was encountered.

When a location change request was made, EPA considered several factors in deciding if the change was acceptable. First, EPA ensured that the request was acceptable to the EPA regional personnel if the request did not come through the region. Next, the effect on the national picture was considered to ensure that major cities did not drop from the list and that the proposed change would not adversely affect the geographical spread of monitors. The SRNL modeling study report (KUR09) noted that "The exact sampler locations given by either the Detection Method or the Summed Plume Method are not critical and adjustments of up to 100 km in rural areas and up to 20 km in urban areas are possible without seriously affecting the results." This indicates that minor changes in the siting plan, such as the approved requests for changes, are not expected to have significant adverse (or beneficial) effects. Almost every request for a change was approved. Disapproval occurred when a monitor would have been removed from a highly populated city or the new location would have been too close to an existing location.

3.7 How Fixed Monitor Data Support Atmospheric Dispersion Modelers

As noted earlier, SRNL noted in their report (KUR09) that "all RadNet placement scenarios will provide useful data to evaluate and calibrate models." Basically, this means all RadNet data, including lack of detections of contaminants, are important to modelers. SRNL also noted that, "Of particular interest to modelers, however, is data to estimate the magnitude of the source term and the particle size distribution." This last quote is of significant importance since model results will be heavily relied upon for determining long-distance contamination spread, and providing timely data to those modelers allows better and quicker decisions to be made if adjustments to the model parameters are needed.

Source term and particle size distribution (fraction of particles in various size ranges) are just two of the major variables needed to run an accurate atmospheric dispersion model. Other important inputs include the source composition, release mechanism and strength, height of release and potential plume rise, and, of course, meteorological conditions. Naturally, this list establishes an infinite set of possibilities.

Some of the information for defining these parameters may be available early in an incident. For example, if the mechanism is a detonation, the height of release should be available, and shortly after the detonation it is possible that an approximation on the amount of explosive used can be made, which will help to estimate the plume rise.

The meteorological data forecasts also will be available based on past and current meteorological measurements. Such forecasts are developed and adjusted based upon thousands of meteorological observations made frequently (e.g., every three hours). However, those forecasts must be verified with actual data, because of the high variability of meteorological prediction.

For radiological incidents, the source composition is usually not readily known. Radiological Dispersion Devices may use a single radionuclide or several radionuclides in different combinations and ratios. Nuclear power plants have highly variable radionuclide release characteristics. Also, in both cases, the particle size distributions are highly variable, depending upon many factors. Finally, the source strength is not likely to be readily available early in the incident.

Of the three major unknowns remaining, all require detection by a monitoring system (or some artificial intelligence) to define the composition. Source composition would require detection by a system that can collect and analyze data such as the fixed RadNet monitors which collect and analyze gamma spectral data, or that collect samples for later analysis, although it is not likely that sample collection with subsequent analysis will provide data to the modelers in a timely manner. There are other responders/systems that may also have the proper equipment to obtain the data needed to determine the source composition. These other systems can provide data to help confirm RadNet measurements or provide measurements where RadNet monitors are not present.

Even when the source composition and the other parameters are known, the source strength and particle size distribution are needed to accurately model the spread of contamination. The source strength may be able to be determined with localized measurements, particularly when there are not many small particles (less than about 25 micron) in the source term. Fig. 3.7.1 shows an example of the affect of particle size on long distance transport. In Fig. 3.7.1, each isopleth represents a similar concentration of particulates in the air for the particle size represented by the color of the isopleth. As can be seen in Fig. 3.7.1, there is little difference between the 5 and 10 micron isopleths, but a rapid reduction in distance for the 15, 20, and 30 micron isopleths. Naturally, particle size distributions will differ for each event depending on the specific characteristics of the event, such as meteorological conditions, release heights and mechanisms.

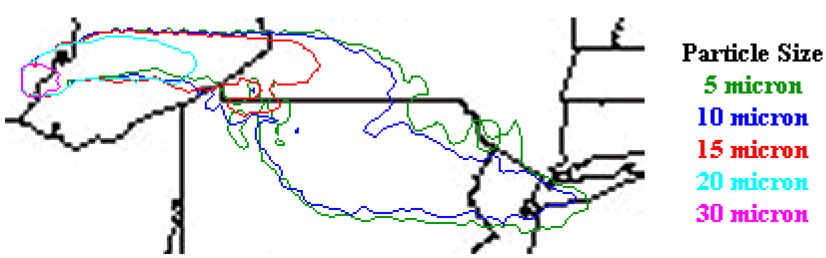

Fig. 3.7.1. Example Effect of Particle Size on Long Distance Contamination Transport

The example plumes shown in Fig. 3.7.1 represent results from simulations using the National Oceanic and Atmospheric Administration's **(**NOAA) HYSPLIT computer model (DRA03). If Fig. 3.7.1 represented the expected plume for each particle size shown, there would need to be measurements (detections) at various locations in the plume before modelers would have enough data to ensure the particle size distribution parameters were satisfactorily close to the actual distribution. For instance, if no particles are smaller than 20 micron, contamination would not be expected in New York or Pennsylvania. If particle size is 15 micron, detections at monitors in western New York might be expected, whereas if particle sizes are as small as 5 or 10 micron, detections might be expected across New York and Pennsylvania and into New Jersey as well. RadNet fixed monitors can help determine the particle size distribution of the source.

3.8 Local Siting Criteria

Selecting the optimal local monitoring location ensures that representative air particulate samples are collected for analysis. Criteria for local siting were developed by first searching for existing standards for selecting sampling locations for particulate matter in air, then reviewing and evaluating those standards for relevance. The conclusion reached after this evaluation was that the guidelines for selecting air sampling locations in EPA's regulations in Title 40 Code of Federal Regulations, Part 58, *Ambient Air Quality Surveillance* (CFR04), and EPA Guidance for Network Design and Optimum Site Exposure for PM2.5 and PM10 (EPA97) were both relevant and appropriate to use as a basis for sampling radioactive particulates. The 40 CFR 58 criteria were further reviewed evaluated, and modified as appropriate by staff from EPA's Office of Air Quality Planning and Standards, and by a consultant (ICF05b) for relevance to real-time monitoring of radioactive particulates in air. The criteria for local site selection for the fixed air monitors are:

- Access to the sampler should be controlled.
- The monitor should typically not be greater than 50 m above the ground surface.
- Practical factors, such as prevention of vandalism, security, and safety precautions, must be considered in locating the sampler.
- The sampler should be kept clear of excessive dust or other materials that may prevent or inhibit air flow.
- There should be unrestricted airflow in an arc of at least 270° around the sampler.
- The space available for the sampler should be at least 16.4 feet (5 m) distant and in the upwind direction from building exhausts and intakes.
- The sampler should be placed at least 6.56 feet (2 m) from walls or other structures that might influence air flow.
- The sampler should be located away from obstacles, such as buildings, so that the distance between obstacles and the sampler is at least twice the height that the obstacle protrudes above the sampler.
- The sampler should be at least 164 feet (50 m) from busy paved highways in order to remain outside the road's immediate zone of influence.

- The sampler should be at least 6.56 feet (2 m) away from any other air sampler intake.
- Sampler inlets should be sufficiently distant (>32.8 feet [10 m]) from public access to preclude sample bias from deliberate contamination.
- The sampler should not be located in an unpaved area, unless there is vegetative ground cover year round, so that the impact of windblown dusts will be kept at a minimum.
- The space available for installation must accommodate the physical dimensions and minimum clearances identified on the monitor installation drawings.
- The monitoring site should be evaluated for potential impact from nearby sources of gamma radiation that might interfere with the real time detector, or of radioactive particulate emissions that may bias the sample.
- The site should be evaluated to ensure that the necessary electrical power and telecommunications services are available.
- The site should be evaluated to determine if satellite line of sight is open.

3.9 Station Operators

The RadNet fixed monitoring system relies on volunteer operators to provide all routine operations, including filter changes, filter screening for alpha and beta particle emissions, and mailing filters to NAREL. NAREL provides all monitoring equipment and supplies and provides funding for site setup and shipping of filters and screening instruments to NAREL, but does not provide monetary support for the time and effort expended by the operators or for recurring costs such as power or phone.

NAREL also provides a training DVD that illustrates the monitor's components and operation and maintenance procedures, a CD of the manufacturer's user manual, and illustrated user's guide, all Standard Operating Procedures (SOPs) for monitor and screening instrument operations (see Section 6.4), and wallet cards with contact numbers for NAREL RadNet personnel. NAREL RadNet personnel are also available for technical support via phone or e-mail each workday.

Current OMB reports for the ERAMS/RadNet air monitoring network estimate operator expenditure of time to be 75 person-hours per year. This estimate is based on station operators collecting air filters at the requested frequency of twice per week (although less frequent filter changing is common for a variety of logistical reasons and does not affect the quality of the data collected by the near-real-time gamma monitoring systems), performing the screening after a five hour wait, and on one routine calibration per year. The addition of the real-time data collection and transmission capability of the fixed monitors relieves a burden during an emergency that existed with the non-real-time fixed monitors. To obtain data, the non-real-time fixed monitors required operator action to change the filter, screen it, and send it to NAREL for analysis. The real-time monitors do not require operator action to obtain data. Table 3.9.1 shows the operator responsibilities and the frequency of operations.

Table 3.9.1 RadNet Fixed Operator Responsibilities

Operation	Frequency	Time Required
Filter Change	Nominally Twice Per Week [3]	10 Minutes Per Change
Filter Screening and Mail to NAREL	Nominally Twice Per Week [3]	10 Minutes Per Count
Background Check of Screening Instrument	Monthly	10 Minutes Per Check
Calibration of Monitor [1]	Annually	4 Hours Per Calibration
Monitor Troubleshooting [2]	Variable	Variable

[1] Only required if service contractor has not made a visit to the monitor in over one year.
[2] Monitor troubleshooting is voluntary for operators, but is included in time estimates.
[3] Twice weekly air filter changes are not required for the near-real-time monitoring system since there is no loss of data quality due to the hourly data transmission capability.

3.10 Fixed Station Operations and Maintenance

Preparations for fixed station installation and setup included provisions for:

- supporting and anchoring the monitoring station (e.g., a concrete pad with anchor bolts or wooden platform for ground-level installation, a pallet for rooftop installation, etc.);
- electrical and telephone utilities; and
- connection to a ground for lightning protection.

After site preparations were complete, a monitoring station was shipped directly from the factory to the installation location. A factory service representative traveled to the site, set up the equipment, performed an initial calibration, and trained the operator(s) on operation and user-level maintenance.

The monitoring stations are intended to be recalibrated periodically at their installed locations. The station operator is given a calibration kit containing transfer standards and all other necessary equipment. An instrumentation technician coordinates by telephone with the station operator to provide calibration data and any necessary adjustments. The station operator assists by placing and removing standards and accessory equipment, taken from the calibration kit, as directed by the instrumentation technician.

During normal conditions, the monitoring stations operate continuously except for the few minutes required for the local operator to change the filter media. During sample collection, the radiation measurement instruments will monitor the filter continuously over programmable intervals for radioactive material. At the end of each measurement interval, the full gamma spectrum and gross beta counts are stored locally, and a new measurement cycle begins automatically.

After each filter change, the operator records the sample collection start and stop dates and times and the total volume of air that has passed through the filter. After waiting at least five hours for radon progeny to decay, the operator performs gross beta and alpha counts on the filter, calculates the gross activity, and mails the results and filter to NAREL. When received at NAREL, each filter undergoes a gross beta count. Measured (at NAREL) gross beta activity greater than 1 pCi/m^3 is investigated by gamma spectrometry or other appropriate methods.

The fixed monitoring stations are covered by a one-year factory warranty for parts and labor. After the first year, they are maintained through a service contract managed by NAREL. The services will include telephone troubleshooting and technical support for the operators, routine calibration and preventive maintenance, and troubleshooting and corrective maintenance as required. It is currently anticipated that the initial intervals for periodic calibration will be one year, with quarterly calibration verification, but these intervals may be adjusted based on experience.

4 DEPLOYABLE MONITORS

The RadNet deployable component consists of 40 portable, radiological monitoring units that measure ambient gamma exposure rates and collect high and/or low-volume air samples on 4- and 2-in round glass-fiber filters, respectively. These units are designed to determine changes in gamma exposure levels and to collect air samples that can be analyzed to provide gross radiation and nuclide specific information.

The potential uses of the RadNet deployable system depend on several factors, including the type of radiological problem, the end-use needs for the data, weather conditions, and the population needs in the area. State, federal, tribal, or local organizations will have a direct influence on the placement of samplers and the associated sampling strategies.

A deployable monitor weighs approximately 280 pounds (127 kg) with individual components that each weighs less than 60 pounds (27 kg). Each component has a specially designed container for storage and shipment. The total shipping weight of a deployable is about 450 pounds (204 kg). A total of forty deployable monitors are stored, ready to deploy, at NAREL and R&IE.

4.1 Equipment Description

Each deployable monitor consists of the following components:

- A **low-volume air sampler** component that is manually controlled and uses a Venturi flow measuring device to electronically record the parameters associated with the collection of the sample. The sampler operates at a flow rate between 0.5-4.0 standard cubic feet per minute (SCFM) (14-113 standard liters per minute [SLPM]). This sampler is designed to draw air through a 2-in (5 cm) diameter glass fiber filter to collect particulate matter from 0.3 to 10 microns equivalent to EPA-2000 (PM10) criteria per nuclear industry standards and through a sample cartridge placed behind the filter to collect radioactive gases. The filter head is approximately 60 inches (1.5 m) above the ground at the breathing zone. The sampler is inside a weatherproof housing and all components are easily removable by quick-connect pins.

  The Venturi flow measuring device monitors barometric pressure, temperature, and flow rate. The sample parameters are calculated by the digital electronic module and sent to the data logger to be transmitted via satellite telemetry or through an analog phone line at pre-set time intervals dictated by authorized personnel, or via manual download by the operator. Recorded data consist of the current, minimum, maximum, and average flow-rate in SCFM; sample volume in standard cubic feet; and associated temperature and pressure values associated with the sample.

