Historical Uses of RadNet Data

United States
Environmental Protection Agency

Office of Radiation and Indoor Air
Radiation Protection Program (6608J)

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TECHNICAL REPORT ON

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U.S. Environmental Protection Agency
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1 Introduction

Purpose

The purpose of this report is to describe the significant historical uses of RadNet and its predecessor systems to monitor the environment for radiation, and how the data from these systems were used to better inform stakeholders and the public. The uses described here span a wide range, including:

- The original use of monitoring for fallout from atmospheric nuclear weapons tests,
- Monitoring of long-term ambient levels of both natural and anthropogenic (human-made) ionizing radiation,
- Monitoring of levels resulting from radiological incidents, and
- Other scientific studies.

This report provides an important context for stakeholders and the incident responder community who may access current and past data. The report also can act as a companion or "bridge" piece to recent descriptions of the ongoing expansion and upgrade for homeland security and related emergency uses for RadNet.

Overview, Not an Inventory

Because of the varied uses of RadNet data over the years, this report should be considered an overview and not a comprehensive inventory. The report focuses on actual uses that have been documented and were identified in a literature search and through discussions with selected individuals familiar with the given use. Also, because of the lack of specificity in some of the documentation of the uses described in this report, and the frequent use of multiple systems to draw conclusions about a given use, not all of the uses and conclusions described in this report can be attributed solely to RadNet monitors. These situations are highlighted as appropriate.

Sections

The remainder of this section provides an overview of RadNet and the predecessor systems, a brief description of the history of the monitoring of specific radionuclides, and a brief description of the routine sharing of RadNet data over the years. Section 2 describes the various categories of use for RadNet data, and Section 3 provides a summary and discussion of this report on significant historical uses of RadNet and its predecessor systems. Section 4 describes the current upgrade of the RadNet air monitoring system.

1.1 Overview of RadNet and Predecessor Systems

Evolution of RadNet

Prior to the formation of EPA, the Atomic Energy Commission (AEC), followed by the Public Health Service (PHS) of the Department of Health, Education, and Welfare (HEW) operated several networks to monitor the environment for radiation, including:

- The Radiation Alert Network (RAN),
- The Tritium Surveillance System (TSS),
- The Interstate Carrier Drinking Water Network, and
- The Pasteurized Milk Network (PMN).

In 1970, under Reorganization Plan No. 3, the responsibility for operating these systems was transferred to the Environmental Protection Agency (EPA). In 1973, EPA established the Environmental Radiation Ambient Monitoring System, or ERAMS, by consolidating the components of the existing radiation monitoring networks into one system (U.S. EPA 2000 and 2001b). In 2005 the name ERAMS was changed to RadNet, to reflect upgrades to the air monitoring portion of the system. Throughout this document, ERAMS and RadNet will be referred to as RadNet. Table 1 provides a timeline of RadNet and significant nuclear events.

Table 1. RadNet: Nuclear events timeline

Key[a]	**= Original radiation monitoring program**	**= Major program and/or name change**
	= Event with potential for increase in radioactivity	**= Enhancement of ERAMS sampling or reporting**
	= Event with potential for decrease in radioactivity	**= Termination of ERAMS component**

Year	Milestone
1945-1955	**Approximately 80 above ground nuclear blasts** are conducted during this period by the U.S., the Soviet Union, and Great Britain.
1956	**Radiation Alert Network (RAN)** is established to provide an early alert for radiation fallout in air and deposition. When incorporated into RadNet (ERAMS) in 1973, RAN consisted of 68 sampling stations distributed across the United States.
1957	**Windscale (Great Britain) nuclear reactor**--a fire results in a limited off-site release of radioactivity (Level 5, based on the International Nuclear Event Scale, or INES).
	Kyshtym (Soviet Union) reprocessing plant--an explosion results in a significant off-site release of radioactivity (INES Level 6).

1956-1958	**Approximately 180 above ground nuclear blasts** are conducted during this period by the U.S., the Soviet Union, and Great Britain.
1958	**Great Britain conducts its last** above ground nuclear blast.
1959	**Executive Order 10831 and Public Law 86-373** issued, providing the legal basis for additional programs that eventually led to RadNet (ERAMS). The Department of Health, Education, and Welfare (HEW) is given the responsibility for radioactive fallout and environmental radiation monitoring under these legal mandates.
1961-1962	**Approximately 100 above ground nuclear blasts** are conducted during this period by the U.S. and Soviet Union.
1963	**The U.S. and Soviet Union cease conducting above ground nuclear blasts**, prompted in part by the Cuban Missile Crisis and subsequent Limited Test Ban Treaty prohibiting underwater, atmospheric, and outer space nuclear blasts.
1964	**Tritium Surveillance System (TSS)** is established to monitor precipitation and tritium concentrations in major river systems downstream of selected nuclear facilities. When incorporated into ERAMS in 1973, TSS consisted of 8 monitoring stations.
	People's Republic of China conducts its first above ground nuclear blast. This is the only above ground blast reported for any country this year.
1965-1967	**Nine above ground nuclear blasts** are conducted during this period by France and the People's Republic of China.
1967	**TSS expanded** to include drinking water and an expanded network of surface water stations. The TSS consisted of 68 drinking water sampling stations and 39 surface water stations before being incorporated into RadNet (ERAMS).
1968-1970	**Three above ground nuclear blasts** are conducted during this period by the People's Republic of China.
1970	**Radiation monitoring responsibilities transferred** from HEW to EPA based on Reorganization Plan No. 3.
1971-1973	**Seventeen above ground nuclear blasts** are conducted during this period by France and the People's Republic of China.
1973	**ERAMS established** by consolidation of several existing monitoring networks. ERAMS renamed RadNet in 2005.
1974	**Seven above ground nuclear blasts** are conducted during this period by France and the People's Republic of China.
1974	**France conducts** its last above ground nuclear blast
1975	**RadNet data begins being reported as summary data in quarterly environmental Radiation Data (ERD) reports.**

1976-1978	**Six above ground nuclear blasts** are conducted during this period by the People's Republic of China. (RadNet Alert Status)
1978	**Analysis of krypton (Kr) in air** is terminated.
1979	**Electronic recording of RadNet data** begins with the inclusion of individual sample analytical results in the RadNet Laboratory Information Management System (LIMS).
	Three Mile Island (U.S.) nuclear power plant--a cooling malfunction causes part of the core to melt in a reactor, resulting in a limited off-site release of radioactivity (INES Level 5). (RadNet Alert Status)
	Analysis of tritium (H-3) in milk is terminated.
1980	**One above ground nuclear blast** is conducted during this period by the People's Republic of China. (RadNet Alert Status)
	The People's Republic of China conducts its last above ground nuclear blast.
	Saint-Laurent (France) nuclear power plant--a fuel rupture results in a minor off-site release of radioactivity (INES Level 4).
1982	**Analysis of uranium (U) and iodine (I) in drinking water** is initiated.
1985	**Analysis of plutonium (Pu) in milk** is terminated.
1986	**Chernobyl (Soviet Union) nuclear power plant**--an explosion and fire causes a major off-site release of radioactivity (INES Level 7). (ERAMS Alert Status)
1987	**Analysis of carbon-14 (C-14) in milk** is terminated.
1996	**Analysis of U and Pu in precipitation** is terminated.
1999	**Surface water sampling** is terminated (to avoid redundancy with state sampling programs around nuclear facilities).
	Tokaimura (Japan) nuclear fuel processing facility--a criticality accident results in a minor off-site release of radioactivity (INES Level 4). (RadNet Alert Status)
2000	**Wildfires** threaten the Los Alamos National Laboratory in New Mexico. RadNet provides regional and national data to compare to samples taken in response to the fires. (RadNet Semi-alert Status)
	Wildfires scorch 200,000 acres of Hanford nuclear reservation in Washington State. ERAMS provides regional and national data to compare to samples taken in response to the fires. (RadNet Semi-alert Status)
2001	**Terrorist attacks on September 11 (U.S.)**--airliners flown into the World Trade Center and Pentagon. RadNet provides regional and national data to compare to samples taken in response to the attacks. (RadNet Alert Status)
2002	**Sample-specific ERAMS** data becomes available on the EPA web.

