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ITRC's Internet-based Training Program

# Real-Time Measurement of Radionuclides in Soil

Real-Time Measurement of Radionuclides in Soil:
Technology and Case Studies

This training is co-sponsored by the US EPA Office of Superfund Remediation and Technology Innovation

**Presentation Overview:** U.S. Department of Energy (DOE) and Nuclear Regulatory Commission (NRC) sites and some Superfund and U.S. Department of Defense (DOD) sites are contaminated with radionuclides. Radioactive contamination is also an issue potentially faced by Homeland Security. Characterization of radionuclides is an expensive and time-consuming process. Using real-time technologies to complete initial screening and characterization of radionuclide contamination results in more timely and cost-effective characterizations. Real-time technologies can also direct excavation resulting in more timely and cost-effective cleanups. The result is earlier protection of human health and the environment.

This training introduces state regulators, environmental consultants, site owners, and community stakeholders to ITRC's Technology Overview document ***Real-Time Measurement of Radionuclides in Soil: Technology and Case Studies*** (RAD-4, 2006), created by ITRC's Radionuclides Team. This training provides information on the basics of real-time measurement systems (detector types and platforms, location control and mapping technologies, surface and subsurface applications and limitations), how the technologies and data are used (characterization, remediation and closure, decision support, sources and types of uncertainty), acceptance issues (QA/QC, decision framework, uncertainty), and case studies. The purpose is to provide a solid background understanding of the technology itself and the context within which it is used.

ITRC (Interstate Technology and Regulatory Council) www.itrcweb.org

Training Co-Sponsored by: US EPA Office of Superfund Remediation and Technology Innovation (www.clu-in.org)

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## ITRC (www.itrcweb.org) – Shaping the Future of Regulatory Acceptance

- Host organization (ECOS)
- Network
  - State regulators
    - All 50 states and DC
  - Federal partners

    DOE DOD EPA
  - ITRC Industry Affiliates Program (IAP)
  - Academia
  - Community stakeholders
- Wide variety of topics
  - Technologies
  - Approaches
  - Contaminants
  - Sites
- Products
  - Technical and regulatory guidance documents
  - Internet-based and classroom training

The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, citizen stakeholders, academia and federal partners that work to achieve regulatory acceptance of environmental technologies and innovative approaches. ITRC consists of all 50 states (and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and advance the regulatory acceptance of environmental technologies. Together, we're building the environmental community's ability to expedite quality decision making while protecting human health and the environment. With our network of organizations and individuals throughout the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.

For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the "contacts" section at www.itrcweb.org. Also, click on "membership" to learn how you can become a member of an ITRC Technical Team.

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## ITRC Course Topics Planned for 2009 – More information at www.itrcweb.org

**Popular courses from 2008**

- Enhanced Attenuation of Chlorinated Organics
- Evaluating, Optimizing, or Ending Post-Closure Care at Landfills
- In Situ Bioremediation of Chlorinated Ethene - DNAPL Source Zones
- Perchlorate Remediation Technologies
- Performance-based Environmental Management
- Protocol for Use of Five Passive Samplers
- Decontamination and Decommissioning of Radiologically-Contaminated Facilities
- Real-Time Measurement of Radionuclides in Soil
- Determination and Application of Risk-Based Values
- Survey of Munitions Response Technologies

**New in 2009**

- An Improved Understanding of LNAPL Behavior in the Subsurface
- LNAPL: Characterization and Recoverability
- Use of Risk Assessment in Management of Contaminated Sites
- Phytotechnologies
- Quality Consideration for Munitions Response
- More in development…

More details and schedules are available from www.itrcweb.org under "Internet-based Training."

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# Real-Time Measurement of Radionuclides in Soil

## Logistical Reminders

- Phone line audience
  - ✓ Keep phone on mute
  - ✓ *6 to mute, *7 to un-mute to ask question during designated periods
  - ✓ Do NOT put call on hold
- Simulcast audience
  - ✓ Use ? at the top of each slide to submit questions
- Course time = 2¼ hours

## Presentation Overview

Introduction and course overview

1. Why real-time measurements and technology description
2. Real-time measurement technologies unique framework

Questions and answers

3. Case studies
4. Observations and conclusions

Links to additional resources

Your feedback

Questions and answers

No associated notes.

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# Meet the ITRC Instructors

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**Tom Schneider** is the Fernald Project Manager for the Ohio EPA. He has worked for the Ohio EPA since 1990 in the area of radioactive site remediation. He managed a team (composed of staff and contractors) charged with implementing Ohio's oversight and environmental monitoring program at the U.S. Department of Energy Fernald site. He was team co-leader of the ITRC Radionuclides team from 1999 to 2005 and continues to be an instructor on the team's Internet-based training courses as well as Ohio's POC. Tom earned a bachelor's degree in biology from the University of Dayton in Dayton, Ohio in 1988 and a master's degree in natural resources from the Ohio State University in Columbus, Ohio in 1990.

**Robert Storms** is the supervisor for the Environmental Restoration Support Section of Radiological Monitoring at the DOE Oversight Division for the Tennessee Department of Environment and Conservation located in Oak Ridge, Tennessee. Since 1988, Robert has been employed with the Tennessee Department of Environment and Conservation with the Division of Groundwater and the Division of Underground Storage Tanks. In 1991, Robert joined the DOE Oversight Division and worked with the Environmental Restoration program for three years prior to joining the Radiological Monitoring program in 1994. He is a member of the East Tennessee Geological Society and an avid mineral collector. Robert enjoys coaching soccer and assisting with the Boy Scouts. Since 2003, Robert has been a member of the ITRC Radionuclides team and became the team's co-leader in 2006. Robert earned a bachelor's degree in geology from Tennessee Technological University in Cookeville, Tennessee in 1986 and has continued studies in Environmental Legislation and Health Physics at Pellissippi State and Oak Ridge Associated Universities located in Oakridge, Tennessee. He is a registered Professional Geologist with the State of Tennessee.

**Ann Charles** is a Research Scientist with the New Jersey Department of Environmental Protection's (NJDEP) Site Remediation Management and Response Program in Trenton, New Jersey. Since 1988, Ann has been working for the NJDEP in the Bureau of Environmental Evaluation and Risk Assessment, overseeing publicly funded investigations and remediations that include radionuclide contaminated sites in the Site Remediation Program. Program and policy initiatives have involved the current development of soil remediation standards for the State of New Jersey, Technical Requirements for Site Remediation, New Jersey remedial process optimization team, and biennial certification and cap value teams. Ann has been a member of the ITRC Radionuclides team since 2004. She earned a Master of Science Degree from Miami University of Ohio in 1990 and a Bachelor of Arts degree from Franklin and Marshall College in 1982.