  Minimum detection limits for the component will be based on the flow rate and sampling time used according to the sample detection limits established by the counting laboratory. These parameters (sample time and flow rate) will be predetermined depending on the minimum detection limits based on the data quality measurement objectives established by the command and control functions of the organization and will be transmitted to the operator of each individual system upon deployment.

- A **high-volume air sampler** component that is electronically controlled and uses a Venturi flow measuring device and a feedback loop to regulate air flow rate through the system between 20-50 SCFM (570-1415 SLPM). The sampler is designed to draw air through a 4-in (10 cm) diameter glass fiber filter to collect particulate matter from 0.3 to 10 microns equivalent to EPM-2000 (PM10) criteria, per nuclear industry standards. Higher flow rates allow for lower detection limits and much shorter sampling times for quick turnaround of data in comparison to the low-volume sampler.

  Other capabilities and parameters are the same as those described above for the low-volume air sampling component.

- A **gamma radiation monitoring component** that is a Genitron Gamma Tracer with two compensated Geiger-Mueller detectors in continuous operation. The detectors are capable of indicating levels from 2 µR/h up to 1 R/h. The minimum accuracy requirement for gamma measurement data was established initially to be within ±15% at the low end, and ±10% at the upper end of a measurement range of 50 µR/h to 80 mR/h exposure rates, per the American National Standards Institute (ANSI) N323A 1997. The instrument is calibrated to Cs-137 and has an energy response of ±20% between 60 keV and 1,000 keV. Fig. 4.1.1 shows the response as a function of gamma energy. The instrument is response checked annually with Cs-137 sources. The energy response at lower (60 keV) and higher (1173 keV, 1332 keV) energies has been verified by exposing an instrument to Am-241 and Co-60 point sources, respectively, and verifying that exposure rates are within 20% of predicted values. The units typically are set to store values in conventional units. The only parameters that are adjustable through interface with the setup functions of the gamma exposure instrument are the data-reporting format, in conventional or international units, and the data-averaging time, between 1 and 30 minutes. A 15-minute averaging time would be typical for this preset, although this is an event-specific value. The longer averaging times result in data values that are significantly more precise. The gamma detector is positioned 39 inches (1 m) above the surface on which the pallet is placed. Gamma-exposure data are sent to the data logger for satellite transmission at pre-set time intervals, which are dictated by authorized personnel.

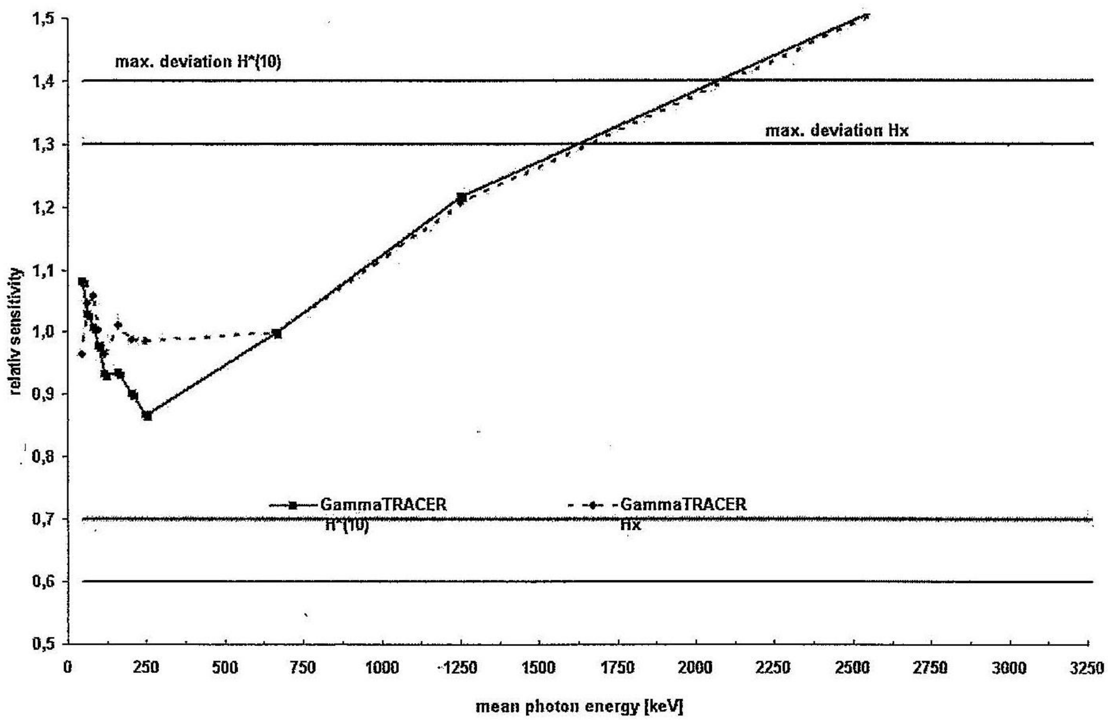

Fig. 4.1.1. GammaTracer Basic hx energy response curve.

- A **power distribution panel** that contains a 115–120 volt, 60 Hz power distribution center with a single power feed. The distribution center has four outlets, giving each component an individual protected circuit. The deployable can be plugged into a U.S. standard household outlet (115–120 volt, 60 Hz, with 20 amps maximum) with total station draw not to exceed 20 continuous amps. A 25 foot (7.6 m) power cord rated at the maximum power draw is attached and hardwired to the power distribution center.
- S**atellite telemetry** that consists of an Iridium modem and uses an external antenna placed 8 ft (2.4 m) above the ground. Information is routed from the deployable station through the Iridium satellite system to the NAREL File Transfer Protocol (FTP) server.
- **Conventional Analog transmission capability** that consists of an analog phone modem to route information from the deployable station to NAREL.
- A **data logger** that has three redundant ways to export collected data: satellite upload to the FTP server, conventional analog phone line, or download to the personal digital assistant (PDA). The data logger controls the sequence of events for each external device. It captures critical data and saves them for up to 30 days. In the event of a power loss, data will be stored for 24 hours.
- A **PDA** that is used to send setup files to the data logger. The setup file is created prior to the deployment to dictate all parameters for the components to start, collect, send, and store data. The PDA also can be used to download data.

- A **Global Positioning System** (GPS) unit that stores and captures the real-time unit location given in latitude and longitude (in decimal degrees) and elevation (in meters or feet). The GPS is integrated into the deployable unit's configuration program. It has a minimum accuracy of 100 feet (30 m) under normal conditions without selective availability.
- A **weather station** that consists of an integrated sensor module (exterior component) and a console (interior component). The integrated sensor module contains the interface module to support the console, rain collector, and anemometer. The integrated sensor module and console measures the following parameters:
    - Barometric pressure
    - Inside and outside humidity
    - Rain rate, rain storm amount, and total rainfall amount
    - Inside and outside temperature
    - Dew point, wind chill, and heat index (all calculated)
    - Wind speed and direction, direction of peak wind speed
- A **component mounting platform** that also serves as a **shipping pallet**. During deployment, all components attach to the platform using thumbscrews, but the component shipping containers can be placed on it and secured for transportation. The components are stored and transported in containers, and each container includes a diagram and parts list on the inner lid.

A picture of an assembled deployable monitor is shown in Fig. 4.1.2. The high volume air sampler is on the right and the low volume air sampler is on the left with the power distribution panel toward the back. The ambient gamma radiation detector is in the cage near the middle of the assembly and the meteorological tower and telecommunications systems are behind the gamma detector. Fig. 4.1.3 shows a deployable monitor ready to be shipped.

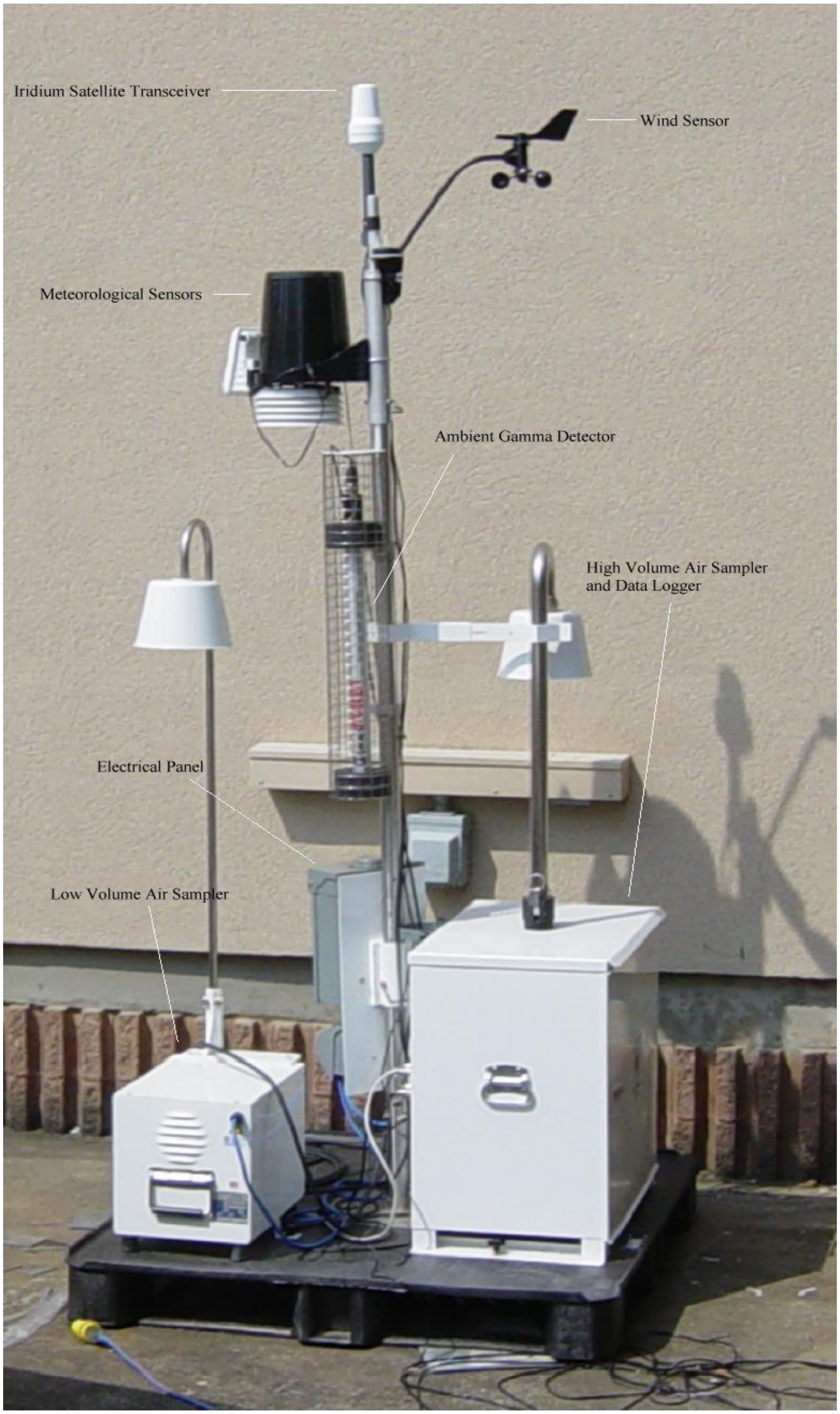

Fig. 4.1.2. Assembled deployable monitor.

Fig. 4.1.3. Deployable monitor ready for shipment.

4.2 Differences Between Fixed and Deployable Monitors

The fixed and the deployable air monitors are different from each other for several reasons. Conceptual design for the deployable monitors began before 9/11 in response to needs identified in responding to the Hanford and Los Alamos fires. Due to the sense of urgency to improve readiness, actions were taken to procure them in parallel with further development of the concepts for designing fixed monitoring equipment with real-time spectrometric measurement capability.

There are also practical reasons for differences between the fixed and deployable air monitors. Because they are permanently installed, the fixed stations can be equipped with instrumentation that may be more susceptible to damage during transit, and thus may have a higher probability of needing service after shipping. Additionally, there are more options for data telemetry in large metropolitan areas, particularly when there are no time constraints on preparing for the installation. The deployable monitors must use equipment that has a low probability of failure from the handling that occurs during packing, shipping, and unpacking. They must also be capable of transmitting data from small cities or rural towns, with little or no time for pre-arranging telecommunications services.

Table 4.2.1 provides a summary of the major equipment differences between the fixed and the deployable monitors.

Table 4.2.1 RadNet fixed and deployable monitor equipment

Data	Fixed Monitor	Deployable Monitor
Gamma Spectrometer	Yes	No
Ambient Gamma Detector	No	Yes
Beta Spectrometer	Yes	No
High Volume Air Sampler	Yes	Yes
Low Volume Air Sampler	No	Yes *
Air Filter	Polyester	Glass Fiber
Uninterruptible Power Supply	Yes	Yes
Onboard Computer	Computer with Windows	Data Logger
Telemetry	Four Independent Modes	Two Independent Modes
Meteorological Sensors	Yes	Yes

* Allows for charcoal cartridge to be used to sample for gases such as vapor iodine.

The major difference in the near-real-time capability of the two monitors is the radiation detection capability. The fixed monitor uses the sodium iodide detector, along with a multi-channel analyzer to obtain a gamma energy spectrum, whereas the deployable monitor uses a standard radiation measuring technique that provides gross ambient gamma levels. Table 4.2.2 outlines the differences in data produced by the fixed and deployable monitors.

Table 4.2.2 Near-real-time radiation data produced by fixed and deployable RadNet monitors

Data	Fixed Monitor	Deployable Monitor
Ambient Gamma Exposure Rate	No	Yes
Gross Gamma Count Rate in 10 Energy Regions from Filter	Yes	No
Gross Beta Count Rate from Filter	Yes	No
Gamma Spectrum from Filter	Yes *	No
Beta Spectrum from Filter	Yes *	No

* Not part of the hourly data transmissions. Must be electronically downloaded by NAREL personnel.