2005	**Major upgrade begins to real-time air monitors, additional air monitoring locations, and deployable monitors**.
	ERAMS renamed RadNet to reflect new mission.

[a]Color-coded key—must be viewed with a color monitor or by printing in color.

[b]All nuclear blast data obtained from Oklahoma Geological Survey Observatory, Catalog of Nuclear Explosions (last modified July 14, 1998; last accessed April 6, 2002 from www.okgeosurvey1.gov/level2/nuke.cat.html).

[c]All nuclear accident/incident data obtained from International Atomic Energy Agency (IAEA), INES Factsheet (last accessed April 10, 2002 from www.iaea.or.at/worldatom/Periodicals/Factsheets/index.shtml).

[d]The various additions and terminations of nuclide sampling and analysis indicated from this point forward are only a sample of the many changes that have taken place over the 30+ history of RadNet. Refer to the actual data and the Envirofacts/RadNet User's Guide at www.epa.gov/enviro/html/erams/ for more detail regarding these changes.

RadNet Objectives

RadNet is the nation's most comprehensive means of acquiring and analyzing environmental radiation data. For nearly half a century, RadNet and its predecessor systems have monitored the nation's air, drinking water, precipitation, pasteurized milk, and, on occasion, other media for environmental levels of radiation. The objectives of RadNet are to provide a means of estimating ambient levels of radioactive pollutants in our environment, to follow trends in environmental radioactivity levels, and to detect and assess the impact of fallout and other intrusions of radioactive materials. During the years since RadNet began, it has developed an important environmental radiation database containing over 30 years of data.

RadNet Monitoring System

RadNet is a continuous monitoring system that operates in either an emergency or routine mode. Samples are collected and analyzed on established schedules during routine conditions, producing data that can be used to perform baseline and trend analyses of radioactivity in the environment. During emergency conditions, the sampling schedule is accelerated to daily sampling and the data are used to determine the immediate and long-term environmental and public health impacts. Current routine sample type and frequency are generally as follows:

- Air particulate samples are collected twice weekly;
- Precipitation samples are collected after each measurable rainfall;
- Drinking water samples are collected quarterly; and
- Pasteurized milk samples are collected quarterly.

1.2 Overview of the Monitoring of Specific Radionuclides

Routine Sampling and Analysis

Since the inception of RadNet, the nation's air, precipitation, drinking water, and milk have been sampled on a routine basis, and sent to EPA's National Air and Radiation Environmental Laboratory (NAREL) for analysis. To ensure that the data generated at NAREL are of known quality, a Quality Assurance Project Plan (QAPP) is followed during all phases of sample collection and analysis activities.

Air Sampling

The RadNet Air Program historically consisted of 59 sampling locations. Continuously operating samplers collect airborne particulates on filters that are sent twice weekly to NAREL for analysis. A gross beta analysis is performed on each air filter, and a gamma scan is done if the beta activity is greater than one picocurie (1 pCi) per cubic meter. Annual composites of the air particulates filters are analyzed for plutonium (Pu-238, 239/240) and uranium (U-234, 235, and 238).

This air sampling process is changing as the upgrades to the RadNet air monitoring program are being implemented. The upgraded RadNet air monitors, currently being placed, will also provide near real-time radiation levels.

Water Sampling

The RadNet Drinking Water Program obtains quarterly drinking water samples from 78 sites, primarily located in major population centers. The samples are analyzed for tritium (H-3) quarterly, for gross alpha and beta on annual composite samples from each station, for iodine-131 (I-131) on one sample per year from each station, and for strontium-90 (Sr-90) on one-fourth of all the individual station annual composite samples. All of the annual composite samples are also analyzed by gamma spectrometry. Analyses for radium-226 (Ra-226), plutonium (Pu-238, 239/240), and uranium (U-234, 235, and 238) are performed if a sample shows elevated gross alpha radioactivity. If the Ra-226 result is between 3 and 5 picocuries (pCi) per liter, then a Ra-228 analysis is performed.

Milk Sampling

The RadNet Pasteurized Milk Program consists of 55 sampling locations that represent a significant portion of the milk consumed in major population centers in the U.S. Milk is sampled because it is a readily available food source consumed by a large portion of the population; because it is consumed by children in relatively large quantities, which provides a good indication of children's exposure to nuclear events; and, finally, because it is a good indicator of radionuclides present in the environment.

Primary functions of the milk sampling program are to obtain reliable monitoring data about current radionuclide concentrations and to monitor long-term trends. The quarterly samples are analyzed by gamma spectrometry, looking for fission products such as I-131, barium-140 (Ba-140), and cesium-137 (Cs-137), which could become present in the event of a nuclear accident. On a less frequent schedule, Sr-90 is determined.

Precipitation Sampling

The RadNet Precipitation Program consists of sampling stations at 41 locations. All stations routinely submit precipitation samples as rainfall, snow, or sleet occurs. The precipitation samples are composited at NAREL into single monthly samples for each station. Each month that precipitation occurs, a portion of each monthly precipitation sample is analyzed for H-3, gross beta, and gamma emitting nuclides.

RadNet Radiochemistry Changes

The radiochemistry of RadNet has changed significantly over time, in part because of advances in technology, but also because of changes in the mission of RadNet and the types of radiation and nuclides in or potentially released to the environment. Changes currently being implemented are focused on the Air Program and include using real-time monitors, expanding the air monitoring system, and creating a new deployable monitoring system.

1.3 Data Sharing

Frequency

Prior to the formation of RadNet by EPA, radiation data had been provided to the public through monthly or quarterly reports. Monthly reports called *Radiological Health Data* were originally published by the AEC starting in November 1960, and were followed by *Radiation Data and Reports* published by HEW.

Since 1973, EPA has published quarterly reports called *Environmental Radiation Data* reports (ERD's), with air, precipitation, drinking water, and milk concentrations. Combined, these data provide a wide base of information from which numerous important studies on the health and environmental effects of radiation have been completed.

Distribution

Historically, the ERD's were widely distributed by NAREL. From 1973 to 1995, 400-500 copies of the ERD's were mailed quarterly to EPA Regional Radiation Programs, State volunteer station operators, members of the Conference of Radiation Control Program Directors (CRCPD), other Federal Agencies, and, if requested, universities, scientific researchers, and the general public (Petko, 2006). From 1993 to present, the ERDs have been published online (www.epa.gov/narel/radnet/erdonline.html).

In 2001, a RadNet searchable database became available online at www.epa.gov/enviro/html/erams/. It contains 23 years of environmental radiation monitoring data from all 50 states and U.S. territories and 40 years of measurements of strontium in milk.

2 Categories of Use for RadNet Data

The radiation monitoring data that have been collected from RadNet and its predecessor systems have been used in several different ways. These have provided numerous benefits to the users, including identifying impacted vs. non-impacted areas, comparing pre- and post-event concentrations and risks, adjusting model parameters and verifying outputs, and using the information to provide updates and recommendations to Federal and State officials and the public when elevated levels of radiation are released to the environment. The uses for the data can be categorized into five main areas:

1. Fallout monitoring for nuclear weapons and other tests
2. Releases from major nuclear accidents
3. Releases from smaller radiological events

4. Background levels and trends
5. Other uses

Key examples of these uses were collected, reviewed, and analyzed for this report in order to gain and convey a broader understanding of the significant historical uses and benefits of the data. In this section, examples are provided within these five main categories, and selected uses are highlighted.