**Carl Spreng** is a project manager at the Colorado Department of Public Health and Environment overseeing environmental restoration at DOE's Rocky Flats site and has been with the Department since 1991. Previously, he worked as an energy exploration geologist involved in searching for such diverse energy sources as oil shale, tar sands, coal, uranium, and oil & gas. Since 1999, Carl has been the co-leader of ITRC Radionuclides Team and is an instructor on all of the team's Internet-based training courses. Carl earned a bachelor's degree in 1975 and a master's in 1977, both in geology from Brigham Young University in Provo, Utah.

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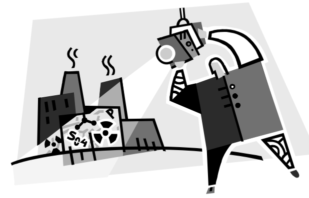
# ITRC Radionuclides Team



- Facilitate the cleanup of radioactively contaminated federal facilities
- Fostering dialogue between
  - States
  - Stakeholders
  - Federal agencies
- Increase awareness of issues and procedures at sites in other states
- Encourage regulatory cooperation
- Share technological successes and approaches
- State members
  - Colorado
  - New Jersey
  - Ohio
  - Tennessee
  - Washington

Facilitate the cleanup of radioactively contaminated federal facilities by fostering dialogue between states, stakeholders, and federal agencies in order to increase awareness of issues and procedures at sites in other states, encourage regulatory cooperation, and share technological successes and approaches

Made up of state and federal regulators, U.S. Department of Energy (DOE) personnel, consultants, and citizen stakeholders primarily from states with large DOE sites.

Facilitate communication and experience sharing among sites

Team originally was primarily focused on DOE sites. Primarily due to the fact that DOE sites present major cleanup challenges in states in which they occur. Often resulting in the creation of special divisions/offices to address them.

Made up of regulators, stakeholders, feds, and consultants. Nice states have members on the team. The team first became active in the late 1990s

More recently new members have joined that are interested in non-DOE radionuclide sites and in many cases the technology and processes used at DOE sites are quite applicable to other rad sites.

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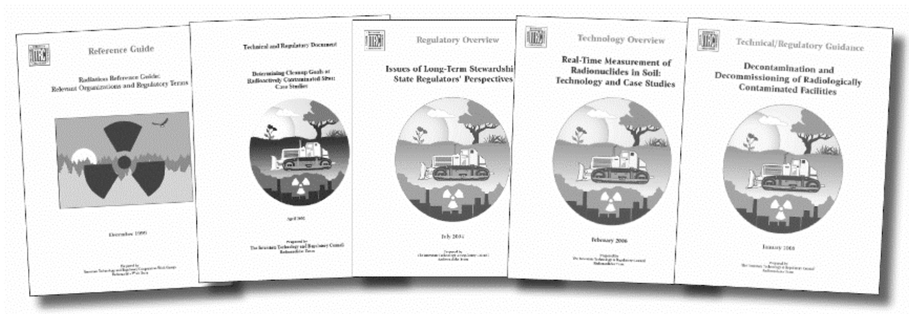
# ITRC Team Products and Activities

- Guidance Documents and Internet-based training



**Details available in Links page at end of presentation or directly at www.itrcweb.org**

The products above have been developed by ITRC's Radionuclides Team – details at www.itrcweb.org

The team has completed 5 final documents, 4 internet training.

The products above have been developed by ITRC's Radionuclides Team – details at www.itrcweb.org

- Radiation Reference Guide: Relevant Organizations and Regulatory Terms (RAD-1, 1999)

- Determining Cleanup Goals at Radioactively Contaminated Sites: Case Studies (RAD-2, 2002)

- Issues of Long-Term Stewardship: State Regulators' Perspectives (RAD-3, 2004)

- Real-Time Data Measurement of Radionuclides in Soil: Technology and Case Studies (RAD-4, 2006)

- Decontamination and Decommissioning of Radiologically Contaminated Facilities (RAD-5, 2008)

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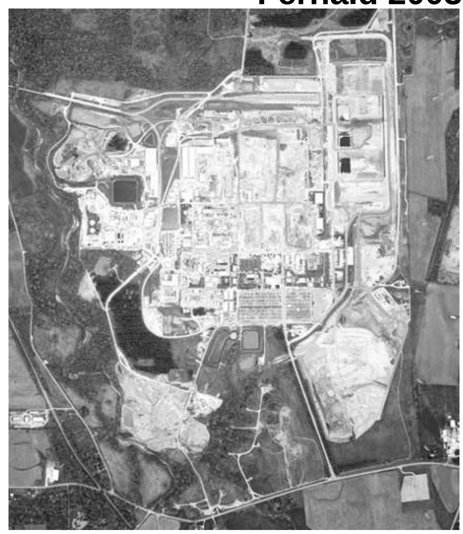
## Why We Are Here Today...

**Fernald 2003**



- Describe tools to improve
  - Characterization
  - Remediation
  - Closure
- Benefits
  - 100% coverage possible
  - Faster turnaround times
  - Integrated field based decision making

We hope to provide you with an understanding of a set of tools to improve site characterization, remediation and closure activities.

Benefits of these technologies include the possibility for 100% coverage, faster turnaround times, and integrated field based decision making.

At Fernald we had 1000+ acres to characterize, remediate and certify clean most of it involving large scale excavations. Anything that allowed those processes to move forward at a faster pace with greater confidence in our decisions was welcomed.

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## What You Will Learn…

***To have a better understanding of the benefits and the operating framework for real-time radiological measurement technologies***

- Basics of real-time measurement systems
- Uses for the technologies in expediting and reducing costs
- QA/QC requirements
- Case studies experience from sites
- Regulatory/stakeholder issues and observations

No associated notes.

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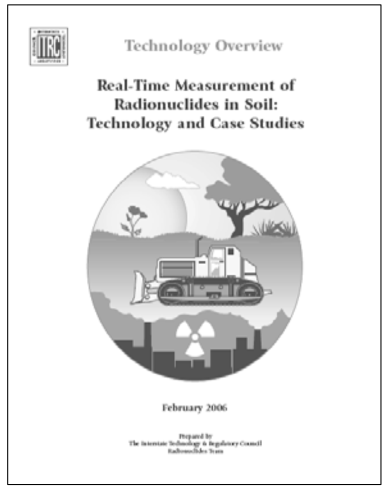
# Presentation Overview

- Module 1: Why Real-time Measurements and Technology Description
- Module 2: Real-Time Measurement Technologies Unique Framework
- Module 3: Case Studies
- Module 4: Observations and Conclusions




This training introduces state regulators, environmental consultants, site owners, and community stakeholders to *Real-Time Measurement of Radionuclides in Soil: Technology and Case Studies* (RAD-3, 2006), created by ITRC's Radionuclides Team, and provides information on the basics of real-time measurement systems (detector types and platforms, location control and mapping technologies), how the technologies and data are used (characterization, remediation and closure, decision support), acceptance issues (QA/QC, sources and types of uncertainty ) and case studies (surface and subsurface applications and limitations). The purpose is to provide a clear understanding of the technology itself and the context within which it is used.