Other data differences exist between the two types of monitors. Table 4.2.3 lists some of the other data for the fixed and deployable monitors.

Table 4.2.3 Other data produced by fixed and deployable RadNet monitors

Data	Fixed Monitor	Deployable Monitor
Sampler Flow Rates and Volume	Yes	Yes
Temperature	Yes	Yes
Pressure	Yes	Yes
Wind Speed and Direction	Some	Yes
Precipitation	No	Yes
Instrument Performance	Yes	Yes

Finally, there are significant differences in the communications capabilities of the two monitors since fixed monitors are located where site preparation allows for establishment of numerous communications pathways prior to monitor installation. Table 4.2.4 lists the different communications methods for the fixed and deployable monitors.

Table 4.2.4 Communications capabilities for fixed and deployable RadNet monitors

Communication Methodology	Fixed Monitor	Deployable Monitor
Land Line Phone	Two Way Communications	Data Receipt
Cellular Phone	Two Way Communications (VIP capability)	No
Direct Internet Connection	Two Way Communications	No
Satellite Communications	Download Routine Data Only	Data Receipt through Iridium

4.3 Mobilization, Setup, and Demobilization of Deployable Monitors

Twenty deployable units are stored at NAREL and the other twenty are stored at R&IE. Each lab has trained professionals who maintain the units and are available for support during deployments. Each monitor component is stored in a case, ready to deploy. Inspection and maintenance of each monitor is conducted at least twice each year during quality control checks, when the monitor is assembled and operated. Data transmission is verified by operating the monitor with both land-line modem and Iridium satellite communication. Periodic drills and training of regional personnel exercise the shipping, deployment, operation, and data transmission of the deployable monitors.

In the event of an actual emergency and the decision has been made to use the deployables, mobilization personnel would be recruited from EPA's Response Support Corps (RSC) in the affected region(s). Volunteers recruited from the RSC would help transport and set up the units. RSC personnel are expected to have an EPA government travel credit card, be willing to travel for two weeks or more, be capable of lifting up to 50 lbs. (22.7 kg), and have basic computer skills. Mobilization personnel are expected to make travel arrangements and arrive at the forward staging location (determined by the deployable leads) as soon as 24 hours following notification. They will support the deployment efforts by setting up stations in teams of two, and collecting air samples as directed.

New volunteers are introduced each year at national EPA meetings. Training is supplemented with frequent hands-on exercises to give the mobilization personnel experience deploying the monitors.

Response Support Corps activation: Requesting activation of mobilization personnel from the RSC varies slightly among EPA regions but is overseen by the National Incident Coordination Team (NICT) in which ORIA is an active participant.

Radiation exposure considerations are minimal for mobilization personnel because deployables are typically intended to be used miles from the site of an incident (outside the affected area). If they are to be used in areas of elevated radiation levels or contamination levels, other personnel, such as RERT personnel, will deploy the monitors.

In the event of a radiation incident or perceived emergency, the deployables will be shipped to a selected location or staging area as directed by appropriate authority. The deployables are shipped with each component or group of components in cut-out foam lined shipping cases with the mounting pallets stacked and shipped as a group. Portable electric generators and calibrators will be shipped in their individual shipping containers as required.

The person selected to operate the deployables shall meet minimum qualifications described previously, but need not have experience or training in the operation of the system. That person would be asked to assemble the components and initiate monitoring and sample collection. Operator manuals and other written instructions are provided to assure proper setup and operation of the systems.

If possible, the system will be assembled and operated at a public facility, such as a fire or police station, or other public office/facility to allow for easy and unrestricted access to line power for the system operation. Selection of, and agreements with, the chosen facility will be negotiated or established by the deployables team lead(s), who, in coordination with EPA Regional staff, will also oversee the mobilization personnel activities. Second choices for sampling sites would be privately owned locations. If a location offering line power is not available, a generator will be used to supply power, and will be maintained/fueled by the operator.

Detailed setup and operation instructions exist in the SOP (EPA08a) and also on a laminated Operator's Guide attached to the unit. It takes approximately an hour to set up one unit. Sample (air filter) collection during incident response will be done by mobilization personnel. Frequency of sample collection may vary between hours and days, as determined by the data goals and practical considerations.

Disassembly and repacking for return to the labs will be conducted by the mobilization personnel or other persons familiar with the disassembly and packing of the deployable monitors. The units are then shipped back to the respective laboratory, where they are inspected and tested prior to being placed in storage.

4.4 Siting the Deployables

Orders to deploy come from ORIA managers upon the recommendation of the RERT commander or in response to a request from other Agency officials or other federal/state officials. Due to the mobile nature of the deployable monitors, there are countless deployment strategies that may be utilized. The final strategy will be determined on a case-by-case basis after consultation with EPA management, technical staff and the RERT Commander along with other appropriate scientists and officials. Several important issues must be rapidly evaluated before the final decision for locating the deployable monitors is made. Some of these issues include meteorological predictions, expected contamination release duration, and sensitivities such as population and food production areas.

The deployable monitors may also be pre-deployed if there is concern that a potential radiological incident may occur. In this case, there will usually be more time to consider the specific needs of the event to develop a more detailed, statistical evaluation of meteorological predictions to allow the monitors to be sited best. Depending on the amount of time the deployables will be pre-deployed, the locations may be determined based on actual weather forecasts or, if pre-deployment is more in the future, a probabilistic evaluation of weather conditions may be performed.

The deployable monitors may serve several functions. They can be used to monitor uncontaminated areas near the contaminated area to ensure contamination is not spreading due to natural or man-made resuspension. They can also be used for plume monitoring if pre-deployed or if the plume remains airborne for several days. Another potential use is to place them in slightly contaminated areas to monitor the reduction in exposure rate due to decay and weathering of contamination while also monitoring for resuspension.

The expected duration of release of contamination will play a large role in the placement of deployable monitors. If the duration is short (e.g., an explosive radiological dispersion device), the contamination will migrate with the wind patterns at the time of detonation. However, if the duration is long (e.g., a fire similar to that of the Hanford Reservation fire in 2000 that lasted several days and had the potential for releasing radiological contaminants), the strategy to locate deployable monitors is likely to be significantly different. Short duration monitor placement will likely focus on the path the contamination has already taken, whereas for a long-duration release, the monitors would likely be used to surround the source, looking for deposition dose rate changes and monitoring the air for radioactive contamination coming directly from the source.

Another consideration that will affect deployable monitor siting is the time available to deploy the monitors. For example, to monitor passage of a large plume the sampling locations must be ahead of the projected plume path. The time required to transport and set up monitors should be considered to ensure that monitors are not belatedly sited in locations that the plume has already passed.

The following sub-sections discuss possible monitoring strategies for the deployable monitors for several general scenarios. The data that are likely to be useful to scientists and decision makers are also discussed.

4.4.1 Monitoring Near a Contaminated Area

The purpose of monitoring near a contaminated area is to provide data to assist in confirming that no detectable levels of contamination are being spread from a contaminated area to a non-contaminated area. Contamination may be spread from a contaminated area by natural means (e.g., resuspension due to wind) or by man-made means (e.g., vehicular traffic, clean-up efforts). It is important to determine if contamination is being spread to uncontaminated areas because it is not likely that protective actions are in place in the uncontaminated areas, and it is also unlikely that those areas will be monitored or sampled more than once by response personnel.

The siting of deployable monitors in this scenario would mostly consist of surrounding the contaminated area since this type of monitoring is expected to last long enough that wind direction changes will render directional sampling ineffective. Attention can be placed on increasing monitor density in the direction of the prevailing winds and/or for other important factors such as nearby cities, food production areas, etc.

Siting should also consider the contamination pattern and likelihood of contamination transport being detected. In general, contamination spread via resuspension from even highly contaminated areas to uncontaminated areas would not be in sufficient quantity to be detectable by the deployable monitor's gamma detector or its low volume air sampler. Preferably, the deployables would be located in the uncontaminated area immediately surrounding the highest contamination areas to maximize their effectiveness. Generally, this is close to the source location.

For example, the airborne concentrations from resuspension from a contaminated zone (120 $\mu Ci/m^2$ over a one mile radius area, which would be the resulting surface contamination level for I-131 at the 4 day PAG of 1 rem) could produce airborne contamination that would be detectable using the high volume air sampler as far as a few miles away. Fig. 4.4.1 shows an example of where detectable contamination might be collected by the high volume air sampler. In this figure, the yellow area with the trefoil is the contaminated area of one mile radius, the red represents the area outside of the contaminated area where the high volume air sampler will collect enough contamination to be measureable in a laboratory or Mobile Environmental Radiation Laboratory (MERL) if the wind were to blow from west to east for 8 hours. Likewise, the green represents the area outside the contaminated area where the high volume air sampler will collect enough contamination to be measureable in a laboratory or MERL if the wind were to blow from west to east over a 24 hour period. The deployable's low volume air sampler might collect enough contamination to be measureable in a laboratory or MERL on a standard filter if it was placed near the downwind edge of the contaminated area with the wind blowing in that direction for most of the sampling period. The gamma radiation levels from resuspended radioactive material outside of the contaminated area would be masked by background levels that would be up to five orders of magnitude higher, but gamma rays emitted by the contamination on the soil are likely to be seen. Table 4.4.1 shows gamma radiation levels that deployable monitors will be exposed to based on distance from the contaminated area. The data in the table indicate that it is important to be close to the contaminated area for the monitor to detect gamma levels above background, particularly for some nuclides.

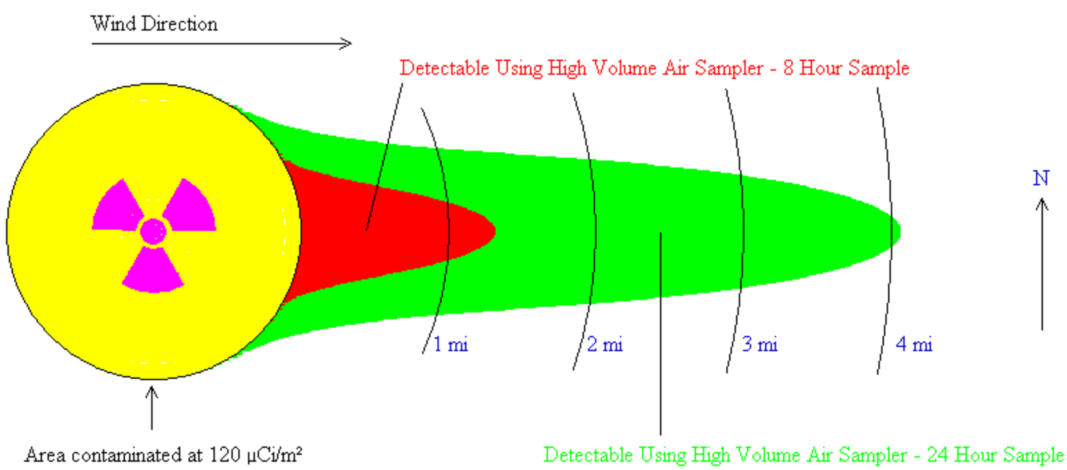

Fig. 4.4.1. Example of detectable airborne concentrations due to resuspension from a contaminated area using the deployable's high volume air sampler.

Table 4.4.1 Example of gamma radiation detected by a deployable RadNet monitor at varying distances from a contaminated area

Nuclide [1]	Surface Contamination Concentration ($\mu Ci/cm^2$) [2]	Gamma Reading 10 m from Contaminated Area (μR/hr)	Gamma Reading 100 m from Contaminated Area (μR/hr)	Gamma Reading 400 m from Contaminated Area (μR/hr)
Ba-140 [3]	1.09×10^{-2}	1030	220	15
Ce-144 [3]	2.00×10^{-3}	4	1	< 1
Co-60	3.16×10^{-3}	300	65	4
Cs-134	4.78×10^{-3}	310	64	3
Cs-136	2.09×10^{-2}	1900	390	21
Cs-137 [3]	2.66×10^{-3}	64	13	< 1
Eu-152	1.12×10^{-3}	52	11	< 1
Eu-154	9.41×10^{-4}	50	11	< 1
I-131	1.30×10^{-2}	220	42	1
Ir-192	1.40×10^{-2}	510	98	3
La-140	3.24×10^{-2}	2900	640	46
Ru-103 [3]	3.01×10^{-2}	640	130	4
Ru-106 [3]	1.59×10^{-2}	14	3	< 1
Te-132 [3]	2.24×10^{-2}	230	47	2
Zr-95	1.59×10^{-2}	490	100	5

[1] Nuclide list includes nuclides identified in section 3.3.1 as well as primary nuclides detected by RadNet (then ERAMS) following the Chernobyl nuclear reacotr accident.
[2] Surface contamination concentration is calculated for each nuclide, by determining the surface level that would result from exceeding the 4 day protective action guideline of 1 rem due to constant airborne contamination over the first 24 hours and deposition and resuspension for the full 96 hour period.
[3] Contamination levels and gamma readings include daughter nuclide at equilibrium.

4.4.2 Monitoring Inside a Contaminated Area

Another potential use of the deployable monitors is to monitor inside a contaminated area. This might be done for several reasons, including continuous monitoring of gamma radiation levels to determine if there are changes in the contaminated zone as well as airborne particulate monitoring to determine the effects of resuspension. Monitors would likely be located at key points of interest in this scenario.

Using the same example as shown in Fig. 4.4.1, the airborne contaminant concentration would be well in excess of detectable levels inside the affected (yellow) area. The airborne concentrations could be used to help verify that predicted resuspension rates are accurate. If the measured resuspension rate is different than predicted, protective action decisions might have to be altered. The airborne contaminant concentration could also be used to help radiation safety personnel assess potential worker dose and the need for respiratory protection if workers are near the monitor.

Gamma dose rates are also likely to be discernible from background inside a contaminated area. The gamma dose rate could be used to check for changing radiological conditions and by radiation safety personnel to assess potential worker doses. Particularly in highly contaminated areas, the gamma radiation readings could be useful to monitor decay of contamination without personnel having to enter the highly contaminated area more than once. This can be important in a scenario where contamination levels are very high, making large-scale sampling and routine monitoring undesirable. In this case, the data may provide critical information for site commanders to determine the earliest time that clean-up activities could begin.