2.1 Fallout Monitoring for Nuclear Weapons and Other Tests

The monitoring systems that preceded RadNet were designed to monitor fallout from nuclear weapons tests. Responsibility for these monitoring systems was transferred to EPA when it was formed in 1970. By that time, the Nuclear Weapons Test Ban Treaty had been signed (1963) and aboveground nuclear weapons testing had ceased in all countries except China and France, who conducted atmospheric tests into the mid to late '70s. However, other types of nuclear testing, including underground tests, continued in the U.S. and worldwide.

Figure 1. Detonation at the Nevada proving grounds. *(Photo courtesy of U.S. Department of Energy, Nevada Operations Office.)*

Thus, there was continued need for radiation monitoring associated with radioactive fallout from these tests as well. The following discussion describes the testing and the long-term studies that ensued. It is organized by two major timeframes: (1) U.S. and foreign high-yield weapons and other tests (RadNet's predecessor systems, monitored by HEW) and (2) annual radiological monitoring following termination of atmospheric testing (the current RadNet).

2.1.1 RadNet's Predecessor Radiation Monitoring Systems, 1951-1973

Aboveground tests for nuclear weapons (such as the one shown in Figure 1) resulted in the creation and dispersion of substantial amounts of radioactivity into the environment. As shown by the red bars in Figure 2, representing estimates of annual nuclear blast yields in megatons, the U.S. and other foreign powers conducted hundreds of high-yield, aboveground weapons tests from the 1940s through 1960s. And as shown by the blue line in Figure 2, representing levels of Sr-90 (a human-made radionuclide) in milk, substantial amounts of radioactivity were released to the environment; some of this radioactivity remains today.

The various systems that preceded RadNet (and EPA for the most part) were the predominant means for monitoring near-term fallout from nuclear weapons and other tests. The following examples illustrate how these systems were used during this period.

Iodine-131 in Pasteurized Milk

In 1964, List et.al. conducted a study of the possible sources of radioiodine in milk in the midwestern states, using results from the Pasteurized Milk Network. This study used results from the May and early June 1962 milk samples. The results indicated that the 1962 atmospheric testing at Christmas Island was the principal contributor of significant concentrations of I-131 in milk (exceeding 300 picocuries per liter), and that underground testing at Nevada played only a minor role during this period.

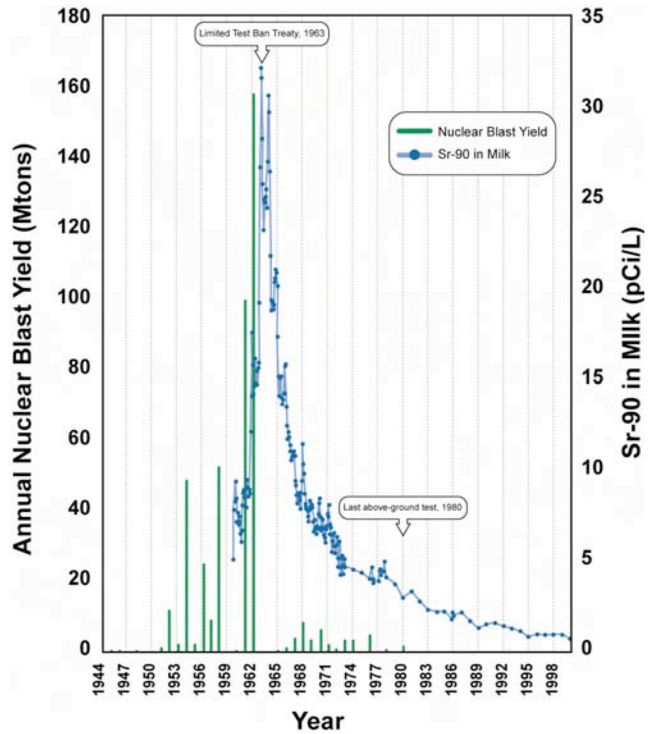

***Figure 2. Nuclear blast yields and concentrations of Strontium 90 in milk.** (www.epa.gov/radiation/rert/nuclear_blast.html; see pages 6 and 9 in this document.)*

Elevated Cs-137 Concentrations in Milk, Tampa, Florida

In the 1960's, Cs-137 concentrations in milk samples in the Tampa area were found to be elevated; they were the highest in the Pasteurized Milk Network. The Florida State Board of Health reported similar results throughout Florida. In contrast, Sr-90 concentrations in Tampa milk were similar to those in other southern states and were below the national average. In order to determine the source of the elevated Cs-137, a study was conducted of additional samples of the milk and feed for the cows in the Tampa area. The study concluded that pangola hay, a feed component that is native to Florida, had high Cs-137 content and thus was responsible for the high Cs-137 content of the milk (Porter et. al. 1966). These elevated levels were likely a product of general atmospheric fallout. However, the amount of Cs-137 in two liters of Tampa milk per day is small compared to the intake of 4,000 pCi per day on which the Maximum Permissible Concentrations are based by the International Commission on Radiological Protection (ICRP). (S. Telofski, 2006).

Localization of Fallout in United States from May 1966 Chinese Nuclear Test

Samples from the Pasteurized Milk Network following the Chinese nuclear weapon test on May 9, 1966, showed that the heaviest concentration of fallout in the United States occurred in the state of Arkansas. This was believed to be due to heavy rainfall in the Mississippi Valley during the time the plume of radioactivity was passing over the United States. As a result of these findings, an expanded milk sampling program was initiated in Arkansas, where disappearance half-times for fission products in milk were found to be 4.1 days for I-131, 4.6 days for Ba-140, and 4.9 days for Sr-89 (Strong et.al, 1967).

Department of Health and Human Services (HHS): Report on the Feasibility of a Study of the Health Consequences to the American Population from Nuclear Weapons Tests

One of the most recent and important examples of RadNet data use, related to high-yield weapons and other tests prior to the mid '60s, is the 2005 report by the Centers for Disease Control and Prevention (CDC) and the National Cancer Institute (NCI). In 1998 the Senate Appropriations Committee requested HHS to conduct an initial assessment of the feasibility and public health implications to the American population from radioactive fallout from nuclear weapons testing. In response, two HHS Agencies—CDC and NCI—made estimates of doses and health risks from exposure to radioactive fallout using data collected from 1951 to 1962. Their very rough estimates were based on data collected by several radiation monitoring systems, including RadNet's predecessor systems, other large organizations, and some additional calculations (CDC/NCI 2005).

This report summarized the public health implications of the nuclear weapons tests, using RadNet and other radiation data to determine the dose to the U.S. population from high-yield weapons tests conducted from 1951 through 1962 at the Nevada Test Site and other sites throughout the world. Deposition density estimates were developed for a number of radionuclides for each of the approximately 3,000 counties within the contiguous United States. These estimates of radionuclide deposition density were based on the I-131 deposition densities reported previously by NCI, which in turn were based primarily on measurements made at the time of fallout and reported from the gummed-film network operated by the AEC.

Because the measurement sites were few compared to the large number of counties, and because the deposition in each county is so highly influenced by the occurrence of rainfall, the measurements were extended to other nearby locations through mathematical interpolation procedures and, in some cases, atmospheric dispersion and deposition modeling. These doses were then compared to estimates provided by others, as well as to other RadNet measurements. For example, radionuclide concentrations in milk used RadNet data to validate the modeling as seen in Table 2. That is, doses from milk concentration were calculated using the measured daily average concentration of radionuclides in milk from the 62 stations in the Pasteurized Milk Network (now part of RadNet) and were compared to the estimated doses modeled using concentrations of global fallout radionuclides. The authors of the CDC/NCI report concluded that this comparison was satisfactory and that there are no gross errors in the modeling process.