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## Who Will Benefit from This Training...

**Fernald 2006**

- States
- U.S. Department of Homeland Security (DHS)
- U.S. Department of Defense (DOD)
- U.S. Department of Energy (DOE)
- Nuclear Regulatory Commission (NRC)
- U.S. Environmental Protection Agency (EPA)
- International participants

These technologies (and thus this training) have wide applicability to dealing with radionuclide contaminated site cleanup be they DOE, DOD, NRC or DHS response actions. If the site includes gamma emitting radionuclide contaminants it is likely these technologies can be of benefit to your project. There is likely a significant role for these technologies in the arena of homeland security in terms of planning, detection and incident response.

States – Superfund sites, NORM, Agreement states (NORM = naturally occurring radioactive material)

DHS – incident response planning and remediation.

DOD – Depleted uranium sites, accident sites, storage sites

DOE – many sites

NRC – Decommissioning and Decontamination (D&D) projects

USEPA – Superfund and other sites

## Real-Time Measurement of Radionuclides in Soil

# MODULE 1:

Why Real-time Measurements and Technology Description

No associated notes

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## Module 1 Learning Objectives

- Why real-time measurements?
- Two main detector types
  - Sodium iodide (NaI) scintillators
  - High-purity germanium (HPGe) semiconductor type detectors
- Platforms for the detectors
- Location control and mapping technologies
- Surface and subsurface applications
- Limitations

No associated notes.

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## Why this Technology Is Important

- Cost
- Performance (coverage)
- Schedule
- EPA wanted discrete sampling but costs were so high they had to be open to less expensive options



No associated notes.

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# Traditional Versus Real-time Approach

**Why real-time measurements?**

- Advantages
  - Cost
  - Complete coverage
  - Reduction of uncertainty
- Disadvantages
  - Limited to certain radionuclides

Gator System

Radiation Scanning System

No associated notes.

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## A Generic System

**A real-time measurement system is an integration of three off-the-shelf components on a platform:**

1. Field detectors for radiological contamination
2. Location control technology (global positioning system (GPS))
3. Mapping (geographic information system (GIS)) and data integration

No associated notes.

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# Field Detectors for Radiological Contamination

**Two main detectors:**

- Sodium iodide (NaI) scintillators
- High-purity germanium (HPGe) semiconductor type detectors

No associated notes.

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## Sodium Iodide (NaI) Scintillators Detectors

- Scintillation detector
  - Gamma ray and crystal interact electronically - light is emitted
  - Light proportional to absorbed gamma ray energy
  - Light detected by a photo multiplier tube
  - Thallium doping of crystal shifts light to detectable range
- Detector is more properly referred to as NaI(Tl)
- Primarily used for scanning

No associated notes.

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## High-purity Germanium (HPGe) Semiconductor Type Detectors

- Operate using semiconductor crystals
  - Gamma ray produces electron-hole pairs and hence electric charge
  - Bias voltage across detector collects charge
- High-quality stationary measurements
- High level of resolution
- Complementary to sodium iodide (NaI) scintillators

No associated notes.

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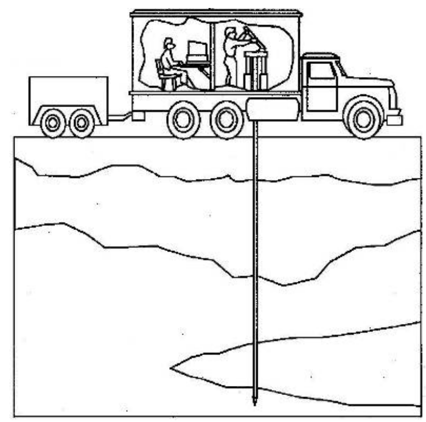
# Location and Mapping Technologies

- A number of options available
- More complex give better accuracy
- Can get down to sub-centimeter resolution
- Global positioning system (GPS)-based and laser tracking
- Benefits
  - Enhanced QA/QC of data sets
  - Enhanced documentation
  - Enhanced data analysis
  - Full coverage

**Site Characterization and Analysis Penetrometer System ( SCAPS) Truck**



No associated notes.

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## Real-time Measurement Platforms

- Applicable to both surface and subsurface
- Platform is the tractor and speed control
- Major components
  - Detector
  - Global positioning system (GPS)
  - Geographic information system (GIS)
  - Computer that integrates it all
- Number of systems available
- Range of sizes available

**Gator System**

No associated notes.

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## Old Time Mounted System

No associated notes.

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## Radiation TRAcKing System (RTRAK)

- Mobile platform
  - Farm tractor
- Sodium iodide (NaI) scintillators detector at rear
- Two operators
  - Driver
  - Detector system
- Features
  - 1 mph
  - Spectra every 4-seconds
  - 1 acre per hour
- Maps within a day of data collection

No associated notes.

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## Gator System

- Mobile platform
  - All-terrain vehicle (ATV)
- Sodium iodide (NaI) scintillators detector at front
- Same as RTRAK
  - Detector and computer global positioning system (GPS)
  - Areas scanned
  - Field-of-view
  - Area coverage rate
  - Data acquisition, transmission, review and mapping
- Lighter weight for more difficult terrain
- Daily excavation progress and soil removal volumes

No associated notes.

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# Radiation Scanning System (RSS)

- Mobile platform
  - Converted 3-wheel jogging stroller
  - Smallest, lightest, most maneuverable mobile platform
- Sodium iodide (NaI) scintillators detector at center
- Single operator
- Features
  - Data in 4-second scans, transmitted, analyzed and mapped as with other
  - Coverage rate same as for others
- Used in areas
  - Inaccessible to larger platforms or
  - Where there are impediments (trees, etc)

No associated notes.

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# Excavator-mounted Excavation Monitoring System (EMS)

- Mobile platform
  - Standard excavator
- All on mast attached to excavator arm
  - Sodium iodide (NaI) scintillators
  - High-purity germanium (HPGe) semiconductor type detectors
  - Computer, global positioning system (GPS), etc.
- Controlled from support van
- Differential global positioning system (GPS) – accurate three-dimensional positioning
- Used in deep excavations and trenches
- Permits remote measurements in high contamination areas

No associated notes.

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# Other Real-time Measurement Systems

- Tripod-mounted high-purity germanium (HPGe)
- Excavation Monitoring System (EMS)-mounted HPGe
- Site Characterization and Analysis Penetrometer System (SCAPS)
- Canberra In Situ Object Counting System (ISOCS)
- Global Positioning Radiometric Scanner (GPRS)
- ISO-CART®
- UltraSonic Ranging and Data System (USRADS®)
- Laser-Assisted Ranging and Data System (LARADS)
- Global Positioning Environmental Radiological Surveyor System (GPERS-II)

**Tripod-mounted HPGe detector**

Shows availability of many systems without being comprehensive. General capability includes measurement of surface and subsurface. In choosing the technologies, one needs to work with hands-on experts who would know the applicability in the specific topography.