4.4.3 Monitoring for Plume Passage

Deployable monitors may be valuable for monitoring plume passage following large events (e.g., a large foreign radiological event) where the plume will be present in the atmosphere for days or longer. If this is the case, deployable monitors may be used to supplement the fixed monitoring network.

Again, the primary importance of the deployable monitors will be the collection of air particulate samples from their high volume air samplers. If vapors are involved, the charcoal cartridge with the low-volume air sampler will be the only way to sample them. The deployable monitor’s gamma detector will provide real-time data, but the increases in radiation levels would be masked by background (e.g., dose rates increases from RadNet samples collected following the Chernobyl reactor accident would be approximately four orders of magnitude below background). This is the reason that the fixed monitors do not have exposure rate measurement. However, the gamma detector’s near real-time data would provide continuous indications of radiation levels to assure the public that there is no noticeable effect from radiation due to the event.

4.4.4 Monitoring a Long-Term Release

Deployable monitors can be used to monitor a long-term release, such as a fire involving radioactive materials (e.g., the fire near the Hanford Reservation in the summer of 2000). In an event where the release lasts longer than the time required to ship and set up the deployable monitors, the monitors may be used to monitor for direct contamination spread. In general, the plan for monitoring might typically include setting up monitors to surround the site and locating monitors at critical locations such as cities or food supply areas.

In an event of this type, it is likely that other monitoring assets will be deployed from EPA as well as other federal, state, and local assets. The deployable monitors will be used to monitor where those resources are not able to monitor. For example, these other monitoring assets may be more concerned with local monitoring, and not the regional transport of contamination, so the deployables can fill the void of assessing the regional impact. Also, the capabilities of the deployables are likely to be greater than other monitoring assets due to the ability to not only collect airborne particulates but also to continuously measure gamma radiation levels in near-real time.

Analysis of samples collected by the high volume air sampler would have sufficient sensitivity to assist in determining whether protective actions are necessary. The data will also inform the public and decision makers of contamination spread.

Depending upon several factors associated with the characteristics of the release and meteorology, the gamma detector may detect elevated levels above background from submersion in the plume. However, this may not easily be noticed initially if the monitor is deployed and sampling is initiated during the release since there would be no known background established prior to monitoring. Additionally, radiation levels may increase over time due to deposition of contamination on the ground. Again, any contamination that has deposited on the ground before the monitor has begun operation will appear to be natural background. However, any increases over time once monitor operation begins would indicate that contamination has been spread since the beginning of the monitoring period.

The low volume air sampler may also be of use in special scenarios. Although the low volume air sampler cannot match the sensitivity of the high volume air sampler, it can perform specialized, element specific sampling. For example, if the release involves radioiodine, specialized cartridges for iodine sampling may be connected to the low volume air sampler. The cartridges collect iodine in various chemical forms, some of which would not be collected by the high volume air sampler. Specialized sampling from the low volume air sampler also will be important during nuclear reactor accidents and nuclear weapon detonations.

4.4.5 Pre-Deployment of Deployable Monitors

There may be situations where it is advantageous to deploy the deployable monitors in anticipation of a potential radiological release. These situations would typically be when there is an elevated threat of a radiological incident at a general location (e.g., a specific city). There are several advantages and disadvantages to "pre-deploying" the deployable monitors. The following discussion assumes that EPA can operate the monitors prior to a radiological event.

The advantages include getting the monitors to their location more quickly, hopefully prior to the event so that location specific baseline data can be obtained. Also, the monitors will be set up and operating, verifying that there were no problems associated with shipping the units to their deployment location. Operators will also be trained and operating the units prior to the potential event.

Some of the disadvantages include potentially losing a number of deployable monitors for other responses, since the monitors will be deployed and thus would not be ready for rapid shipment. Also, the siting of the monitors in a pre-deployment situation would be based on random sampling (i.e., no knowledge of potential contamination areas), whereas siting following the incident is based more on biased sampling (some knowledge of contaminated areas).

Development of a set of criteria for pre-deploying the deployables was considered, but ultimately, it was decided that it would be best to respond to each pre-deployment request on its own merits. Criteria to be considered include significance of event, probability of a radiological incident at that event, affect of appearance of monitors on the event (e.g., will people not go to an event due to fear because of numerous radiological monitors in the area), other possible monitoring systems in the area, and other factors. Input from potential stakeholders, EPA regional personnel, RERT Commanders, and other agencies may also be included in the final determination to pre-deploy the monitors. ORIA management maintains the authority to direct pre-deployment activities.

5 DATA

In this section, the real-time data flow process, from generation at the monitor to final dissemination is discussed. Data from filter analysis at a fixed or mobile laboratory are also briefly discussed. The general flow process is described in Section 5.1.

5.1 Overview

1. Information is collected by the fixed or deployable monitor.

2. The collector compiles a data file for transfer.

3. The data are transferred from the fixed collector to the primary file server using one of four possible media (deployable has two media).

4. The data file on the file server is processed by the parsing software. Parsing includes the following:

   - Check for integrity
   - Check for abnormal readings
   - Profile against specified rules

5. Based on the results of the parsing, automation software completes the following actions:
   - If an abnormal reading occurs,
     - provide notification of the error to an on-call NAREL representative, or
     - flag the abnormal data and hold until disposition is determined by a NAREL representative.
   - If error-free, prepare data for final processing.
   - Input into final form within database.

6. NAREL reviews the flagged data.

7. Data are then available for viewing via the Internet according to established access controls.

5.2 Generation and Transmission

5.2.1 Fixed Monitoring Stations

5.2.1.1 Real-Time Data

Data generated and stored locally in the fixed monitoring stations are integrated over two separate user-programmable intervals. The longer of the two is the sample collection interval, or segment of time between filter changes. The shorter is the radiation data acquisition interval, which is one hour but can be programmed to intervals as short as 10 minutes. A data record, generated and stored at the end of each of these intervals, includes the following:

- Date and time that filter collection and one hour acquisition began and ended
- Real time and live time for data acquisition in seconds
- Beta count rate
- Count rate for each gamma energy range
- Air flow rate and sample volume (corrected to STP) measured during the one hour acquisitions and since the beginning of the current filter collection period
- Complete beta and gamma spectrum files
- Meteorological data (ambient air temperature, pressure, and optional wind speed and direction, if so equipped)
- Instrument health indicators

The gamma spectrum is divided into 9 contiguous energy ranges that extend from 100 to 2800 keV. The purpose of dividing the spectrum into ranges is that it allows for more sensitive screening of the data because there will be fewer counts in each region than in the entire spectrum. The one energy range is reserved by the manufacturer around the Am-241 gamma peak for gain stabilization and extends from approximately 20 to 100 keV. The nine contiguous energy ranges cover the following energy ranges (in keV): 100-200; 200-400; 400-600; 600-800; 800-1000; 1000-1400; 1400-1800; 1800-2200; and 2200-2800.

Beta data are expressed as gross beta count rate. There are no energy ranges for beta data.

A new one hour radiation data acquisition interval is automatically initiated every time a new filter sample acquisition begins, and any in-progress radiation data acquisition interval automatically terminates when the air sampler is stopped. This ensures that radiation data acquisition intervals can always be correlated with the integrated sample volume.

Each time a data acquisition interval for the radiation detector ends, the data are automatically transmitted to NAREL through redundant telemetry methods. The telemetry methods are integral to the monitoring station. RadNet staff can also initiate data transfer by connecting to the monitor from a remote location. The beta and gamma spectra files can only be transmitted to a remote location by connecting to the monitor and downloading the files.

5.2.1.2 Field Measurements and Laboratory Analyses

Five hours after each filter change (to allow time for decay of radon progeny) the fixed monitor station operator measures gross alpha and beta radioactivity on the filter and calculates the corresponding concentrations in air. If the alpha activity exceeds 0.7 pCi/m^3 or beta activity exceeds 1 pCi/m^3, the operator waits 30 minutes and performs a recount. If either activity still exceeds its respective value, the operator notifies NAREL RadNet staff. The RadNet staff decide whether to ship the filter to NAREL overnight for more rapid analysis or to ship it to NAREL the routine way using first class mail.

Fixed monitor filters received at NAREL are logged into the Laboratory Information Management System (LIMS) upon arrival. Data entered include the results of the gross beta counts performed by the station operator and the volume of air that has passed through the filter along with the sample collection start and stop dates and times. Filters are then counted in the laboratory for beta radioactivity. If the resultant air concentration exceeds 1 pCi/m^3, additional analyses may be performed. Data from the operator screening and the laboratory analyzed gross beta concentrations and each additional analysis performed are stored in the LIMS.

Additional routine laboratory data generated are from isotopic uranium and plutonium analysis on a composite of all filters collected at each site during the calendar year.

Depending on circumstances, NAREL may also perform any or all of the following laboratory analyses on individual air filters:

- high-resolution gamma-ray spectrometry (high-purity germanium)
- Pu-238 and Pu-239 (alpha-particle spectrometry)
- U-234, U-235, U-238 (alpha-particle spectrometry)
- Am-241 (alpha-particle spectrometry)
- Th-227, Th-228, Th-230, Th-232 (alpha-particle spectrometry)
- Sr-89 and Sr-90 (gas proportional counting)
- Ra-226 (alpha scintillation counting)
- Ra-228 (gas proportional counting)

Counting times for most analyses can be adjusted to achieve a range of detection and quantification capabilities, although all Ra-226 analyses involve 1000-minute count times. In an emergency these count times may be reduced to improve turnaround times, or when necessary, samples may be counted for longer intervals, up to several days, to improve the counting statistics.

Turnaround times for gamma-ray spectrometry, alpha-particle spectrometry, and liquid scintillation counting may be as short as one or two days in an emergency. Strontium-90 analysis requires more time, because a delay of several days is needed to allow the decay product Y-90 to build up before counting begins. Ra-226 analysis is time-consuming and may require weeks, depending on the required detection limit.

5.2.2 Deployable Monitoring Stations

5.2.2.1 Real-Time Data

In general, these monitors are expected to be deployed only in response to a radiological incident or emergency. However, they may occasionally be pre-deployed to provide monitoring capability prior to a radiological incident. Thus, rather than having distinguishable routine and incident response modes of operation, they are simply operating or not operating.

When operating, the real-time data generated by and stored in the deployable monitoring stations are integrated over user-programmable intervals. For each interval, the data stored can include:

- Local date and time that the data record was stored
- For both the high-volume and low-volume air samplers (separate data records for each), the average flow rate, integrated sample volume, filter differential pressure, and air inlet temperature and barometric pressure
- Gamma exposure rate (both channels separately as well as the mean)
- Latitude and longitude
- Weather station parameters, including barometric pressure, outside humidity, rainfall amount, outside temperature, wind direction, and wind speed

Data collected by the monitoring system are transmitted to NAREL automatically by the system data logger through the telemetry methods that are integral to the monitoring station. Data can also be downloaded by the system operator to the PDA for transfer to NAREL.

5.2.2.2 Field Measurements and Laboratory Analyses

The analyses to be performed on filter media from the deployable monitoring stations are not pre-defined. Rather, the analyses will be determined based on known or suspected radiological contaminants specific to the reason for which the monitor was deployed. Laboratory analyses that can be performed on the filter media for the high-volume air sampler are the same as those for the fixed monitoring stations. In addition, the low-volume air sampler can utilize specialized media for collecting iodine. These samples would be sent to a fixed or mobile laboratory for analysis. Instrumentation for initial counting of sample media by the operator, prior to sending the samples to a laboratory, is not integral to the deployable monitors, but could be performed if the necessary instruments are available to the operator.

5.3 Data Storage

The RadNet data repository holds the near-real-time air monitoring data from the fixed and deployable monitors, as well as data from the analysis of the filters at NAREL. The repository also holds all laboratory analysis data for the non-real time components of RadNet. The databases are backed up automatically at R&IE.

5.4 Data Review and Evaluation

5.4.1 Real-Time Data

Real-time data are initially reviewed against setpoints for each parameter automatically by computer. If all data in the set are within the established limits for each parameter, the data are considered normal and no manual review of the data is required. If any of the parameters fall outside of the established limits, the data are reviewed manually. This section describes the review process.

5.4.1.1 Automated Review of Near-Real-Time Data

The written guidelines for evaluating RadNet data permit rapid review and evaluation of data during routine and emergency situations. The near-real-time data review process for the fixed monitors is shown in Fig. 5.4.1. All review and manipulation of data are performed by certified personnel. The certification process is described in Section 6.6.