Table 2. Measured compared to modeled doses

Time period	Effective dose to adults, μSv					
	From milk concentration			From modeling		
	^{90}Sr	^{131}I	^{137}Cs	^{90}Sr	^{131}I	^{137}Cs
1960	1.3	0	0.74	0.81	0	3.0
1961	1.3	2.5	0.74	0.84	1.2	3.6
1962	2.1	4.0	3.3	4.4	6.8	17
1963, first quarter	0.64	<0.31	1.3	0.69	0.034	0.48

Source: CDC/NCI 2005

The findings demonstrate that conducting a detailed study of the health impacts on the American people as a result of exposure to radioactive fallout from the testing of nuclear weapons in the United States and abroad is technically possible. Significant resources would be required to implement this detailed study, however, and careful consideration should be given to public health priorities before this path is taken (CDC/NCI 2005, Executive Summary).

CDC/NCI devoted an entire appendix to current and potential future activities for identifying and protecting existing data archives in order to facilitate any future scientific work. They identify a concern that other organizations— including PHS— that conducted their own research or measurements programs, may still have documents that are not covered by a moratorium and could be destroyed at anytime. These documents should be copied and catalogued as soon as possible. A possible future action identified in the report was to locate the PHS gummed film and milk data. (CDC/NCI 2005)

Other Scientific Studies

These data from earlier monitoring systems have been used to support numerous scientific studies. For example, several articles have been published in *Health Physics* that use data to assess fallout; much of May 2002, Vol. 82, Issue 5 is devoted to assessing fallout from weapons testing. Some of these reports included the use of data from RadNet predecessor systems, e.g., "Historical overview of atmospheric nuclear weapons testing and estimates of fallout in the continental United States" (Beck and Bennett 2002).

2.1.2 Early RadNet Data, 1974-1980

This second timeframe begins with the creation of ERAMS (now RadNet) by EPA in 1973 and ends with the final aboveground nuclear test in 1980.

Fallout in the U.S. from Atmospheric Nuclear Testing by the People's Republic of China

Another example of RadNet data use related to high-yield weapons and other tests is seen with the 40 above-ground tests conducted by China and France from 1964 to 1980, after other countries had ceased such testing. France conducted its last aboveground test in 1974, and China stopped in 1980. RadNet continued to monitor ambient radiation during all of these tests.

To assess environmental radiation contributions from some of the largest of these tests, conducted by China in 1976 and 1977, EPA produced two key reports using RadNet data, "EPA Assessment of Fallout in the United States from Atmospheric Nuclear Testing on September 26 and November 17, 1976 by the People's Republic of China" and "Assessment of Fallout in the United States from the Atmospheric Nuclear Test by the People's Republic of China on September 17, 1977" (U.S. EPA 1977a, U.S. EPA 1982). Because these tests were conducted above ground, the radioactive material was expected to move in an easterly direction towards the United States. The Energy Research and Development Administration informed EPA and the public of the upcoming tests and EPA prepared by notifying states and the RadNet air particulate and precipitation sampling stations to increase the sampling (EPA 1977a).

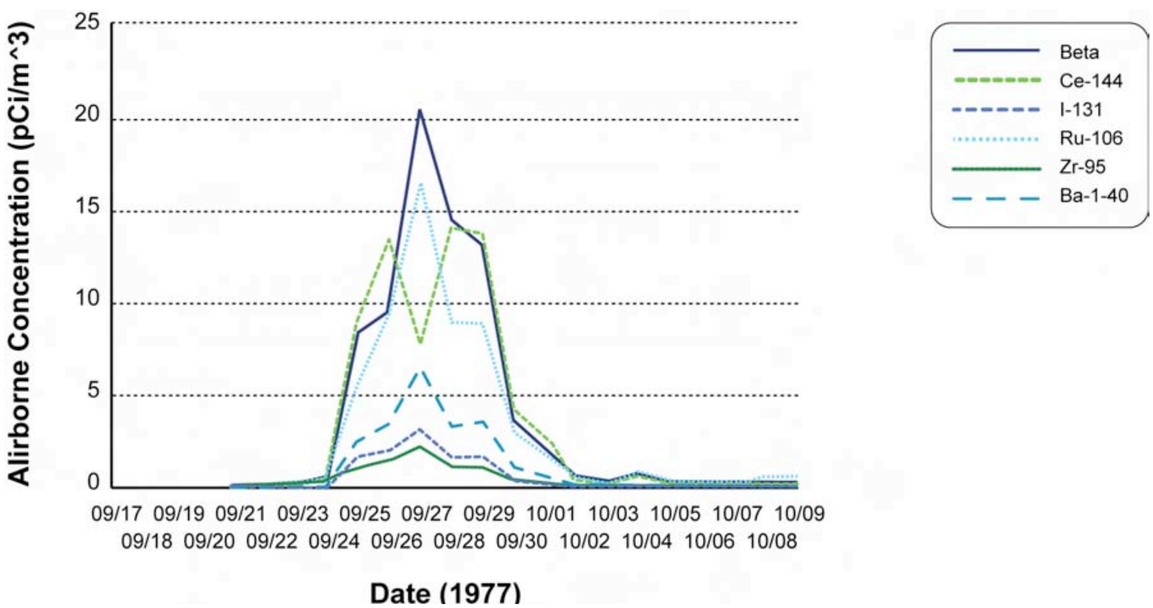

Figure 3. RadNet gamma spectrometry data for Denver, CO following Chinese nuclear testing on September 17, 1977.
(U.S. EPA 2005)

Some of the results for Denver, Colorado, are shown in Figure 3. Once measurements determined if any areas were impacted by the tests, EPA calculated U.S. population doses using levels of radioactivity measured by RadNet for air particulates, precipitation, and pasteurized milk. Radiation dose assessments, including those for commercial aircraft exposure, and their projected health effects are discussed in the reports. For example, EPA estimated that the Chinese 1977 test might result in about 17 cancers and 10 deaths in the U.S. during the subsequent 45 years.

I-131 in Milk

Smith et al. (1978) used RadNet data to estimate risks from I-131 in milk from the 1976 Chinese Tests. They noted that the four excess thyroid cancers they estimated would occur during the subsequent 45 years would be masked by the 380,000 cases of thyroid cancer expected to occur in the U.S. from all causes during the same interval.

2.2 Releases from Major Nuclear Accidents

The second major category for which RadNet data have been used is major nuclear accidents. Following the aboveground nuclear weapon testing era, the RadNet system responded to two high profile nuclear reactor accidents. The first was the Three Mile Island accident in 1979 and the second was the Chernobyl accident in 1986. RadNet proved to be invaluable in the aftermath of these accidents by providing comprehensive radiation monitoring data. This information was used to provide public assurance and to help make decisions on whether actions to reduce or prevent the public's exposure to radiation were needed. The following describe these incidents in more detail.

2.2.1 Three Mile Island

For three days beginning on March 28, 1979, a series of mechanical, electrical, and human failures led to a partial meltdown of the reactor core at the Three Mile Island Nuclear Power Plant (TMI) in Pennsylvania. The air monitoring network had an air particle detector in Harrisburg, Pennsylvania, which is very close to TMI. This monitor could have detected increased particulates had they been transported from TMI to Harrisburg, but had no capability to detect radioactive gas releases. No noticeable increases in beta levels were noted.

Within three days, EPA had stationed experts with additional radiation monitoring equipment around the power plant to assess the potential for radiation exposure to people living around the plant. EPA's radiation monitoring and assessment activities supported information collected by other organizations to assure the public that the release of radioactive material was minimal, and there was no significant threat to public health. Although some radioactive gases did escape to the atmosphere during the TMI incident, the estimated average dose to area residents was far less than levels that would require protective action. For instance, the exposure was one-sixth of what a person receives from a full set of chest x-rays, one one-hundredth of the natural radioactive background dose for the area, and one-third the dose (for I-131) that the same people in the area received from the Chernobyl accident via atmospheric transport from Ukraine (see EPA's website at www.epa.gov/radiation/rert/tmi.html).