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## Circumstances for Optimal Effectiveness

The real-time approach is most effective where

- A dynamic work strategy is in operation
- There is a need for reducing decision uncertainty
- Verification and validation are an integral part of the project plan
- Uninterrupted operations are needed
  - As in excavation

Point out issue where data collection is staged (real-time first, followed by traditional)

Can go with real time alone and take advantage of faster real time but it is more useful to do it where real-time is staged in coordination of traditional sampling.

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## Commonly Encountered Issues

- Large areas
- Radionuclides and chemical contaminants present
- Potential for buried contamination
- Inadequate previous characterization
- Elevated area or hot spot cleanup criteria

Large areas - For federal facilities, the sheer size of potentially affected areas can challenge the design and implementation of traditional characterization programs. While average conditions can be estimated even for large areas with relatively sparse data collection efforts, the primary concern is the identification individual sub-areas that have been impacted by contamination. The availability of real-time measurement systems within the Triad approach provides technically defensible alternative to the traditional approach that can produce superior characterization results at much lower costs.

Radiological and Chemical Contamination - Many sites include collocated chemical and radiological contamination in media, which usually presents special challenges for waste disposal with significant cost and logistical implications. For situations where it can be assured that the radionuclide contamination footprint envelops the chemical contamination footprint and where waste stream segregation is not also an objective, characterization efforts can potentially be reduced to a radionuclide detection program, even when the primary risk concerns are associated with chemical constituents. In this setting, the availability of real-time radionuclide methods can be a boon from a chemical perspective since, in general, the capabilities of radionuclide real-time detection are significantly greater than the capabilities of real-time detection of non-radioactive species.

Buried contamination – is one of the most daunting problems for site remediation since its presence cannot be determined using surface scanning. Key steps in selecting an approach to address areas with the potential for buried contamination include:

• developing a site-specific conceptual site model (CSM) that captures what is known about the presence of buried contamination and the level of confidence associated with conclusions drawn from that information

• using this conceptual site model (CSM) to identify locations that are most likely to yield subsurface samples with contamination above levels of concern

• determining whether geophysical techniques may have potential for reducing spatial uncertainty in the subsurface

• determining whether suspected contamination is amenable to real-time detection using retrieved cores or in situ gamma spectroscopy

• developing the optimal mix of approaches and decision-making logic within a dynamic work strategy setting sample by alpha spectroscopy will be required

Inadequate Previous Characterization - Shortcomings in previous characterization can take many forms. There may be complete areas of a site that were not characterized or were under characterized. Areas may have had adequate surface characterization but have incomplete subsurface data. Areas may have been well sampled, but the analytical suites may have been incomplete. Finally, in cases in which characterization and remedial work have persisted over a long period of time, existing data may no longer be considered representative of the current conditions of the site. Real-time measurement technologies within a Triad process can play a key role in addressing inadequate characterization problems while still maintaining required schedules. Since a Triad approach emphasizes the use of dynamic work strategies, contingencies can be built into work plans to accommodate unexpected results as they are encountered. Real-time data access would ensure that decisions could be made in a timely manner in response to results without compromising overall schedules.

Elevated Area or Hot Spot Cleanup Criteria – establishing compliance with elevated area or hot spot cleanup criteria can

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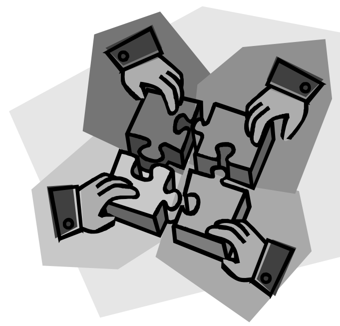
## Real-Time Measurement Technologies Unique Framework

- The technologies operate within a unique framework
  - Regulatory
  - Decision Support
  - Analytical
  - Quality
- Main aspects
  - Data collection approaches
  - Decision support
  - Uncertainty
  - Quality assurance and quality control (QA/QC)



Data collection aspect refers to approaches such as MARSSIM and Triad

Decision-making aspect refers to the decision-support role of real-time measurements during clean up (Preliminary Site Assessment/Site Investigation Support, Remedial Investigation Support, Remediation Support, and Closure Support)

Uncertainty aspect refers to the probability of making a wrong decision on the status of a site, and how this uncertainty can be minimized.

QA/QC aspect refers to quality assurance (the management system – e.g. planning, implementation, review - that ensures data is of the type and quality needed by the decision-makers and specified by the quality objectives), and quality control (the technical activities - such as precautions, calibrations, duplications, documentation - needed to ensure that data the quality objectives).

Regulatory challenge for acceptance of this technology relates to its newness and not having accumulated regulatory base as for traditional sampling. The QA/QC issues related to the acceptance of this technology will be discussed in the next module.

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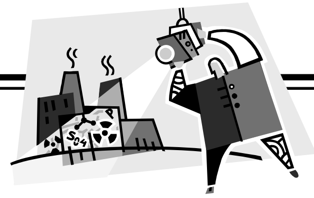

## Real-Time Measurement of Radionuclides in Soil

# MODULE 2:

# Real-Time Measurement Technologies Unique Framework

No associated notes

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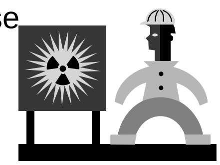
# Module 2 Learning Objectives

- Real-time measurement technologies operate within a unique framework
  - Understanding this framework is critical to acceptance and appropriate use
- Understand that the role of reducing uncertainty in decision-making is needed for better acceptability
- Understand data collection approaches and quality assurance and quality control (QA/QC)
- Real-time measurement technologies do not eliminate the need for expertise



No associated notes.

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## Requirements for Acceptance and Proper Use

- To get acceptance and ensure proper use of this technology, we need
  - Data collection approaches
    - Quality data able to support sound decisions
  - Decision support role
    - Understanding the purpose of decision making
  - Uncertainty in environmental decision making
    - Reduced uncertainty
  - Appropriate QA/QC
- Key elements for QA/QC for real-time measurements

No associated notes.