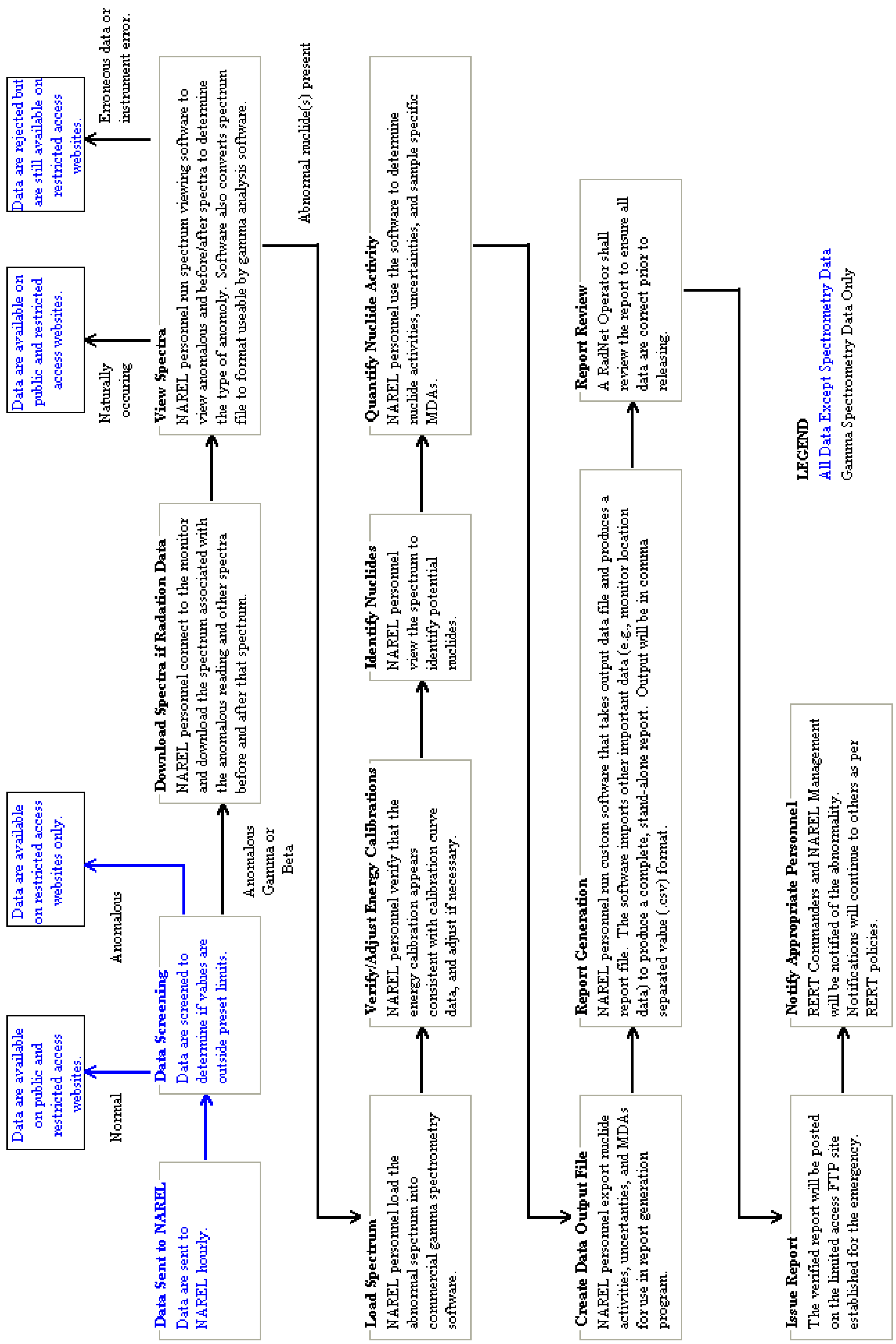

Fig. 5.4.1. Review process for fixed monitor near-real time data.

Near-real-time data stream into NAREL from each fixed monitor at one-hour intervals and from each deployable monitor at the specified interval (typically one hour). Automatic checks of the data against preset limits for each parameter and monitor are conducted by computer. If no abnormalities are noted, the data are automatically approved and archived. If one or more parameters are outside of the limits, the data are flagged. If the flagged parameter is not a radiation parameter, the data are reviewed by RadNet personnel or contractors the next business day.

Radiation parameters have two upper limits. The lower of the two is the abnormality limit. For the fixed monitors, the abnormality limit is based upon normal values and fluctuations for each monitor’s energy range and beta count rate data.

The abnormality limit for deployable monitor radiation data is typically set at a value known to be above background based on initial radiation readings, unless the deployable monitor was pre-deployed and has provided data before the incident. If a deployable monitor was pre-deployed, the abnormality limit is established in a similar manner as for a fixed energy range abnormality limit. If a value exceeds the abnormality limit, the data are flagged and reviewed the next business day by RadNet personnel or contractors.

The upper limit is the warning limit. The warning limit for either fixed or deployable monitor data is based on levels that warrant immediate review, such as if protective actions may be considered. Warning limits for the fixed monitor energy ranges 2-10 are established by selecting levels that would correspond to $1/100^{th}$ of a protective action recommendation (i.e., 10 mrem over a four day period). Warning limits for deployable monitors are event specific and are set following an event based on information and potential expectations. If the warning limit is exceeded, designated personnel can be notified immediately (by page, email, and/or text message) and the review is conducted as soon as possible.

5.4.1.2 Review of Flagged Radiation Data From a Fixed Monitor

Review of non-radiological flagged parameters may result in those parameters being disapproved. If a temperature datum, say, is obviously incorrect, the temperature datum for that hourly transmission is disapproved. If all other data are satisfactory, they are approved and are available for dissemination. The ability to disapprove individual parameters ensures that other existing good data remain available.

Data review of flagged radiological parameters is much more intensive than review of flagged, non-radiological data. When a radiological parameter is flagged, a RadNet staff member or contractor connects to the monitor and downloads the flagged beta and gamma spectra along with those from a few hours before and after (if applicable). The spectra from before and after the flagged spectra provide a context that enables the evaluator to determine the nature of an abnormality.

Experience to date reveals that there are typically three reasons why abnormal gamma data are flagged. The first is fluctuation of naturally occurring radon daughters. These fluctuations may be high enough that the energy range counts may exceed the abnormality limit. This is easily verified by seeing an upward shift in the spectra near the Bi-214 peak at 609 keV. If no other abnormal peaks are noted, the flagged gamma data are approved. Fig. 5.4.2 shows comparison spectra from a significant radon fluctuation.

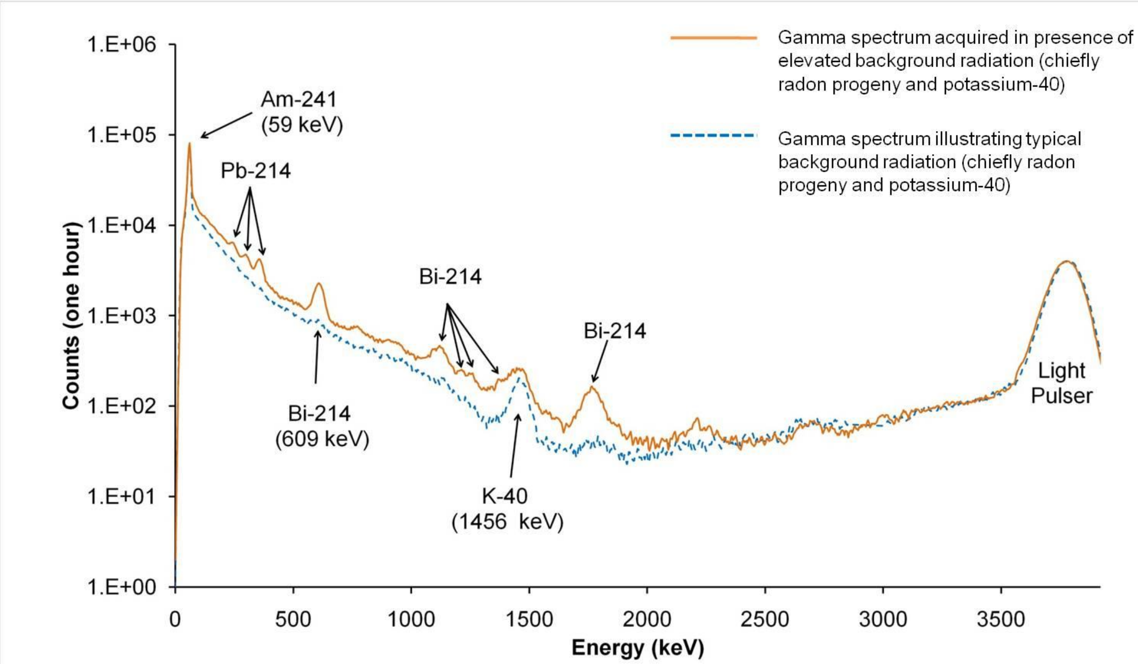

Fig. 5.4.2. Example of effect of radon fluctuations on a spectrum.

The second cause of flagged radiation data is instrument error. The most common instrument error is a shift in energy due to a failure of the gain stabilization. When this occurs, the channel numbers for the energy ranges no longer correspond to the proper energy ranges. This causes elevated levels in some energy ranges due to the shift because the background radiation levels are not consistent over the entire gamma energy spectrum. For example, a gain stabilization issue might result in the Bi-214 peak shifting to a higher energy range that may cause an artificially elevated count rate that exceeds the abnormality limit, as shown in Fig. 5.4.3. In such cases, the radiation data are not approved because a malfunction has occurred and the data are erroneous. This situation also prompts RadNet staff to readjust monitor gain manually to re-stabilize the monitor.

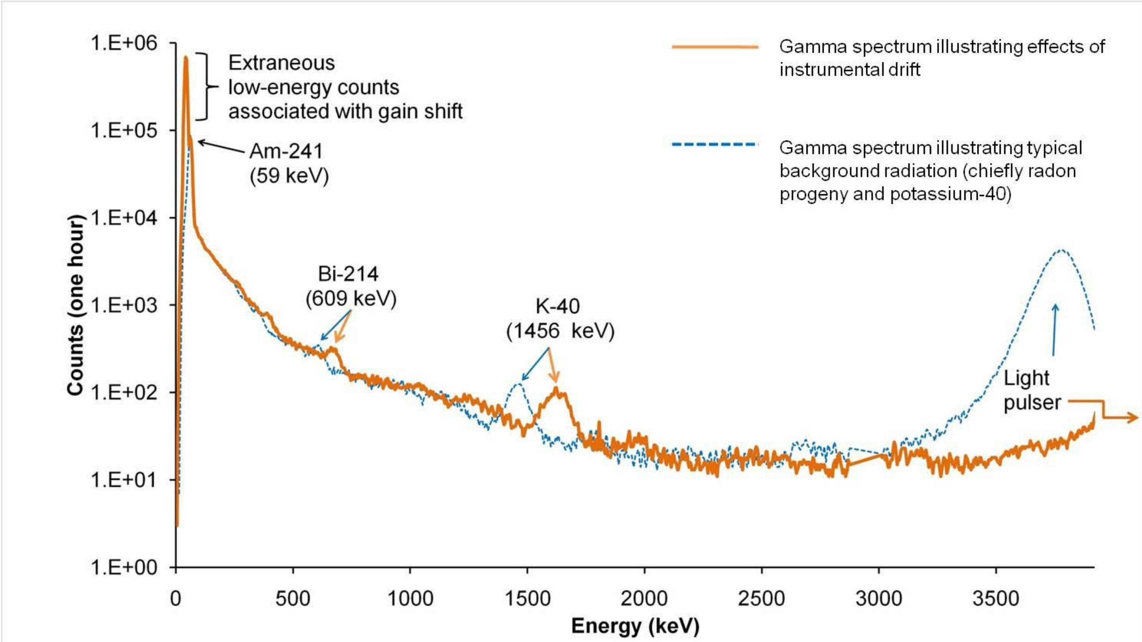

Fig. 5.4.3. Example of shift in energy due to lack of light pulser in appropriate energy range on a spectrum.

The third of the likely causes for flagged radiation data would be the presence of an unexpected radionuclide. When elevated radon daughters cannot be confirmed and the detector appears to be operating properly, a RadNet gamma spectrometrist assumes the abnormality is caused by the presence of an unexpected radionuclide. In this case, the next step following comparison of spectra is to load the spectrum into commercial gamma spectrometry software. Once the spectrum is loaded, the reviewer verifies that the energy calibration is satisfactory. This is done by ensuring the spectrum has the naturally occurring peaks for Bi-214 (609 keV) and K-40 (1461 keV) within 5% of those values. If this is not the case, the data reviewer may adjust the energy calibration based upon those natural peaks before proceeding.

Once the energy calibration is verified to be satisfactory or adjusted if necessary, the gamma spectrometrist identifies the nuclide and determines the activity in each identified peak, along with the uncertainty and sample specific MDA. RadNet personnel generate a formal report of the findings and submit it to the NAREL Laboratory Director for further action.

If the source of the activity is particulate on the air filter, the flagged radiation data will be approved, unless homeland security requirements mandate the data not become available at this time. If the source is not activity on the filter, the flagged radiation data will be disapproved since they do not represent airborne radioactivity.

The system has experienced situations where radioactivity was detected by a fixed monitor that was not caused by airborne particulates. Two different radiography sources

(Co-60 and Ir-192) were detected in separate instances while the source was in use near a monitor. Radioactivity from a person who had undergone radiopharmaceutical treatment (I-131) was also detected at one monitor when a person was working near the monitor. RadNet data reviewers were able to verify that these situations were not airborne contamination since there were no elevated beta activities and because the activities detected went up for short periods of time (one or two hours) and then quickly returned to background. This rapid return to background would not have occurred with these nuclides if they had been collected on the filter. In addition, with the help of station operators, the specific source or person was identified for each situation. Fig. 5.4.4 shows an example spectrum from detection of Co-60 near a fixed monitor.