Initially EPA was a "quiet partner" in the Federal presence at TMI, with monitoring and other information reaching the public through the Nuclear Regulatory Commission, Metropolitan Edison, and the Pennsylvania Department of Environmental Resources (U.S. EPA 1980). EPA continued to support the federal effort to characterize radioactive releases after the accident, assuming responsibility for off-site environmental monitoring and analysis for eight years. EPA transferred this activity to the Commonwealth of Pennsylvania in 1989 (www.epa.gov/radiation/rert/tmi.html).

2.2.2 Chernobyl

On April 26, 1986, Unit 4 of the nuclear power plant at Chernobyl in the former USSR (now Ukraine) exploded, exposing the reactor core and emitting large quantities of radioactive material into the atmosphere. Although the radioactive cloud initially contained a large number of different fission products and actinides, these radionuclides were contained in larger and heavier particulates that deposited closer to the accident site, where 31 people died. In anticipation of a high altitude plume over the U.S. during the first few days of May, EPA augmented its environmental radiation sample collection.

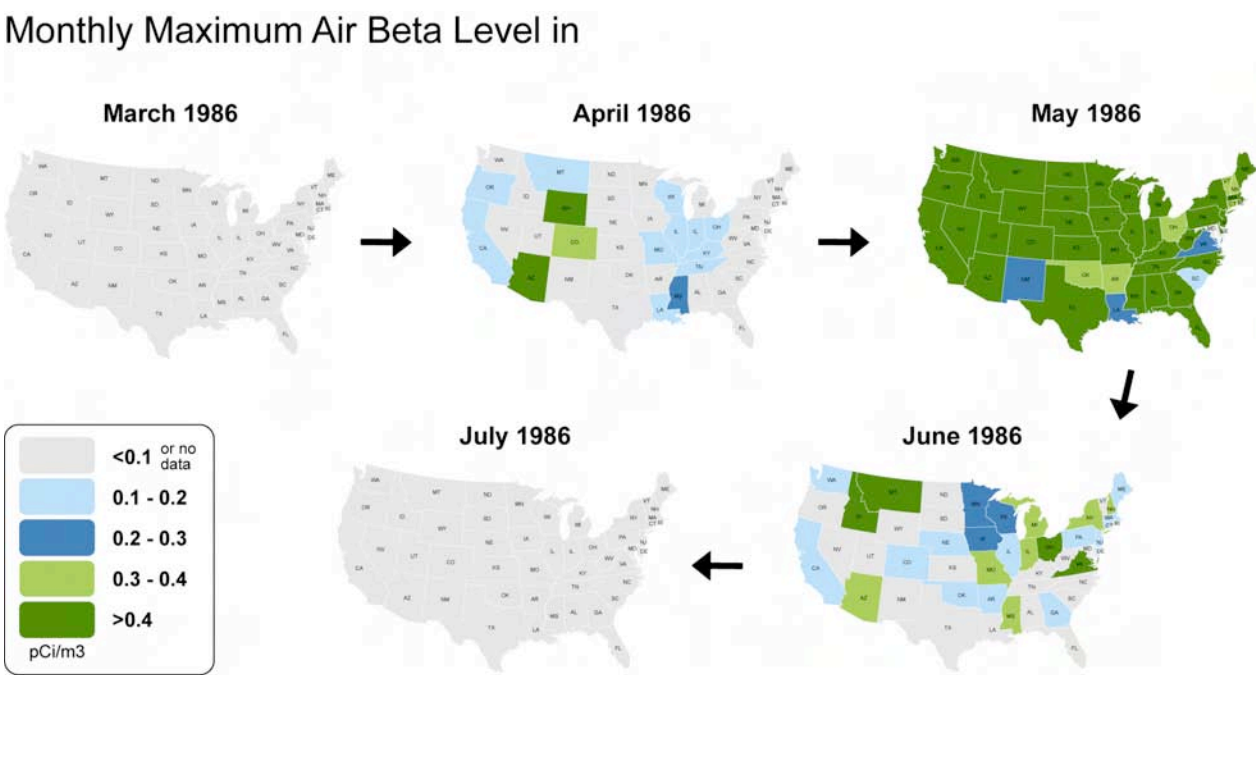

Figure 4. Path and timeframe of the Chernobyl plume across the United States (monthly maximum air beta levels).
See www.epa.gov/radiation/rert/chernobyl.html for an animated version of this graphic.

Air particulate stations were requested to increase the sampling frequency from the usual twice weekly to daily, and milk sampling stations collected at the rate of twice per week instead of once per month.

By the time the plume crossed the western border of the United States, fallout was primarily attributed to rainfall, which transfers airborne radionuclides to the ground. Consequently, changing meteorological patterns at the time of the accident resulted in varied deposition across the U.S. RadNet first detected radionuclides in precipitation and surface air particulates from samples collected in Portland, Oregon, and Olympia, Washington, one week following the accident. Radioactivity was subsequently measured in precipitation samples collected at Bismarck, North Dakota, and Idaho Falls, Idaho. While radiation levels were well above detection limits, as seen in Figure 4, they were well below levels requiring protective action.

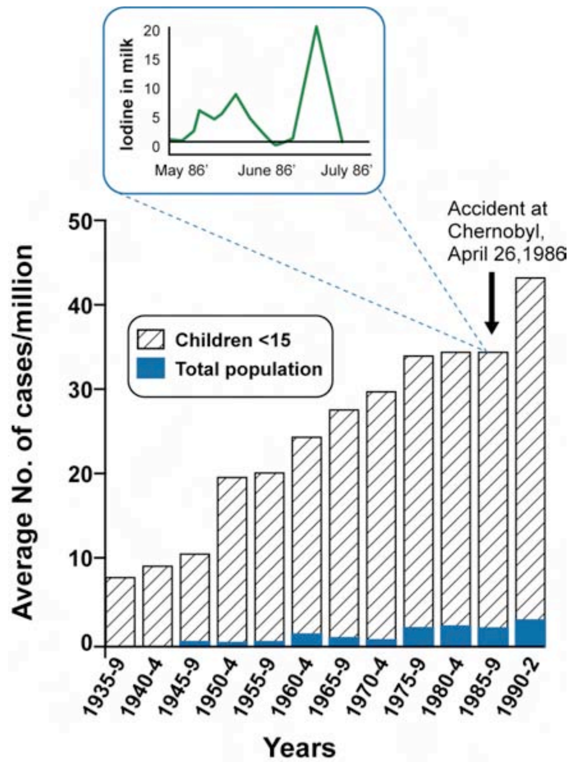

Figure 5. Number of cases of thyroid cancer per million children aged under 15 and age adjusted rate per million population in Connecticut, 1935-92, and concentration of iodine-131 in milk in Connecticut *(Reid and Mangano 1995).*

The White House designated EPA as the leader in coordinating the U.S. response to this global emergency. EPA's radiation monitoring and assessment activities helped provide the information needed to assure the nation that radiation levels in the United States remained below levels requiring protective actions.

During the next few weeks, radioactive clouds from Chernobyl spread slowly westward (U.S. EPA 1986). RadNet—augmented by reports from Department of Energy (DOE) national labs, the military, U.S. diplomatic missions abroad, and commercial nuclear power plants—provided daily radiation measurements based on samples from hundreds of monitoring posts in the United States and abroad.