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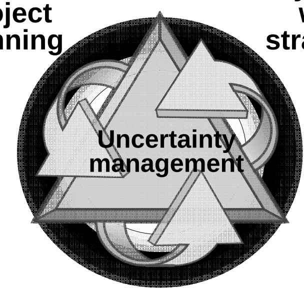
## Data Collection Approaches

**Triad**

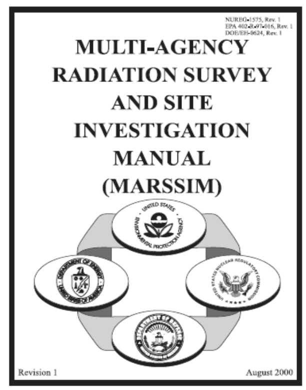
**Systematic project planning**

**Dynamic work strategies**




**Real-time measurement technologies**

**Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)**


MULTI-AGENCY RADIATION SURVEY AND SITE INVESTIGATION MANUAL (MARSSIM)

Revision 1 August 2000

Real-time measurement technologies represent significant site-assessment advances. They also allow improved data collection strategies to be followed and improved decisions to be made with the data from these strategies.

In this way real-time measurement technologies can significantly improve existing remedial approaches, but to understand this improvement it is first necessary to understand the data collection strategies.

Time does not allow this to be done here but we can refer the audience member to existing ITRC document and training on Triad and other references on MARSSIM in Chapter 3 of the Technology Overview.

ITRC’s Sampling, Characterization and Monitoring team published “Technical and Regulatory Guidance for the Triad Approach: A New Paradigm for Environmental Project Management” (SCM-1, 2003). The document is available at www.itrcweb.org under “Guidance Documents” and “Sampling, Characterization and Monitoring.” Information on the associated Internet-based training is available at www.itrcweb.org under “Internet-based Training.” You can access an archive (listen/view slides) of a previous offering by going to: http://cluin.org/live/archive.cfm#itrc (You will have to scroll down to find the course of interest). When you choose to view a course on-line, the link will take you to the course overview page. When you are ready to listen to the training, select Go to Training.

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## Decision Support Role

- Real-time measurements are most effective when
  - Used with a dynamic work strategy (ability to make changes in real-time as we go)
  - Reducing decision uncertainty
  - Integrated with more traditional sampling
  - Simultaneous progress and verification (excavation) are needed
  - Combined with verification sampling

1. The decision that must often be made at a given site is whether or not a specific area (final-status survey unit, remediation unit, etc.) meets cleanup criteria. If a real-time measurement system is to play a role in this decision, it must provide information about the presence or absence of contamination above the criteria. Invariably, the real-time system is combined with some form of traditional discrete sampling and laboratory analysis to provide a basis for decisions. The exact nature of this mix will depend on the specific requirements of the data collection approach combined with the capabilities of the available real-time measurement systems.

2. Real-time measurements are most effective in these settings:

• when a dynamic work strategy, such as is used by the Triad approach, is in operation

• when the real-time data collection and analysis focus on reducing the uncertainty associated

with the decision to be made

• when data collection is staged in a manner that emphasizes real-time measurements at first,

followed by more traditional sampling and laboratory analysis as a follow-up

• during excavation to direct work in a manner that allows continuous progress and verification simultaneously

• when verification sampling and analysis data collection are an integral part of the overall data collection program

3. We do not have time to address these in detail here though the Technology Overview provides many more details in Chapter 4.

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## Uncertainty in Environmental Decision Making

- Types of uncertainty
  - Inferential
  - Analytical measurement
  - Spatial

1 Both the implementation and acceptance of the real-time measurements approach require a solid understanding of the different types of uncertainty. We do not have time to address these in detail here though the Technology Overview provides many more details in Chapter 5.

2 There are three types of uncertainty – inferential, analytical measurement, and spatial uncertainty.

Inferential Uncertainty:

- Addresses the relationship between what is measured and the concentration-based standard
- Often requires statistical regression analysis since real-world relationships are rarely linear
- Can require nonparametric statistical techniques – this recognizes that the decision is binary, i.e. gives an answer to the question “is a contaminated area above or below cleanup criteria?”.

Analytical Measurement Uncertainty:

- Addresses the degree of agreement between the measured value and the true value, and requires consideration of:
  - The concept of Accuracy
  - The concept of Bias
  - The concept of Precision

Spatial Uncertainty:

- Addresses the issue of “sample support” i.e. the actual volume or area of material measured.
  - Traditional soil samples involve 0.5 liter or less,
  - Direct measurements (in situ x-ray fluorescence) involve much less than 0.5 liter
  - But stationary sodium iodide (NaI), 1 foot above ground, covers several square yards down to several inches depth

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# QA/QC for Real-time Measurement Programs

Key elements are

- Establishing real-time data quality
- Developing a quality assurance and quality control (QA/QC) program

No associated notes.

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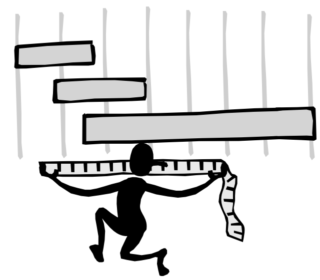
## Establishing Real-time Data Quality

Factors include

- Quality and performance requirements
  - From data quality objectives (DQO) process
- Essential performance requirements and characteristics – establish beforehand
- Important considerations for soil conditions and contexts
- Measurement considerations for contaminant distribution



Essential Performance Requirements and Characteristics need to be established in advance and include:

Applicable action levels

Progeny

Surrogates

Interferences

Detector types

Gamma ray energy and abundance

Total propagated uncertainty

Soil conditions include:

Topography

Surface Coverage

Soil Moisture

Measurement Geometry

Parent Material context

Contaminant distribution considerations include:

Lateral inhomogeneities are not “averaged”

Inhomogeneities have the strongest influence directly beneath the detector

Deviations from assumed uniform concentration with soil depth

Conceptual model of contaminant distribution

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# Five Major Elements of a QA/QC Program

1. Initial setup and calibration
2. Data analysis and reduction
3. Continuing operations
4. Data documentation and defensibility
5. Chain of custody

Error management – approaches such as Triad and MARSSIM explicitly identify and manage the largest sources of decision error; a QA/QC program is essential for proper identification and management of error sources

A: Central theme is explicit identification and management of the largest sources of decision error, especially the sampling representativeness of the data.

A: QA/QC program is essential to ensure that identification and management of these error sources is being accomplished properly.

B: Calibration of detector response to radionuclide concentration in soil is normally the first and most important initial performance test.