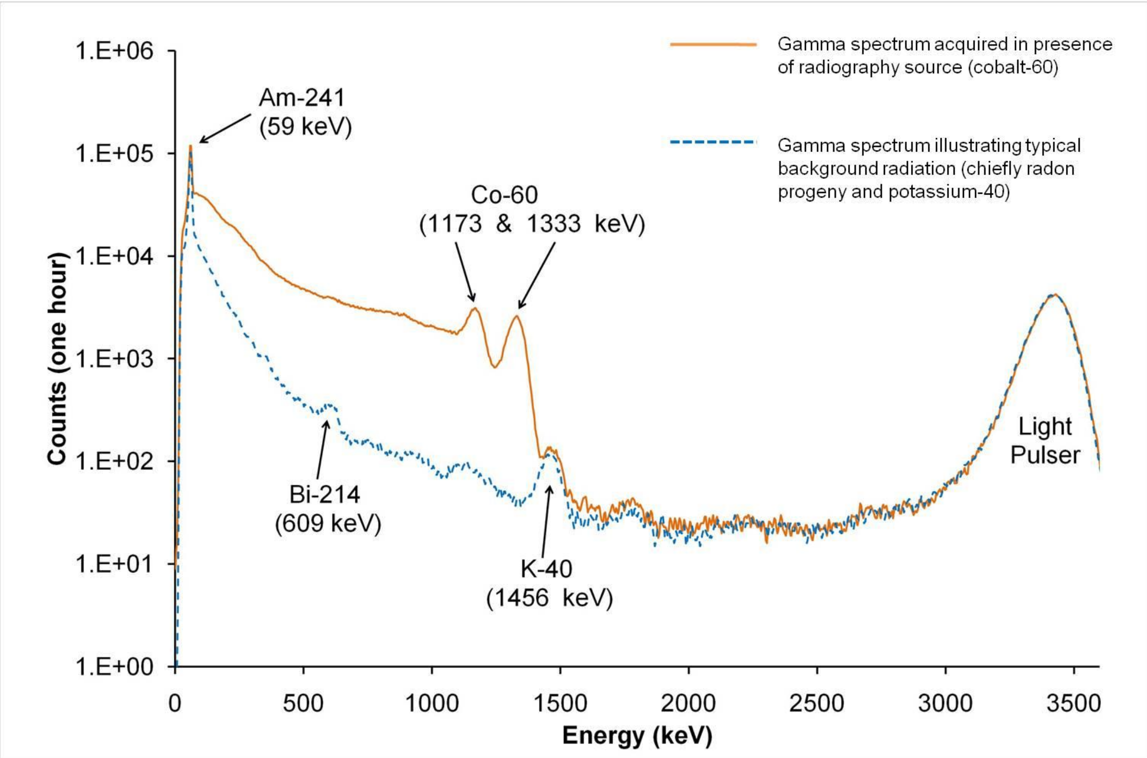

Fig. 5.4.4. Example of Co-60 used for radiography near a fixed monitor.

5.4.1.3 Review of Flagged Radiation Data From a Deployable Monitor

The review process for flagged radiation data from a deployable monitor is similar to that of a fixed monitor, except no spectra are involved. Typically, the review consists of performing a graphical trend analysis of the deployable monitor's ambient gamma radiation levels to determine if the abnormality was caused by a routine fluctuation of gamma radiation levels, instrument malfunction, or if it was elevated above normal fluctuations, which would indicate the possibility that radioactive contamination has increased significantly near the detector. If there was an increase in radiation levels, the operation of the monitor may have to be assumed by RERT personnel and the air sampler filters would be collected and analyzed as soon as possible to confirm the presence of and identify/quantify the contamination.

5.4.2 Analytical Data

All analytical data generated at NAREL are reviewed as required by the *NAREL Radiochemistry Quality Assurance Manual* (EPA09a) and the NAREL *SOP for the Review of Radiochemistry Data* (EPA09b). These documents require two independent, formal reviews of each analysis. The first review occurs at the time the sample results are computed. This is typically done by the analyst, and is done before analytical results are stored in final form within the repository. The second review is performed by a data reviewer not associated with the analysis of the sample. Data reports are reviewed and signed by NAREL's Quality Assurance Coordinator and the Center for Environmental Radioanalytical Laboratory Science Director.

If a RadNet sample contains an unexpected radionuclide, an unusually high level of gross alpha or beta radiation, or a high concentration of any nuclide, the data reviewer completes an event report that is routed to laboratory management and quality assurance personnel.

5.5 Data Dissemination

Under normal conditions, RadNet data are available to the public, once approved by EPA, using EPA's Central Data Exchange (CDX) system. This system allows the public to access any approved energy range data from the fixed monitors and ambient gamma readings from the deployable monitors.

During emergency operations, the timely sharing of data is crucial. RadNet data access during emergency operations can be accomplished either through EPA's public access CDX system or the immediate access CDX system, which is limited for official use and contains approved and unapproved data. Results from gamma spectrometry performed by scientists at NAREL and gross gamma from the deployable monitors will be available to government officials through a secure File Transfer Protocol (FTP) site.

5.5.1 Access to Near-Real-Time Data by Recipient Groups

The CDX data access model is designed to provide appropriate access and information to ensure stakeholders receive RadNet data in a timely manner during normal and emergency operations. There are two types of access provided to users depending on need - immediate access and general public access. Access for the immediate users is approved by the NAREL Laboratory Director. Once approved, the NAREL Information Security Officer submits the request to the OEI-CDX helpdesk, where the registration process begins. Pre-identified immediate data users have already received their access rights. The approval process can be streamlined should access to immediate data be needed in an emergency situation.

5.5.1.1 Immediate Access Group

Specific radiation professionals including EPA Regional Radiation Representatives, FRMAC, and others (upon request) are provided immediate, anytime access to all of the RadNet data on the EPA Central Data Exchange (CDX) site. These data include unconfirmed or erroneous elevated readings. Access will be provided on the EPA website through a secure login, password, and token.

5.5.1.2 General public

After completion of the normal review, the general public will have internet access to the final released data set through the EPA Central Data Exchange (CDX) website, http://cdx.epa.gov. Anyone with an internet connection can visit the site and create a login and password that will grant them access to different EPA program data, including RadNet.

5.5.2 Data Dissemination by System Status

5.5.2.1 Routine Operations

Data collected, transferred, stored, or shared during routine operations follow a procedure that is documented in the Quality Assurance Project Plan (QAPP) (EPA10). During routine operations all groups have access to the near-real-time data within a short period of the data's arrival at NAREL. Spectral analysis data are not available during routine operations because spectra are not analyzed when elevated readings do not occur.

5.5.2.2 When Unforeseen Elevated Real-Time Readings Occur

RadNet has the capability to provide data continuously from both deployable (if operating) and fixed air monitoring stations. Routinely, the near-real-time data are transmitted hourly. Once the data are received at the data repository they are available to the immediate access users. The data undergo an initial electronic data review, comparing the incoming data to trigger levels for each station. If an anomaly is identified, NAREL scientists will conduct further review and analysis to determine if the reading can be confirmed (see Section 5.4.1). If the reading appears to be credible, RadNet personnel will notify NAREL management, who may request implementation of notifications.

Data review and analysis require several hours, and appropriate decision groups will be notified in the event that an abnormal reading is confirmed to be from an unexpected radionuclide. It is anticipated that the data will be available to the public within 24 hours after it has completed the normal review process as long as EPA is authorized to release the data to the public. The results of spectral analysis are only available through a password protected FTP site.

5.5.2.3 During a Known Radiological Emergency

EPA will share data in compliance with existing federal policies and procedures (see Section 2.4). Data availability will be the same during an emergency as it is during routine operations, unless EPA is told by appropriate authority to cease making data available. Results of fixed monitor gamma spectral analysis will only be available through a password protected FTP site.

5.5.3 Communications Plans

Several plans have been developed for describing the RadNet monitoring system. A RadNet Air Monitoring Information Package (EPA09c) gives basic information about the fixed and deployable monitoring systems, the types of data available from each, where the data are available, and how to get access to those data.

Also, a one page paper describing messages concerning the history of RadNet has been developed to assist communications personnel. Draft messages for use by EPA communications personnel have also been developed and tested for use during emergencies, so that consistent messages will be produced concerning the data and their impacts.

Additionally, EPA has published a document for Crisis Communications for Emergency Responders (EPA07). This plan outlines methods to effectively communicate during emergencies, how to explain radiological information, working with the media, and other topics. It also gives example communications for three potential radiation incidents.

5.6 Data Security

Telemetry from the air monitoring sites to the data repository will be through secure encrypted communication modes as outlined in the RadNet IT Security Plan (EPA05b). Information security is based on Federal Information Processing Standards 199 (FIPS 199) (NIS04) and National Institute of Standards and Technology requirements (NIS98, NIS01, NIS05).

The RadNet data are rated as “high” categorized data in the areas of confidentiality, integrity, and availability. The high rating for categorization is based on several factors as defined by FIPS 199. The primary factor is that RadNet data, along with lab functionality and emergency response data, were identified by the EPA and then designated by DHS as a “Key Asset and Critical Infrastructure.” Other categorization factors were “Disaster Monitoring and Prediction” and “Environmental Monitoring and Forecasting.” These are rated as high because the lack of data availability or integrity could aide in lack of proper protective actions being taken.

6 QUALITY ASSURANCE AND QUALITY CONTROL

6.1 General Quality System Requirements

In order to ensure that RadNet data are accurate, reproducible, of known and desired quality, and suitable for their intended use, EPA requires that a formal, documented, and monitored system of quality assurance (QA) and quality control (QC) activities be in place. This Quality System must address all aspects of RadNet as it functions in both routine and emergency situations. The Quality System must include requirements and guidance for all aspects of RadNet operation, including sample collection and handling, monitor operation and maintenance, sample analysis, data evaluation and data dissemination. For the purposes of this document, discussion of QA and QC will be limited to the fixed and deployable air monitoring systems and the data directly produced by them. QA/QC for laboratory analyses is discussed in the *NAREL Radiochemistry Quality Assurance Manual* (EPA09a).

CIO 2105, formerly EPA Order 5360.1 A2 (EPA00a) states:

> "A consistent, Agency-wide Quality System will provide, when implemented, the needed management and technical practices to assure that environmental data used to support Agency decisions are of adequate quality and usability for their intended purpose."

In addition, Section 2.1 of QA/R5 (EPA01) requires:

> "All work funded by EPA that involves the acquisition of environmental data generated from direct measurement activities, collected from other sources, or compiled from computerized databases and information systems shall be implemented in accordance with an approved Quality Assurance Project Plan (QAPP). The QAPP will be developed using a systematic planning process based on the graded approach. No work covered by this requirement shall be implemented without an approved QA Project Plan available prior to the start of the work except under circumstances requiring immediate action to protect human health and the environment or operations conducted under police powers."

EPA and NAREL policies for RadNet and other programs require adherence to QA procedures established by Agency mandates, EPA Quality Staff directives, and established and recognized good laboratory practices at all times. These directives apply to a fixed or mobile laboratory, sample collection in the field, and fixed and deployable data-collecting units. Such adherence requires that at a minimum

- equipment and facilities included in a mobile, off-site, or deployable data-collecting unit are maintained and monitored to prevent adverse impact on data quality;

- technicians, professional bench scientists, project officers, and line managers are well qualified and trained in laboratory and field methodology in their areas of responsibility;
- personnel qualifications and training are fully documented;
- field and analytical activities for RadNet are governed by formal policies mandated in the NAREL's Quality Management Plan, the RadNet Quality Assurance Manual (QAM), and a number of applicable Standard Operating Procedures (SOPs); and
- periodic audits and inspections are conducted of facilities, programs, and operations that provide samples or environmental data.

6.2 Evaluation of the RadNet Quality System

In 2005, an assessment of the expansion of the RadNet air network was performed. The assessment showed that while RadNet had strengths, there were also critical tasks and activities that needed to be improved, expanded, or implemented. These included improved documentation for the system, improved training for station operators, addition of quality control samples when analyzing RadNet samples in the laboratory, plans for periodically evaluating RadNet, and a plan for preparedness exercises for emergency readiness.

As part of the reassessment of QA and QC policies and procedures for RadNet, a team worked through EPA's recommended Data Quality Objectives process (EPA00b), evaluating the entire process of collecting, receiving, and analyzing RadNet samples, and reviewing and reporting of RadNet data, both transmitted near-real-time data and the filters collected by the fixed or deployable monitors (EPA00c). As a result of this exercise, decision points were recognized and the team made an effort to provide guidance for improvements in quality control and quality assurance of RadNet data, both the near-real-time data from air monitors and for the laboratory analyses of air filters received at the laboratory.

6.3 The Quality Assurance Project Plans for Routine and Emergency Operations

Reviews of the ERAMS QAPP, published in 1982, and the ERAMS Manual, published in 1988, were begun during the first consideration of reconfiguration of ERAMS in 1995 and 1996. In 2008, the QAM (EPA08b) was revised extensively to include the current expansion of the RadNet air monitoring capabilities.

Two QAPPs were developed, one for the system of fixed air monitors (EPA10) and the second for the system of deployable monitors. The QAPPs cover routine operations and outline acceptable practices for operation during an emergency situation. Guidelines to provide data quickly in a time of emergency, with adequate quality control, are also presented.

6.4 Standard Operating Procedures

EPA policy requires that SOPs be written for all routine activities. SOPs contain specific details and procedures to ensure that data generated by their use will be of known and adequate quality. An SOP details the method for an operation, analysis, or action, with thoroughly prescribed techniques and steps.

Written procedures are in place for operation of the fixed (EPA06) and deployable monitors (EPA08a) and for operation of the fixed monitor filter screening instruments (EPA05c, EPA08c) and calibration of the screening instruments (EPA05d). SOPs are included in the NAREL document control system to ensure that revisions are distributed to all station operators in a timely manner. Written documentation describes all steps for calibration, maintenance, and use of the units; procedures for screening and shipping filters to NAREL; reception and evaluation of real time data at NAREL; and reporting and dissemination of the data.

6.5 Training and Quality Control Protocols for Station Operators

A major area that was emphasized to ensure sample quality and consistency was training those who operate the fixed air monitors. To address this critical area, a training video was produced to augment the SOPs for monitor operation and sample collection and handling. This was a cost-effective and efficient way to ensure consistency in collecting, handling, screening, documenting, and shipping RadNet samples. Mentoring by NAREL staff also provides continuing training for fixed monitor operations. Also, an internet site designed for RadNet Fixed Monitor Operators has been established to provide information to the operators. As each fixed monitor was set up, the manufacturer calibrated and tested the monitor and provided initial training to the operator of the monitor.

For the deployable monitors, operators are trained by specialists from NAREL or R&IE to set up and operate the monitors. This training has occurred in all 10 EPA Regions for over 100 potential operators. An easy to use operations guide was also developed to augment the SOP for operation, and field testing of this guide has enabled untrained operators to satisfactorily set up and operate a deployable monitor. Specialists from NAREL and R&IE are also available in the field or from their respective laboratory for consultation with any of the deployable monitor operators.

6.6 RadNet Personnel Certification and Proficiency

Because of the unique and specific procedures required to operate the RadNet system remotely as well as to review and evaluate the data, a certification and proficiency system has been established for RadNet operations personnel. Currently, there are three specific certifications required. The first is as a “RadNet Data Reviewer,” the second is the “RadNet Data Evaluator,” and the third is the “RadNet Supervisor.”