Americans remained concerned about possible adverse health effects in the U.S. EPA established a group, chaired by HHS, to provide advice on preventing contamination of the food supply and protecting public health. EPA also established an Information Center to assemble, coordinate, and disseminate information to the public. Through the Information Center, EPA organized daily press conferences to keep the public up-to-date and to address their concerns.

Subsequent studies using RadNet data tracked both the short- and long-term health effects from the incident. For example, Reid and Mangano (1995) analyzed the potential link between exposure to radioactive fallout from Chernobyl and rising rates of thyroid cancer in Connecticut, approximately 7,250 km west of the reactor. The authors tracked the concentration of iodine-131 in Connecticut's milk, which showed an increase about 15 days after the incident, to determine if there were any effects from the fallout from Chernobyl. They noted that the rate of thyroid cancer among children aged under 15 in Connecticut rose sharply (from 1.6 to 3.1 per million) after 1989 (see Figure 5), when increased rates in children in the area around Chernobyl began.

The authors also noted an apparent five year lag between exposure to radioactive fallout from Chernobyl and rising rates of thyroid cancer. In contrast, lag times have been reported to be up to 40 years for iatrogenic thyroid cancer due to irradiation. Thus, they argued, continued tracking of rates may show a progressive rise in thyroid cancer attributable to fallout of a variety of iodine and other high energy nuclides from Chernobyl, and that it seems prudent to examine further the long-term effects, in particular thyroid cancer, on populations distant from Chernobyl.

In another study, Broadway et al. (1988) used RadNet data to estimate both individual and collective doses received by the U.S. population following the Chernobyl accident, including first measured in precipitation and surface air particulates at Portland, Oregon, and Olympia, Washington, on May 5, 1986. These authors estimated three excess lung cancer deaths and an additional four deaths due to cancers of thyroid, breast, and leukemia in the U.S. population over the subsequent 45 years from exposure during the May-June 1986 interval.

Air monitoring for radiation from an atmospheric release from the nuclear accident at Chernobyl highlighted the need for increased radiation monitoring coverage across the U.S. Air monitoring during this accident required good national coverage, as the most elevated levels are more likely to be found in the area of a rain event rather than the first place the air plume may cross the border of the U.S. The upgraded RadNet includes up to 180 fixed radiation monitoring stations to insure major population areas and large geographic areas are adequately covered. The near real-time monitoring capabilities of these new stations also provide data quickly to decision makers on levels of radiation in the environment

2.3 Releases from Smaller Radiological Incidents

In the late 1990s and early 2000s, several smaller incidents occurred which the RadNet air monitoring network was not well designed to monitor. These incidents included an accident at a nuclear fuel processing facility in Japan, a wildfire incident in the U.S., and several satellite launches and reentries. The following describe these events in more detail.

2.3.1 Tokaimura Facility Accident in Japan

In September 1999, employees at a uranium conversion plant in the village of Tokaimura, Japan, accidentally triggered an uncontrolled nuclear reaction which was sustained for 17-20 hours (U.S. NRC 2000). The mishap released radiation to the surrounding area and into the atmosphere. Two employees died and many others were exposed to elevated levels of radiation. Very few particulates are believed to have escaped the containment building, but some contaminated radioactive gases may have been released to the environment.

The low volume of gas releases and the prevailing wind pattern led to the belief that there would not be a significant effect on the United States. However, for confirmatory purposes, RadNet was placed in emergency operation mode. This increase in sampling was reported by EPA and several other groups (U.S. EPA 2005, PA DEP 1999, TDOH 2003/4, Lochner 1999). The system did not detect elevated levels of human-made radionuclides.

Detection of an atmospheric release of radioactive gases was not part of the historic mission of RadNet. The accident at Tokaimura underscored that RadNet was not designed to detect these gases. EPA re-evaluated the need for this type of monitoring. One of the recent upgrades to the RadNet air monitoring system includes a sodium iodide detector that may be able to detect radioactive gases. Also, the gamma spectra may be downloaded and analyzed to determine if radioactive gases are present.

2.3.2 Wildfires

Other events, potentially involving radiation releases to the environment, were wildfires at radiation-related sites, one near DOE's Los Alamos National Laboratory (LANL) in New Mexico and the other near DOE's Hanford Reservation in Washington State. Both fires were widely publicized and resulted in significant public concern about radioactivity. Some states and other entities provided significant outreach, including the development of websites that posted monitoring data (e.g., see Figure 6).

Figure 6. Example of state outreach website that displays monitoring data and analysis on the wildfires of 2000. *(Washington State Department of Health (WSDOH), 2000)*

The first of these two wildfires occurred in May 2000 when the National Park Service (NPS) lost control of a prescribed burn in northwestern New Mexico. The fire became known as the Cerro Grande fire and is reported to have eventually burned nearly a third of LANL's 43 square miles (LANL, undated). Although RadNet was not activated, portable air monitors were deployed by the EPA Radiological Emergency Response Team (RERT) at the request of EPA Region 6.

The second fire incident occurred on June 27, 2000. The fire started after an automobile accident, spread to part of the Hanford Reservation in eastern Washington State, and burned approximately half of the site's 560 square miles (U.S. EPA 2005, Feder 2000). Hanford is one of the nation's most contaminated nuclear sites. Air samples were taken on a total of 24 locations around the Hanford facility, including populated areas immediately adjacent to the facility and up to 80 miles away, and on tribal lands (WSDOH 2000). The results of these samples were compared to regional and national results from the RadNet program to determine if abnormal radiation levels exist (U.S. EPA 2006). Based on the preliminary screening analyses from the RadNet system, no radiation levels above background were found in any samples of gamma spectrometry and gross alpha/beta count, which was similar to the initial offsite results obtained by DOE monitoring (WSDOH 2000).

The Value of Zeroes

An important consideration of long-term trends, ambient background, and even of post-incident reporting is the "value of zeroes." That is, many—and often most—monitoring results are zeroes. (Technically, such results are more appropriately called "non-detects" because they simply are below a given reporting threshold and thus are not necessarily zero. Indeed, for risk assessment purposes, nondetects often are assigned the value of ½ the reporting threshold.) Zeroes as results, however, can be extremely valuable because they mean that the safety programs are effective, that people are working according to procedures, and that systems are working efficiently. Furthermore, in the event of a release, zeroes can provide important information about a plume's path and strength.

Exhibit 1. *The Value of Zeroes*

Based on more specific analyses conducted during the Hanford fire, several radioactive materials were detected at concentrations above typical background levels in the air near the Hanford site measured via RadNet, including plutonium, strontium-90, and gross alpha and beta (U.S. DOE 2001). Analyses showed elevated levels of plutonium associated with five of the air filters onsite (including samples from Pasco and Richland), and uranium-238 associated with four locations onsite and offsite (WSDOH 2000, U.S. DOE 2001). Elevated levels of plutonium contamination in air were measured; however, officials from the State Health Department noted that the radioactive materials were below the threshold deemed hazardous to human health and below levels that would have triggered an emergency response based on EPA's protective action guides for emergency situations. These results were also within or below the EPA National Emission Standards for Hazardous Air Pollutants (NESHAP) dose limits and limits set by the State of Washington (WSDOH 2000).

In the later stages of the Hanford fire, uranium was not detected above background levels. Five offsite samples did show elevated levels of plutonium that were attributed to suspected ash and/or dust from the site (U.S. DOE 2001). About three weeks after the fire, elevated plutonium levels were found in some air samples measured in and around Hanford, also likely due to radioactive dust being blown around the site in the wind (Easthouse 2000). The fire was widely publicized and resulted in significant public concern about radioactivity. Some states and other entities provided significant outreach, including the development of websites that posted monitoring data (e.g., see Figure 6).

In summary, the fire incidents data were used to help identify impacted and non-impacted areas, reassure citizens and decision makers, compare pre- and post-event concentrations and risks, and provide state and other systems with comparison data for verification or other purposes.