C: Data conversion and data reduction processes are the second major aspect of setting up the real-time measurement process that requires development and verification

C: Two basic types of gamma ray measurements are involved in real-time programs, gross count and isotopic. Both measurement types generally require that count rate data be converted to soil activity

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# Five Major Elements of a QA/QC Program (continued)

1. Initial setup and calibration
   - Point source
   - Calibration pad
2. Data analysis and reduction
   - Primary standards
   - Verified calibration algorithms
   - Verified data conversion algorithms
   - Peak identification and stripping
   - Resolution, minimum detectable concentrations
   - Linearity of detector response
   - Verify and validate system software

The first two elements of developing a QA/QC program are

•Initial Setup and Calibration

•Data Analysis and Reduction

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# Five Major Elements of a QA/QC Program (continued)

3. Continuing operations
   - Daily use of the system after initial setup and calibration
   - Would contain (for example)
     - Pre-operations check list
     - Daily global positioning system (GPS) pre-operations and calibration checks
     - Daily pre-operations test on moisture determination instrument
     - Daily pre-operations tests on wireless data communications systems
     - Post-operations check list

Consists of a set of requirements, checks, measurements, and procedures that are designed to assure that measurement systems are operating within acceptable limits as established by the requirements of the measurement program and confirmed during the initial setup and calibration

And: Annual detector characterization/calibration; Annual minimal detectable concentrations (MDC) determinations; Periodic comparison tests with alternate methods (e.g., laboratory); Procedures for performing soil moisture measurements; Specifications of limits on soil and topographic conditions related to soil type, moisture, obstructions, debris content, surface cover, roughness, and deviations from flat terrain

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## Five Major Elements of a QA/QC Program (continued)

4. Data documentation and defensibility
   - Real-time gamma data collected in support of soil remediation must meet the data quality and documentation requirements of the regulatory program under which it is collected


Typically CERCLA or Nuclear Regulatory Commission (NRC) decommissioning

Chemical analysis protocols established under CERCLA provide a good model for designing a program to meet such requirements. While detailed guidance documents, a long history of use, and a well-established market have rendered high-quality chemical analysis data a readily available commodity, a similar level of development has not occurred for radiological measurement and for real-time measurements in particular

Data Documentation and Defensibility

- •Must meet the requirements of the regulatory program (CERCLA or NRC decommissioning)
- •Is well established for traditional approach but not for real-time
- •CERCLA requirements provide a useful guide

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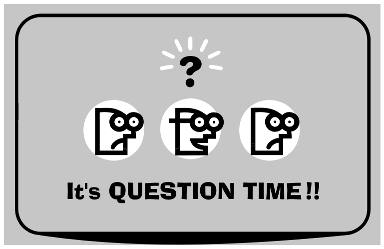
## Five Major Elements of a QA/QC Program (continued)

5. Chain of custody
   - Greatly reduced for real-time measurements
   - Completion of
     - Field logbooks
     - Log files in the various data systems associated with each measurement
   - Integrity of that information is assured through
     - Use of secure data systems and networks
     - Log entries of all individuals
       - Collection
       - Archiving

Integrity of that information is assured through the use of secure data systems and networks, and through the log entries of all individuals working on the data from the point of its collection to its ultimate archiving in a secure database.

## Questions and Answers




No associated notes.

## Real-Time Measurement of Radionuclides in Soil

## **MODULE 3**: Case Studies

No associated notes

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## Module 3 Learning Objectives

- How real-time radiological surveys have been conducted at various sites
- Advantages
- Limitations

No associated notes.

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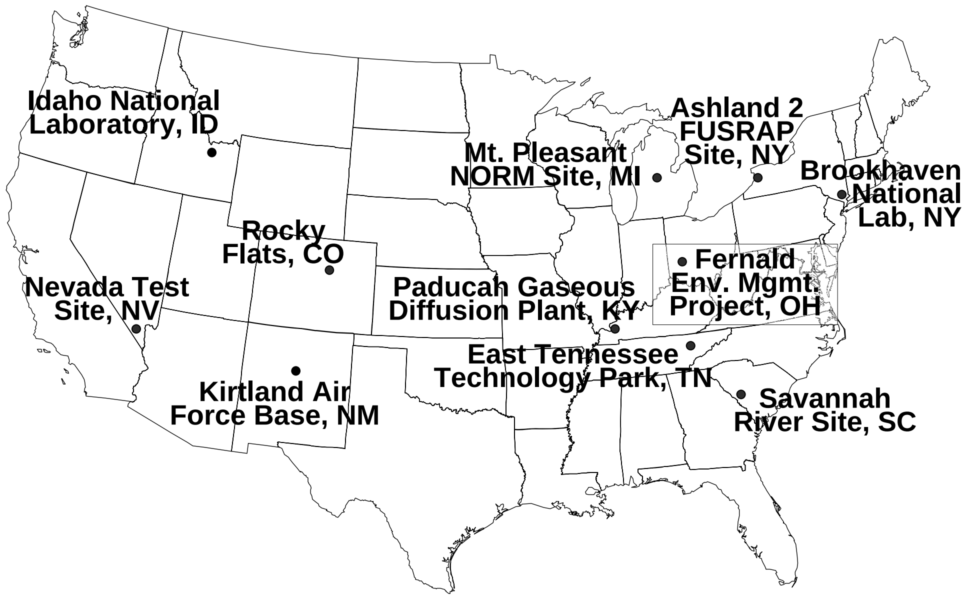
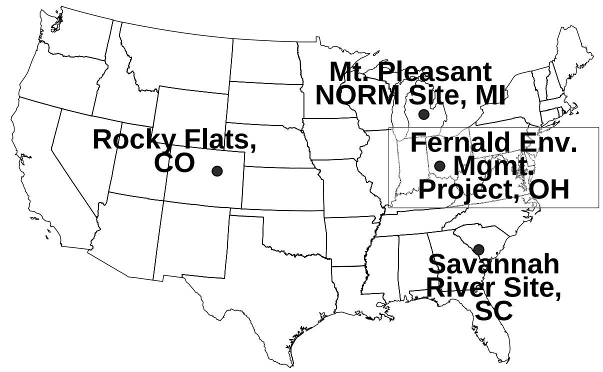
# Case Study Sites Included in ITRC RAD-4 Document




NORM = naturally occurring radioactive material

# Case Study Sites Included in This Training Course

- Surface techniques
  - Mt. Pleasant NORM Site, Michigan
  - Fernald Environmental Management Project, Ohio
  - Rocky Flats, Colorado
- Subsurface techniques
  - Savannah River Site, South Carolina




NORM = naturally occurring radioactive material

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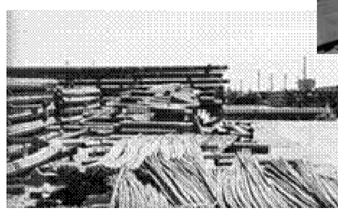
# Mt. Pleasant NORM Site, Michigan


- Private pipe storage yard
- Naturally occurring radioactive material (NORM) scale on outside of pipes
- Ra-226 / Ra-228



No associated notes.

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# Mt. Pleasant NORM Site, Michigan

- Owner survey (1991)
- Excavation
  - 38 cubic yards
  - With up to 1,000s pCi/g Ra-226
- Michigan Department of Environmental Quality survey (1997)

Shovel with NORM-contaminated pipe scale

No associated notes.