The RadNet Data Reviewer’s primary function is to review hourly data sent to NAREL. When abnormalities are noted, this person records the abnormality for review by the RadNet Data Evaluator. If a radiation abnormality exists, the RadNet Data Reviewer downloads appropriate spectra files that will be evaluated by the RadNet Data Evaluator.

The RadNet Data Evaluator requires a strong knowledge in gamma spectrometry and environmental radiation, since they are expected to interpret data and spectra. The RadNet Data Evaluator’s functions include the ability to:

- remotely connect to a monitor using all of the telemetry modes;
- utilize the manufacturer provided software for performing operations remotely;
- query the monitor for data, including downloading spectra from the monitor; and
- view and interpret calibration files.

The Certification process for the RadNet Data Reviewer and the RadNet Data Evaluator are described in SOPs (EPA08d and EPA08e, respectively). The certification process includes demonstrating to a RadNet Supervisor all of the actions required to demonstrate proficiency associated with the functions of the RadNet Data Reviewer or Data Evaluator.

The RadNet Supervisor requires a very strong knowledge in gamma spectrometry and environmental radiation, since he/she is expected to interpret data and spectra, make decisions concerning possible airborne contamination, and operate gamma spectrometry software for radionuclide concentration determinations. He/she is also expected to understand emergency response communications procedures for EPA, FRMAC, and in the NRF. Understanding of integral calculus and dose assessment procedures are important for the RadNet Supervisor, since persons in that position may be required to perform detailed calculations in abnormal situations. Certification as a RadNet Operator is a pre-requisite to certification as a RadNet Supervisor. The RadNet Supervisor’s functions include the ability to perform all of the RadNet Operator’s functions as well as to:

- visually identify peaks and potential radionuclides from a gamma spectrum;
- use the gamma spectrometry software to quantify activity of nuclides from peaks in the spectrum;
- calculate an average airborne concentration from the activity, including uncertainty; and
- communicate results of calculations, including potential doses to appropriate personnel.

The Certification process for a RadNet Supervisor is described in an SOP (EPA08f). The certification process includes demonstrating to a RadNet Supervisor all of the actions required to demonstrate proficiency associated with the functions of a RadNet Supervisor.

To ensure certified personnel are ready to perform critical RadNet functions during an emergency without refresher training, each certified person is required to maintain proficiency in accordance with the SOP for maintaining proficiency (EPA08g). The SOP ensures Operators and Supervisors maintain the ability to perform all of the functions associated with their positions. Maintaining proficiency also ensures that persons are up to date on changes in procedures, software, or hardware. Proficiency must be demonstrated each month to senior RadNet staff or NAREL management.

6.7 Instrument Calibration, Verification, and Maintenance

When a location met the local siting criteria (Section 3.7) and had power available to operate the monitor, the fixed monitor manufacturer shipped a monitor to the site, installed and calibrated the monitor, performed required initial performance checks, and trained the operator(s). Once NAREL RadNet personnel verified that the monitor was correctly installed, it was operated with the manufacturer present for the first hourly data transmission to ensure all systems were operating correctly and that the initial calibrations were accurate.

Each monitor is re-calibrated at least annually. The operator is sent a calibration kit that includes all information and transfer standards to calibrate the parameters of importance, such as air flow rate, temperature, barometric pressure, and counting efficiencies of the detectors. The addition of broadband cell phone communications and software that allows control of the monitor’s onboard computer from NAREL reduces the burden on the operator. The operator now only performs the physical aspects of placing sources on the monitor or connecting calibration equipment. To further reduce burden on the operator, when repairs are made by the fixed monitor maintenance contractor, the contractor performs a full calibration of the monitor. This also extends the time to the next annual calibration, thus delaying the operator’s responsibility to assist in the calibration. Results of all re-calibrations are monitored at NAREL by a contracted service calibration technician. NAREL personnel must approve all calibrations.

Subsequent to each above-described field calibration, NAREL personnel use gamma spectrometry software to construct energy and efficiency calibrations of a monitor's gamma detector. These calibrations are applied by NAREL personnel during evaluation and interpretation of subsequent gamma spectra acquired by a monitor.

In addition to annual calibrations, a variety of quality assurance activities are conducted more frequently. Each work day, the operational status of each monitor is checked and documented. Each week, data from all system components on each monitor are inspected and documented to verify proper operation and a full gamma spectrum from each monitor is evaluated and documented to verify that the detector is functioning properly and its calibration remains satisfactory. At least once each month, a full gamma spectrum from each monitor is evaluated with gamma spectroscopy software to *quantitatively* verify the most recently applied gamma detector calibration.

Routine operations of installed monitors have indicated that the monitors generally operate continuously with minimal need of preventative maintenance. Monitors run steadily until a component requires adjustment or fails, at which time the component is adjusted, repaired or replaced, the instrument is re-calibrated, and the monitor returned to service.

6.8 Alerts, Corrective Action, and Decision-Making

If any data indicate a possible problem with instrumentation, a corrective action process is initiated. If evaluation of anomalous radiation values indicates temporal fluctuations of natural radiation then a summary of the evaluated energy spectrum is documented. If evaluation indicates instrument malfunction then NAREL RadNet staff remotely connect to the monitor and correct the cause of the malfunction if possible (*e.g.,* energy recalibration or detector gain adjustment). If instrument malfunction cannot be corrected remotely by NAREL personnel, then a service contractor will be tasked to repair the malfunction.

If evaluation of anomalous radiation values indicates activity from unanticipated nuclides, then procedures described in Section 5.4.1 are performed. Investigation into the cause of the abnormal nuclide identified includes checking with the site operator, re-calibration or re-setting of instrument parameters if necessary, or reporting gamma or beta activity to the Laboratory Director. At that point, actions will be event specific.

When the presence of elevated gamma or beta activity is verified, the NAREL Laboratory Director has the responsibility of notifying appropriate people and determining next steps.

6.9 Field Audits and Periodic Evaluation of RadNet

It is vital to the continuous improvement of RadNet that formal evaluations be performed regularly, with emphasis on updating equipment and methods, maintaining levels of sample collection efficiency, and evaluating use and dissemination of the data. At NAREL, such an evaluation is part of the mandated annual internal audit. The QA Manager annually assesses each part of the laboratory against NAREL's QA/QC policies, EPA requirements, and good laboratory practices. A broader, RadNet-wide evaluation is conducted every three years. The evaluation includes review of RadNet documentation including the QAPP, sampling and field procedures and equipment, sample tracking, analytical procedures and equipment, and QC data associated with RadNet since the previous review. On a broader scale, the review will look at the interest of the current users of the data to determine how well RadNet data are meeting the needs of the public and the scientific community. The review may include an evaluation of media sampled, sampling locations and frequencies, and the overall data quality objectives for the system.

6.10 Training, Testing, and Preparedness Exercises for Emergency Readiness

Because RadNet must be prepared for rapid response following an incident, NAREL personnel must be able to communicate with operators quickly, completely, and efficiently. NAREL must also be able to get additional supplies to the operators quickly. To enhance overall system readiness, emergency activation of the system is simulated periodically at NAREL.

Emergency readiness drills improve the response capability of the sampling networks and personnel. Annually, a mock incident is developed. NAREL staff, presented with the incident information, are required to evaluate the possible scope of the incident and determine what type of emergency samples are needed and from which locations in the network. NAREL staff will then notify all appropriate station operators that an exercise is being conducted and provide to them the nature of the incident and the needed numbers, types, locations, and frequencies of sampling, and any special shipping instructions. NAREL staff monitor the time required to locate and inform operators and their response time during the readiness drill. NAREL monitors review the response and present a report of findings and suggestions to the laboratory director and other appropriate personnel. A report of the results of the drill may be sent to the sample collectors as part of their continual training, information, and evaluation. At regular intervals, an emergency readiness drill is performed that includes physical transport and setup of at least some of the deployable air monitors. Frequently, this drill is performed as part of a larger radiological emergency response exercise.

In the final analysis, the ultimate goal of the RadNet QA and QC program is the continuous monitoring and improvement of all steps in the process, thus ensuring data that are accurate, reproducible, defensible, readily available, and useful to the public and the scientific community.

7 FUTURE PLANS FOR RADNET

7.1 Fixed Monitors

The highest priority for upgrading the fixed monitors is to improve the redundancy of the communications systems. Initially, the preferred communication methods were direct internet connection and land-line phone modem. However, most locations have not been able to provide either method. The upgrade of the monitor's cell phone modem provided a high speed connection that allows continuous communication to and from the monitor. The cell phone modem is now the primary communication method. However, there is still a lack of redundancy in communications if neither the land-line phone nor the direct internet connection is available since the current satellite communication system allows only one-way transfers of data files from the monitor to NAREL and is not fast enough to allow communications from NAREL to the fixed monitor or to download spectra. Furthermore, the current fixed monitor cell phone technology is 3G, meaning communications will be interrupted for a period of time when 3G is phased out while upgrades are made to the fixed monitors to enable the use of 4G technology. Therefore, investigation into a new, high speed internet satellite communication system is underway. This high speed satellite communication system will provide full redundancy in communications for all monitors.

Another priority for upgrading the fixed monitors is to improve detection capability. There are several limitations associated with the use of the sodium-iodide detector, including instability due to temperature changes, the need for gain stabilization using Am-241, and low resolution of gamma peaks. Investigations into detectors that are compatible with the current system that will correct one or more of these limitations are in progress.

7.2 Deployable Monitors

There are limitations associated with the deployable monitors as well. The limitations or non-desirable traits include their weight and bulkiness, the lack of spectrometric capability, and the lack of reliability of the control system and communication system following transportation. At this time, EPA is considering alternatives to the current deployable monitors.

8 EVALUATION OF EPA'S RADNET AIR MONITORING NETWORK DURING THE FUKUSHIMA NUCLEAR POWER STATION ACCIDENT

EPA's upgrade and expansion of its RadNet air monitoring network over the past five years significantly enhanced the Agency's response to the accident at the Fukushima Daiichi nuclear power station (NPS) in Japan that began on March 11, 2011. At that time, EPA was operating a network of 124 fixed, near-real-time RadNet air monitoring stations and had 40 deployable RadNet air monitors available to supplement the fixed network.

Throughout the months of March and April during peak releases from Fukushima, EPA continuously measured the concentrations of radionuclides in ambient air in the contiguous United States, Alaska, Puerto Rico, Hawaii and several U.S. Pacific Territories. On-board radiation detectors in the fixed RadNet monitors enabled EPA to detect minute amounts of radioactivity collected on the filters during sampling and to report the results of the gross beta and gamma measurements on the Agency's website in near-real-time. In addition, RadNet deployable monitors reported near-real-time gamma exposure rate measurements that could indicate increases in deposited activity on the ground surrounding the monitors. These monitors also collected high- and low-volume particulate air samples and charcoal canister samples for subsequent laboratory analyses.

Compared to the 1986 Chernobyl nuclear power plant accident where air sample results were delayed by several days or weeks due to shipping and laboratory analysis times, EPA's response to the Fukushima accident was much more rapid and comprehensive. Specifically, the combination of near-real-time monitoring capabilities, the strategic use and rapid set up of deployable monitors in remote locations, and constant assessment of air monitoring data allowed the Agency to provide the public and decision makers with timely and scientifically defensible information for making protective action decisions.

This chapter examines the operation of the RadNet air monitoring network during the early phase of the Fukushima Daiichi NPS accident and provides lessons learned. EPA views this evaluation as a valuable opportunity for improving the RadNet program.

8.1 Accomplishments of the Deployable and Fixed Monitors During Fukushima

With the exception of a few site-specific monitoring systems, EPA's fixed and deployable RadNet monitors provided all of the air monitoring data for the United States following the releases of radioactive contamination into the air from the Fukushima Daiichi NPS. In the first month following the earthquake and tsunami, over 85,000 near-real-time data sets from the fixed monitors were received at NAREL. Deployable monitors were set up in a few locations in the contiguous U.S. and some highly remote locations including mainland Alaska, the Aleutian Islands, Hawaii, Guam, and Saipan. Over 17,000 near-real-time data sets from these deployable monitors were received.

The volunteer operators for both fixed and deployable monitors generally performed well under the stress of being involved in an actual event. Operators followed all normal, standard procedures during the incident with the exception that filters were returned via express shipment to save time. Following the response, it was noted the volunteer operators rarely participate in emergency drills, so EPA plans to evaluate having operators participate in future drills.

8.1.1 Deployable Monitors

Along with providing air particulate filters that were analyzed for radionuclide concentrations at NAREL, the deployable RadNet monitors also provided the capability to sample vapor-phase radioiodine (particularly I-131). Vapor-phase iodine concentration is important to dose assessors because vapor-phase forms of radioiodine behave differently in the environment and have different effects on human health than their particulate counterparts.

The ratios calculated from the results of the deployable RadNet monitors' filters (particulate I-131) and charcoal cartridges (vapor-phase I-131) indicate the I-131 in the vapor-phase concentrations averaged five times higher than particulate concentrations. In the case of the Fukushima Daiichi incident, all radioiodine measurements were at extremely low levels posing no significant health risk. While the RadNet system served well during this incident, the Agency is considering this issue in the context of fixed monitor capabilities (see section 8.2.5 in this chapter).

8.1.2 Fixed Monitors

The hourly near-real-time data from the RadNet fixed monitors provided information for the public and decision-makers about the radiological conditions in locations across the nation. EPA reviewed these data hourly for abnormally high readings to ensure no significant contamination from the Fukushima accident was being spread in the air across the nation.