These fires once again highlighted the concern 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 in to cover gaps (U.S. EPA 2005). As a result, 40 deployable real-time radiation air monitors were added to RadNet to provide an effective and rapid means to place air monitors in areas to cover gaps.

2.3.3 Satellite Launches and Reentries

In many spacecraft, nuclear reactors are incorporated into the design to provide power and maintain constant temperatures aboard the craft. Consequently, satellite launches and reentries carry the risk of becoming radiological incidents (see EPA website at www.epa.gov/radiation/rert/satellites.htm). After the crash of the Soviet nuclear powered satellite Cosmos 954, in a remote part of Canada in 1978, the U.S. became concerned about accidents with satellites containing radioactive material. Because of the potentially wide distribution of radionuclides during an aborted launch or reentry, this effort required considerable coordination between EPA and other federal, state, and local government agencies and the international community (U.S. EPA 2000). In response to this incident and the potential for accidents related to nuclear-powered satellites, EPA has developed contingency emergency plans for both launches and reentries of satellites that include increased frequency of radiation monitoring. These plans were tested as part of the 2004 “Ruby Slippers” exercise in which a hypothetical foreign satellite containing radioactive material breaks up on re-entry and crashes in the United States.

2.4 Background Levels and Trends

The following describe some of the uses of RadNet data related to the study of ambient levels and trends. RadNet data provide a means to estimate levels of radioactivity in the environment, including background radiation as well as radioactive fallout from atomic weapons testing, nuclear accidents, and other intrusions of radioactive materials. Continuous background concentrations are measured to provide the public with information and keep track of the ambient radioactive concentrations in various media. RadNet also provides the historical data needed to estimate long-term trends of environmental radiation levels.

2.4.1 Long-term Trends

The long-term RadNet data set has been made available to the public on the EPA website at www.epa.gov/enviro (click on radiation and then on RadNet). Data can be easily accessed for any monitored location by media, specific radionuclide, and date range using the "Query" Link. The "customized Query" is geared toward the experienced user and provides a much more sophisticated process to sort data. Most of the data is from 1978 to present, although the data set for strontium-90 in pasteurized milk goes back to the 1960's.

The website also provides a tool to graph the data, comparing annual trends for a selected location to the annual trends for all locations that have been monitored for a particular media and radionuclide. The graphs also provide three different "benchmarks" where available, to help users interpret their RadNet query results. These benchmarks present the regulatory-based concentrations; examples are the drinking water maximum contaminant level (MCL), the target risk concentration based on EPA's cancer risk range, and the minimum detectable concentrations (MDC's). For a variety of reasons, no benchmarks are available for some query results, while several are available for others. The site also provides links to the EPA radiation website fact sheets on the different radionuclides, risk assessment tools, and information on health effects from radiation.

2.4.2 Studies on Trends and Health and Environmental Effects

RadNet data have been used to assess historical trends and variations in radionuclide levels to determine short- or long-term changes over time from baseline levels. For example, EPA Region 2—in response to local and state agency requests sparked by concerns about a possible increase in Sr-90 in baby teeth—asked NAREL to compile the historical data for Sr-90 in environmental samples (U.S. EPA 2001a). The results of Sr-90 in milk analyses for sampling locations in or near the New Jersey/New York City area thus were tabulated, analyzed, and graphically presented. These results were similar to those shown above for Figure 2. That is, the study concluded that Sr-90 concentrations in milk were highest during the atmospheric testing period of the early 1960s, but after most aboveground testing ceased, the levels of Sr-90 continually decline. Individual stations may show some increase due to non-Soviet and non-US testing that was conducted after 1962 (as well as to the Chernobyl nuclear reactor accident).

Similarly, Stevenson and Pan (1996) assessed historical trends and regional variations of uranium in surface air within the continental United States from the late 1970s to the present, using results from the East Environmental Monitoring program of.DOE's Argonne National Laboratory (ANL), and from 25 monitoring stations from RadNet. In addition, Pan and Stevenson (1996) assessed the temporal variation of plutonium concentrations in surface air for the DOE monitoring sites near Richland, Washington, and Chicago, Illinois, using historical databases from the Battelle Pacific Northwest Laboratory (PNL) and ANL, and compared these values to RadNet data to verify the levels. The PNL and ANL post-1984 average monthly values fall within the range observed in Europe as well as in four other U.S. cities through the RadNet network.

2.4.3 Radiological Quality of the Environment in the United States

In 1976 and 1977, EPA's Office of Radiation Programs published "Radiological Quality of the Environment" Reports as part of their dose assessment program, evaluating the radiological quality of the environment in the United States (U.S. EPA 1976, 1977b). These reports emphasized the use of RadNet data for identifying trends in the accumulation of long-lived radionuclides in the environment. Trends are presented for radioactivity in air, precipitation, water, and milk for RadNet data collected as far back at the 1960s. The use of RadNet data was not found in other environmental quality reports that were reviewed, including the EPA Report on the Environment (http://cfpub.epa.gov/eroe/) and Air Trends (www.epa.gov/airtrends/index.html).

2.4.4 State and Other Programs

In many cases, State employees collect the ambient radiation samples for the RadNet system and send them to NAREL for analysis. Some government officials use the data in RadNet to analyze trends and ensure public safety on the local, state, and regional level. For example, Oregon has a radiological surveillance program in place that makes use of RadNet data (Oregon Health Division 1994). This state surveillance program was established in 1961 and was modeled after the radiation monitoring network.

As another example, the Tennessee Department of Energy Oversight Division implements EPA's RadNet air and drinking water programs. The division's integrated air quality monitoring is performed to verify and enhance the monitoring of the air quality on the Oak Ridge Reservation (ORR), as well as the surrounding areas that may be impacted from DOE Oak Ridge Operations (TDEC 2004). The division provides radiological surveillance of ambient air quality in the vicinity of ORR and compares the results to that of the national RadNet program. In addition to its other uses, the RadNet program provides a mechanism to evaluate the impact of DOE activities on drinking water systems located in the vicinity of the Oak Ridge Reservation and to verify DOE monitoring in accord with the Tennessee Oversight Agreement.

RadNet data often are used to characterize background levels of radiation for site and other specific purposes. For example, RadNet data from a monitor located immediately downwind from an Oak

Ridge incinerator were used to show that activity levels were safely below health-protective comparison values (ATSDR 2005). And a recent California initiative to develop a drinking water public health goal for tritium illustrates the use of RadNet data to characterize the background levels of tritium in drinking water (CalEPA 2006). This analysis showed that for the period of July to September 2003, the reported concentrations for the two California RadNet sites ranged from below the level of quantification to 84 pCi per liter; these were comparable with other reported measurements described in the report.

RadNet data are specifically identified in the "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" and elsewhere as useful for establishing background levels for site-specific assessments (U.S. EPA et al. 2000, U.S. NRC 1999). The NRC and a licensed nuclear power plant illustrate this by using RadNet data as a baseline from which to ensure compliance with NRC release limits, in particular to confirm site data showing non-detects in milk from the area near the plant (U.S. NRC 1999).

2.5 Other Uses

In addition to the four main categories for which RadNet data are most commonly used, there are other uses; some examples are described below.

The Food and Drug Administration currently conducts a milk survey to analyze milk for pesticides, taking advantage of the existing milk samples collected through RadNet monitoring and split between EPA and FDA; (U.S. FDA 1994). This program highlights the use of leveraging with different federal agencies to coordinate and provide services beyond the originally intended scope of RadNet.

Also, RadNet data were used in a Los Alamos Scientific Laboratory (LASL) study to show that Pu-238 at the site was likely due to atmospheric fallout rather than a site source (LASL 1976). Because of these results, LASL did not need to conduct a dose assessment of atmospheric Pu-238.