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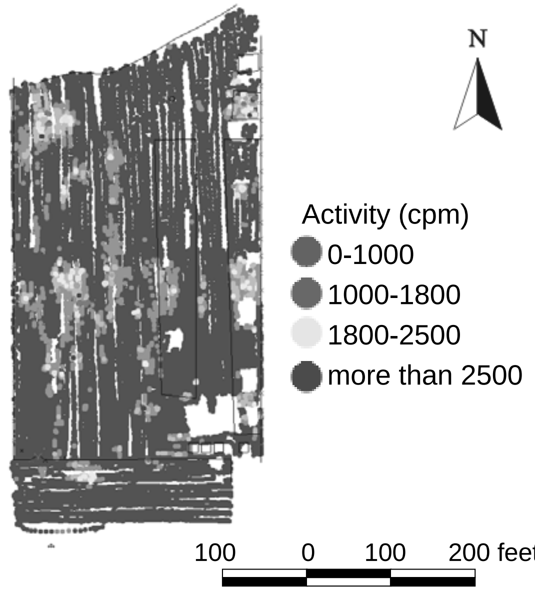
## Pre-Excavation Scan

- Mini-FIDLER with global positioning system (GPS)
- High-purity germanium (HPGe) semiconductor type detectors
- 5-foot parallel paths




Data collected in 2-second intervals (= approximately 3-foot spacing between data points)

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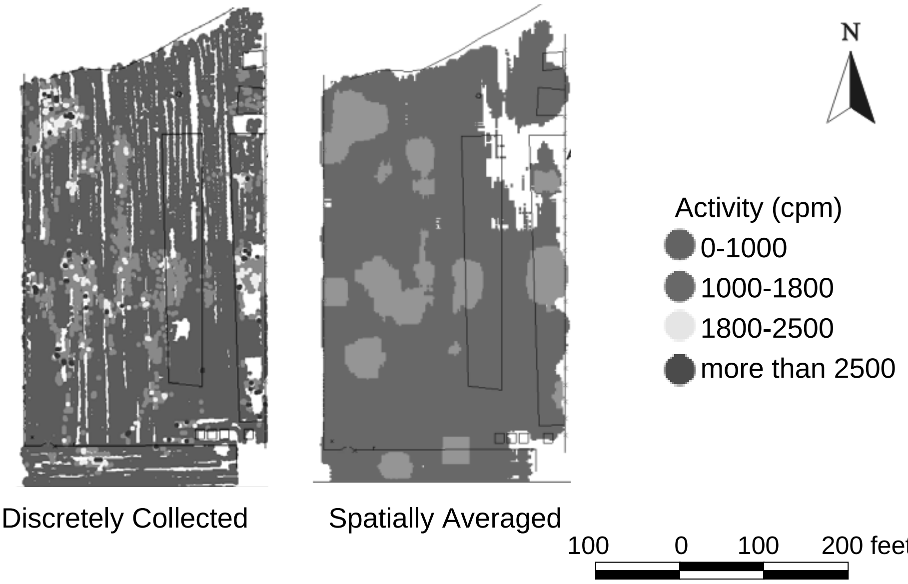
## Excavation Results




$10/measurement with the in-situ sodium iodide (NaI) gamma spectroscopic system

Vs.

Several hundred dollars to analyze a soil sample with gamma spectroscopy at an off-site laboratory.

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## Mt. Pleasant Site - Observations

1. Systematic planning when using multiple technologies
2. Include validation and verification in data collection strategy
3. Meet closure data requirements with real-time surveys more efficiently
4. Integrate characterization, remediation, and closure data collection into one effort:
   - Shorten schedule
   - Lower costs

No associated notes.

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# Fernald Environmental Management Project, Ohio


- DOE closure site
  - Radium
  - Thorium
  - Uranium

View to the west from the top of the On-Site Disposal Facility (2004).

Views of the Fernald site during active remediation and after remediation was complete are in slides earlier in this presentation.

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# Systems Used at Fernald

**Radiological Scanning System**

**Excavator Mounted System**

**RTRAK**

**Gator**

No associated notes.

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## Regulatory Issues

- Soil remediation program
  - Pre-design of excavations
  - Excavation support
  - Pre-certification
  - Certification
- Primary concerns
  - Undocumented data quality
  - Uncontrolled environmental conditions
  - In-situ definition of “a sample”
  - Differences between measurement and data quality produced

No associated notes.

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## Technical Studies

- Baseline comparison studies
- Radiation tracking system (RTRAK) / radiation scanning system (RSS) study
- Gator report
- Excavation monitoring system (EMS) report
- Sodium iodide (NaI) calibration
- Sodium iodide (NaI) minimal detectable concentrations (MDC) / trigger level report
- Cost analysis report
- Integrated technology suite (ITS) user manual

No associated notes.

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# Rocky Flats, Colorado

- DOE closure site
- Construction completed in 2005


No associated notes.

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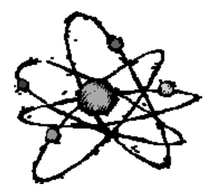
## Gamma-emitting Surrogates for Alpha Emitters

- Plutonium (Pu)
  - Weak gamma emitter
  - Alpha spectroscopy results normally take at least seven days
- Determine Pu activity levels
  - Measuring americium (Am) as a surrogate
  - Calculate Pu:Am ratio for weapons-grade Pu
- Studies supporting theoretical Pu to Am ratio of **5.7 to 1**



No associated notes.

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# Activities and Activity Fractions for Weapons-grade Plutonium Isotopes

| ISOTOPE | ACTIVITY FRACTION Year 0 (% total activity) | ACTIVITY FRACTION Year 34 (% total activity) |
|---|---|---|
| Pu-238 | 0.38 | 0.84 |
| Pu-239 | 13.08 | 37.50***** |
| Pu-240 | 2.93 | 8.42 |
| Pu-241 | 83.46 | 46.63 |
| Pu-242 | 0 | 0 |
| Am-241 | 0.14 | 6.61***** |

* Pu-239 : Am-241 = 5.7 to 1

No associated notes.

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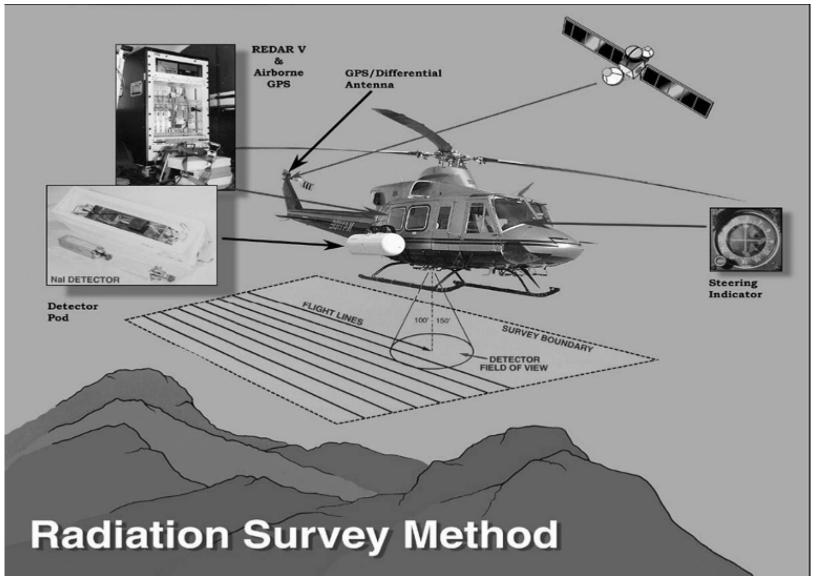
# 903 Pad Remediation Project


No associated notes.