The gamma spectral data from the fixed monitors was of great value in two ways. First, the spectra allowed RadNet scientists to rapidly evaluate abnormalities in the hourly data to affirm that the increases were not caused by radionuclides that could have been emitted during the Fukushima accident. Second, the ability of the near-real-time monitor to detect and accurately quantify contamination on a filter was affirmed. For example, RadNet scientists were able to use gamma spectra from the Honolulu, HI monitor to find a radionuclide associated with the Fukushima accident. RadNet scientists determined that I-131 was present on the filter after spectrometric analysis at a concentration near the detector's Minimum Detectable Activity (see Table 3.3.3). Subsequent laboratory analysis of this filter using a high-purity germanium detector at NAREL found I-131 present at a similar concentration. Another benefit to collecting hourly data from the fixed monitors is the more precise determination of when the contamination occurs during the sampling period which is important information for dose assessors.

8.2 Areas Identified for Improvement with the RadNet Air Monitoring Network

The Fukushima accident provided a live test of the RadNet system while it was being implemented. Although RadNet performed well during this challenge, there were areas identified that require improvement or at least warrant further discussion. The more important areas for improvement associated with fixed or deployable monitoring systems or their data are discussed in the following paragraphs.

8.2.1 Fixed Monitor Communication Issue

One of the first issues noted in the Fukushima response was that only about 80% of the fixed monitors were reporting hourly data to NAREL on March 11, 2011. Some of these monitors were collecting an air filter sample and actively measuring radioactivity, but the communications systems were not functioning properly, giving the appearance that the monitors were not operating. Typically, this issue is corrected when RadNet staff contact the operators and ask them to go to the monitor and reset the cell phone modem. To improve system communications, EPA is procuring a high speed satellite system that will be a primary means of communication for fixed monitors.

8.2.2 Fixed Monitor Maintenance and Parts

Twenty-five fixed monitors were not operating when the Fukushima event occurred. Twenty-two of these monitors required highly specialized components for repair. EPA had ordered these parts through a recently awarded contract. EPA obtained the parts needed to fix the twenty-two non-operating RadNet monitors by cannibalizing parts from ten new monitors that were under construction, and from components furnished from partial delivery of the contract's first delivery order.

To address the main problem of monitors being down due to insufficient availability of components, EPA has built and will maintain a component stockpile. Stockpiling components was not possible until recently because almost all available parts were used to construct new monitors. EPA executed a contract modification for expedited repair of fixed monitors following the Fukushima accident. The modification allows for rapid repair of monitors during emergencies, cutting the nominal repair time from two weeks to approximately two days.

The remaining three of the twenty-five non-operating monitors were returned to service quickly. One of the monitors needed a part that was easily obtained and two of the monitors required new volunteer operators since the previous operators had departed from their respective organizations. EPA was able to quickly secure volunteer operators at these locations during the Fukushima accident. To date, these two stations have performed reliably with their new site operators. The Agency is exploring mechanisms to increase the frequency of contact with volunteer operators.

8.2.3 Data Availability

During the Fukushima response, primary data (gamma radiation data) from a number of monitors were not available to the public because of issues with secondary (non-radiation) data, such as ambient temperature, atmospheric pressure, and others. For RadNet, EPA holds the entire data set for review whenever ANY data element in the set is outside the screening limits. EPA does not approve any data that are outside of the established limits unless they are verified to be legitimate. When a data set is flagged for review, no element in the set is available to the public until the review is complete and all valid elements in the set are verified. The color coding used on the EPA website indicated that data under review were not currently available, but this was frequently misinterpreted as the monitor was not operating.

To remedy this problem, EPA is considering limiting data availability to only radiation data. The purpose of the fixed and deployable monitors is to collect samples and measure radiation in the environment. Other data not directly associated with this purpose should not delay the release of satisfactory radiation data to the public. This change will greatly improve the availability of data on the internet and will also convey that monitors are operating properly.

8.2.4 Fixed Monitor Beta Detector

Beta detectors exhibited two areas of problems, one had to do with the actual operation of the equipment and the other was a problem with how the beta data were represented on the website. The equipment problem with the beta detectors centered on the fact that the fixed monitor beta detectors are subject to interference (see section 3.3.2). When that happens, there can be significant, artificial elevations in the beta reading that rise above the review setpoint. In turn, the elevated readings cause the entire data set to be held from release until it is reviewed by a RadNet scientist. If the elevated beta number is associated with beta particles emitted from the filter, the data are approved; but if the elevated beta count rate is caused by interference, the beta data are disapproved because they do not represent beta emitted from radionuclides on the filter.

Second, the order that the beta and gamma radiation graphs were displayed on EPA's website potentially caused confusion and unnecessary concern for the public. During the Fukushima response, beta radiation graphs were shown first on the EPA website, with the more important gamma radiation graphs shown below them. Users would see only an empty beta graph at first on a typical computer screen, and many did not know to scroll down to the more important gamma radiation data. During the Fukushima Daiichi NPS incident, the gamma information was the more important indicator of whether radiation had reached the United States. Because of this, EPA decided to remove the beta graphs from the website until the beta interference issue is resolved.

8.2.5 Fixed Monitor Vapor Collection Capability

The fixed monitor has a high volume air sampler (see section 3.1) but has no low volume air sampler. While the high volume air sampler works well for particulates, it is unable to collect gases such as radioiodine vapors, which may be the prevalent form of iodine after long-distance transport following a nuclear reactor accident.

While it is not feasible to add low volume air samplers to the routine monitoring performed by the fixed monitor network, EPA is considering purchasing low volume air samplers to collect gaseous samples using charcoal cartridges. These low volume air samplers would not be used routinely, but would be used following an event where gaseous iodine is likely to have been released.

9 REFERENCES

CFR04 Code of Federal Regulations, U.S. Environmental Protection Agency. Title 40, Part 58, *Ambient Air Quality Surveillance*, Washington, DC: U.S. Government Printing Office, July 2004, http://ecfr.gpoaccess.gov.

DAV03 Davis, Lynn E., Tom Latourrette , David Mosher, Lois Davis, David Howell, eds. 2003. *Individual Preparedness and Response to Chemical, Radiological, Nuclear, and Biological Terrorist Attacks*, Santa Monica, CA, Rand Corporation. http://www.rand.org/pubs/monograph_reports/MR1731/index.html.

DHS08 U. S. Department of Homeland Security (DHS), *National Response Framework*, January 2008, http://www.fema.gov/pdf/emergency/nrf/nrf-core.pdf.

DRA03 Draxler, R. R. and Rolph, G.D., 2003. HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD.

DRA09 Drake-Richman, Zora E. and Lydia H. Brouwer, "Aerosol Sampling Efficiency Test of the RadNet Monitor," Alion Science and Technology, TR-WDE-09-01(1), May 2009.

EPA00a U. S. Environmental Protection Agency, Office of Environmental Information. 2000. EPA Order CIO 2105.0 (formerly 5360.1), *Policy and Program Requirements for the Mandatory Agency-Wide Quality System*, Washington, DC, http://www.epa.gov/irmpoli8/policies/21050.pdf.

EPA00b U. S. Environmental Protection Agency, Office of Environmental Information. 2000. EPA *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, Washington, DC, http://www.epa.gov/quality/qs-docs/g4-final.pdf.

EPA00c U. S. Environmental Protection Agency, Office of Environmental Information. 2000. *EPA Guidance for Data Quality Assessment*, EPA QA/G-9, Washington, DC, http://www.epa.gov/quality/qs-docs/g9-final.pdf.

EPA01 U. S. Environmental Protection Agency, Office of Environmental Information. 2001. *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5, Washington, DC, http://www.epa.gov/quality/qs-docs/r5-final.pdf.

EPA05a U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, *Expansion and Upgrade of the RadNet Air Monitoring Network: Concept and Plan, Volume 1 and 2*. 2005, Washington, DC.

EPA05b U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory. 2005. R*ADNET Security Plan*, Montgomery, AL.

EPA05c U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *SOP for Using the Technical Associations Drawer System for Counting RadNet Air Filters*, RadNet/SOP-12, Montgomery, AL, October 2005.

EPA05d U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *SOP for Calibrating the Technical Associations Drawer System for Counting RadNet Air Filters*, RadNet/SOP-14, Montgomery, AL, October 2005.

EPA06 U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *SOP for Routine Sample Collection with the General Atomics RadNet Air Monitor*, RadNet/SOP-13, Montgomery, AL, May 2006.

EPA07 U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, *Communicating Radiation Risks: Crisis Communications for Emergency Responders*, EPA-402-F-07-008, Washington, DC, July 2007.

EPA08a U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *SOP for Deployable Monitoring Setup and Operation (Adapted from RIENL Cer-360)*, FMM/SOP-12, Montgomery, AL, August 2008.

EPA08b U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *RadNet Quality Assurance Manual*, Rev. 1, Montgomery, AL, QA/QAM-4, November 2008.

EPA08c U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *SOP for Using the Ludlum Alpha/Beta System for Counting RadNet Air Filters*, FMM/SOP-10, Montgomery, AL, January 2008.

EPA08d U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *SOP for RadNet Control Room Data Reviewer Certification*, QA/SOP-28, Montgomery, AL, December 2010.

EPA08e U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *SOP for RadNet Control Room Data Evaluator Certification*, QA/SOP-13, Montgomery, AL, December 2010.

EPA08f U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *SOP for RadNet Control Room Supervisor Certification*, QA/SOP-11, Montgomery, AL, December 2010.

EPA08g U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL *SOP for Maintaining RadNet Control Room Personnel Proficiency*, QA/SOP-12, Montgomery, AL, December 2010.

EPA09a U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory. 2009. *NAREL Radiochemistry Quality Assurance Manual*, Montgomery, AL.

EPA09b U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory NAREL *SOP for the Review of Radiochemistry Data*, , Montgomery, AL, DR/SOP-2, Rev. 3, March 2009.

EPA09c U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory. *RadNet Air Monitoring Information Package*, Washington, DC, June 2009.

EPA10 U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, National Air and Radiation Environmental Laboratory, NAREL Quality Assurance Project Plan, *Expansion of the RadNet Fixed Station Air Monitoring System to Include Near-Real-Time Gamma Monitoring*., RadNet/QAPP-1, Rev 1, August 2010, Montgomery, AL.

EPA92 U.S. Environmental Protection Agency, Office of Radiation Programs. 1992. *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents,* Washington D.C., (EPA-400/R-92-001).

EPA97 U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1997. *EPA Guidance for Network Design and Optimum Site Exposure for* $PM_{2.5}$ *and* PM_{10}, Research Triangle Park, (EPA-454/R-99-022), http://www.epa.gov/ttnamti1/files/ambient/pm25/network/r-99-022.pdf.

EPA99 U. S. Environmental Protection Agency, Office of Air and Radiation. 1999. Federal Guidance Report 13, *Cancer Risk Coefficients for*

Environmental Exposure to Radionuclides, Washington, DC, (EPA-402-R-99-001), http://www.epa.gov/radiation/docs/federal/402-r-00-001.pdf.

F&J11 F&J Specialty Products, http://www.fjspecialty.com/filtpap/it020008.htm, accessed August 9, 2011.

ICF05a ICF Consulting. *Summary of Selected Radiological Environmental Monitoring Activities*. 2005. Fairfax, VA, ICF Reference #: 095220.0.075.

ICF05b ICF Consulting. *Evaluation of EPA's Draft Local Siting Criteria for Fixed Monitoring Stations*. 2005. EPA, Contract GS-10F-0124J, ICF Consulting Technical Memorandum dated July 26, 2005, Fairfax, VA.

ICF05c ICF Consulting. *Summary and Analysis of Quality Control Measures in Selected Real-Time Monitoring Programs*. 2005. RE: DAG.095220.0.075, Fairfax, VA.

JOH07 Johnson, Stephen L., United States Environmental Protection Agency, Letter to Dr. Jill Lipoti, Science Advisory Board, September 12, 2007, Washington, DC.

KUR09 Kurzeja, Robert, Kuo-Fu Chen, et al., "National Siting Methodology for EPA's Fixed RadNet Air Network," Savannah River National Laboratory, WSRC-STI-2007-00548, January 8, 2009.

LRR05 Lovelace Respiratory Research Institute. Yung Sung Cheng, Ph.D., *Testing of Polyester Fiber Filters for the Collection Efficiency,* September 13, 2005.

MOR07 Morgan, M. Granger and Jill Lipoti, Science Advisory Board, Letter to Stephen L. Johnson, United States Environmental Protection Agency, July 2, 2007, Washington, DC.

NCR01 National Council on Radiation Protection and Measurements. 2001. Report No. 138, *Management of Terrorist Events Involving Radioactive Material*, (ISBN 0-929600-71-1).

NCR76 National Council on Radiation Protection and Measurements. 1976. Report No. 50, *Natural Background Radiation in the United States,* (ISBN 0-913392-27-8).

NIS01 National Institute of Standards and Technology. Special Publication 800-26, *Security Self-Assessment Guide for Information Technology Systems*, Washington, DC: U.S. Government Printing Office, 2001, http://csrc.nist.gov/publications/nistpubs/800-26/sp800-26.pdf.

NIS04 National Institute of Standards and Technology. Federal Information Processing Standards Publication 199, *Standards for Security Categorization of Federal Information and Information Systems*, Washington, DC: U.S Government Printing Office, 2004, http://csrc.nist.gov/publications/fips/fips199/FIPS-PUB-199-final.pdf.

NIS05 National Institute of Standards and Technology. Special Publication 800-53, *Recommended Security Controls for Federal Information Systems*, Washington, DC: U.S Government Printing Office, 2005, http://csrc.nist.gov/publications/nistpubs/800-53/SP800-53.pdf,

NIS98 National Institute of Standards and Technology. Special Publication 800-18, *Guide for Developing Security Plans for Information Technology Systems*, Washington, DC: U.S Government Printing Office, 1998. http://csrc.nist.gov/publications/nistpubs/800-18/Planguide.doc.

NRC95 U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research. 1995. *Accident Source Terms for Light-Water Nuclear Power Plants*, Washington, DC, (NUREG 1465).

SAL05 Salaymeh, Saleem, Raymond Dewberry, and Timothy Brown, "Minimum Detectable Activity for the EPA's Fixed RadNet Air Monitors," Savannah River National Laboratory, WSRC-TR-2005-00527, October 30, 2005.