Because this report focuses on documented actual uses of RadNet and predecessor system data spanning 50 years, many other undocumented but actual examples likely exist; thus this report should be considered an overview rather than a comprehensive inventory. Furthermore, because of the frequent use of multiple systems for verification and other purposes, not all of the uses and benefits described in this report can be attributed solely to RadNet monitors.

3 Summary of Significant Historical Uses of RadNet and Its Predecessor Systems

The uses and benefits of RadNet have grown considerably over the years. Few realized 50 years ago—during the development of the gummed paper and other systems for monitoring fallout from above ground nuclear weapons testing—that this system would evolve into the multi-media, multiuse system seen today. Historically, in the 1950's to the 1960's, the system was designed to monitor releases from fallout from nuclear weapons testing. In the 1970's, 1980's, and 1990's it evolved to a system that also monitored releases from nuclear or radiological accidents.

RadNet data have been used to assure the nation that radiation levels in the environment, both during and after nuclear events, remained below levels requiring protective actions. For example, as the radioactive cloud from Chernobyl spread slowly westward, RadNet data were used to track levels of radiation in several environmental media across the country. Over the past 47 years of monitoring, data from RadNet and its predecessor systems have shown that strontium-90 in milk is reducing steadily, but is still present. And RadNet data have been used to support several important studies on radiation in the environment.

4 Upgrading the RadNet Air Monitoring System

Mission and Design Goals for the Air Monitoring System

The mission of RadNet today, and the purpose of the upgrade of the air monitoring system, is to support homeland security concerns as well as the special problems posed by possible intentional releases of radiation to the nation's environment. EPA's vision of the new monitoring system was developed on the basis of four design goals (U.S. EPA 2005):

- Better response to radiological emergencies,
- More flexible monitoring capability,
- A more integrated and dynamic network, and
- Cost considerations.

The upgraded RadNet will better support EPA's other related emergency response assets by including additional fixed monitoring locations and augmenting the fixed monitoring network with deployable monitors. Both systems can operate in either routine or emergency mode. The ultimate goal of RadNet air monitoring is to provide timely, scientifically sound data and information to decision makers and the public.

Very early on, it was determined that upgrading the air monitoring network would provide the best support for the homeland security objectives. Although the precipitation, pasteurized milk, and drinking water networks continued to monitor the environment for levels of radiation, the review of these sampling networks was deferred to a later time.

Needs for Upgrade

The historical air network received full scrutiny in the system assessment. It was determined that in order to more effectively assess widespread impacts from an incident that might occur anywhere in the U.S, decision makers need to access data more quickly than historically available; and data would be needed from more locations than were historically monitored. Since there will be no more than 180 near-real-time fixed radiation air monitors, RadNet is limited as to what it can actually do.

Specifically, the upgraded RadNet is designed to measure:

- Large-scale atmospheric releases of radiation due to nuclear weapon detonations,
- Radiological dispersion devices resulting in widely impacted areas (e.g., multi-county or larger),
- Large nuclear facility incidents or accidents, or
- Large foreign radiological incidents or accidents.

The upgraded system also measures ambient levels of radiation in the environment on an ongoing basis.

The RadNet air monitoring program 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.), or serve as an early warning or first detection system.

4.1 RadNet Air Monitoring System Components

The upgraded RadNet system includes both fixed and deployable near-real-time radiation air monitors.

4.1.1 Capabilities of the Fixed versus the Deployable Monitors

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

The deployable monitors have a gamma exposure rate monitor that provides continuous near-real time gamma radiation level measurements. However, the deployables have two air samplers, one low volume and one high volume. The low volume sampler collects particulates or iodine speciation using special cartridges; the high volume sampler collects particulates only. These filters too, can be removed and field screened for gross alpha and beta emissions, and can be shipped to a fixed or mobile laboratory for more specific analysis.

RadNet has the capability to provide data continuously from both deployable and fixed air monitoring stations, without the need for operator action. Routinely, the near-real-time data will be transmitted hourly, but can be transmitted more frequently during emergency operations. Both the fixed and deployable monitors have the capability to automatically transmit the near-real-time data to a central database at EPA's laboratory in Montgomery, Alabama, for data verification and communication, in support of emergency response efforts.

4.1.2 Deployable Air Monitoring System

EPA maintains 40 deployable near-real-time air monitors at two laboratories, in Montgomery, Alabama, and Las Vegas, Nevada. The logistics for rapidly and effectively distributing deployable stations during a radiological emergency can be difficult. However, EPA plans to have the stations in place and transmitting data within two days of the beginning of a major nuclear or radiological event.

The deployable monitors may be used in several different scenarios. They may be pre-deployed providing baseline data on environmental levels of radiation in a given area during a high profile event such as a NASA launch, or they may be deployed in response to an emergency, such as a dirty bomb. Once deployed, they may remain deployed in the region of the event to continue monitoring the environment in the aftermath of a radiation incident. They will provide follow-up monitoring data to detect any residual contamination, or to provide assurance to citizens and decision makers in unaffected areas that the airborne radionuclide concentrations are normal.

4.1.3 Fixed Air Monitoring System

EPA proposes placing up to 180 near-real-time fixed monitors across the United States by 2012. The siting plan for these monitors provides good coverage of the U.S. considering population centers as well as geographical areas. The communications plan provides the capability to deliver verified near real-time data quickly to decision makers and the public. 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 other notifications occur.

The upgraded RadNet system will operate continuously, providing background levels of radiation in the environment, detecting any anomalies of radiation in the environment, and insuring the operator skills remain current. It will provide near-real time data as well as subsequent more detailed data from the laboratory analysis of the filters. Data collected from these monitors will be used to perform trend analyses and to establish a baseline for comparison to abnormal data. These data may be used by the public, scientists, decision makers, and other stakeholders.

4.2 Data Sharing

During emergency operations, the timely sharing of data is crucial. EPA is proposing a structure and process to provide access to the RadNet during emergency operations. However, both routine and ultimate control of radiation data during an emergency will reside with the Department of Homeland Security or the coordinating Federal Agency.

4.3 Stakeholders and Partners

The contribution of stakeholders throughout the planning process of the air monitoring upgrade has been invaluable. The RadNet planning team aggressively sought information and guidance from sources inside and outside the Agency on issues that could benefit from special expertise.

Stakeholders within EPA have made major contributions.

- The Office of Air Quality Planning and Standards (OAQPS) was consulted on broad issues regarding environmental monitoring that could benefit the design and implementation of RadNet.
- The Office of Environmental Information (OEI) has provided essential guidance on developing and incorporating the RadNet information technology assets (a central database receiving near real-time data and eventually providing public information) into EPA's overall IT architecture.
- The Office of Radiation and Indoor Air (ORIA) formed a special Technical Evaluation Panel that also has offered commentary and constructive advice on key issues in the RadNet air project, particularly on the best sites for the fixed monitors.

External sources of expertise have also been important. For example:

- The National Atmospheric Release Advisory Center (NARAC) and the Savannah River National Laboratory (SRNL) have made substantive contributions.
  - NARAC provided modeling support and computer scenarios to help assess ORIA's RadNet siting plan.
  - SRNL provided guidance on siting and performed equipment testing of the RadNet fixed monitor.
- Members of the Conference of Radiation Control Program Directors (CRCPD) have provided state input on system goals and objectives, scenario assessments, location of monitors, and identification of station operators.
- EPA's Science Advisory Board's (SAB) Radiation Advisory Committee (RAC) provided valuable input on the overall expansion plan.

- Existing RadNet volunteer station operators also have provided very useful input on their issues and concerns as well as on the monitor prototype.
- ORIA secured additional expertise through contract support on a number of specific technical issues, including practices for quality assurance and 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.

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