# Final Radiological Survey




No associated notes.

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## Final Radiological Survey (continued)

- Multi-processor data acquisition system records
  - Gamma-ray spectra
  - Aircraft position (global positioning system (GPS) + radar altimeter)
  - Meteorological parameters
  - Time
- Effective detector footprint is a function of
  - Detector shape
  - Distance from source
  - Air mass attenuation
  - Aircraft speed, etc.

No associated notes.

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# Savannah River Site, South Carolina

- DOE site
- Spectral gamma probe for subsurface
- Spectral gamma probe testing objectives
- Advantages of cone penetrometer (CPT) technologies
- Cost savings
- Comparison with field measurements
- Implementation and results


No associated notes.

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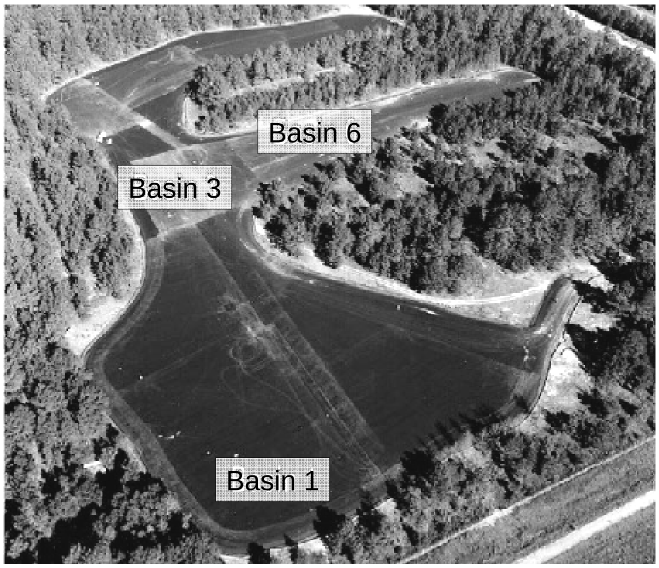
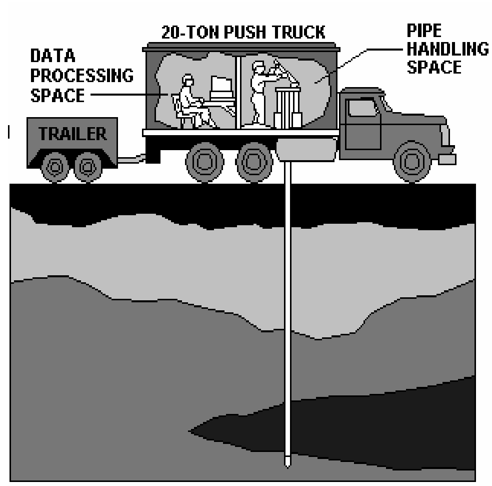
# Savannah River Site's Basins




No associated notes.

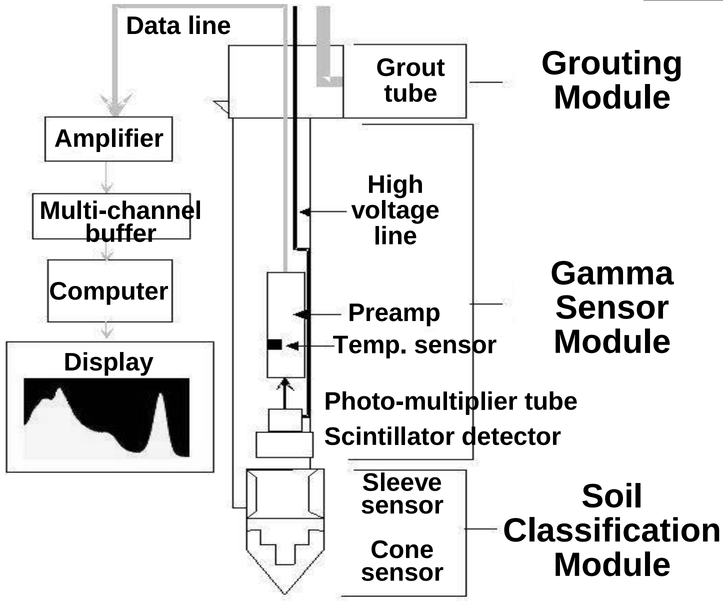
# Vehicle for Spectral Gamma Probe

- Vehicle
  - Push probe
  - Configurations
    - Sensoring
    - Sampling
  - Ground capability
  - Equipment decontamination
  - Hazardous environment protection
- Data acquisition and analysis
  - Acquisition – sensors
  - Analysis
  - Visualization




No associated notes.

# Spectral Gamma Probe




No associated notes.

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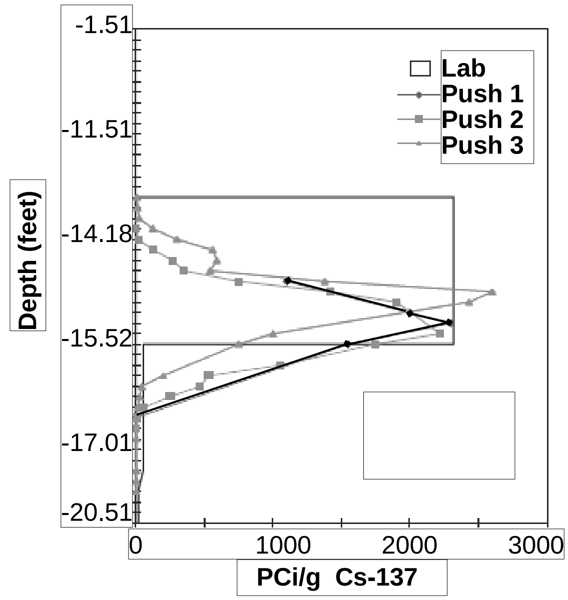
# Spectral Gamma Probe Results

**Gamma probe compared with soil samples**




No associated notes.

70

## Spectral Gamma Probe Limitations

- Lower limit of detection (LLD)
- Dynamic range of the sensor (designed to detect low-level activities)
- Limitations of cone-penetrometer technology
- Wide variation in contaminant levels
- Poor energy resolution of sodium iodide (NaI) detector

No associated notes.

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## Spectral Gamma Probe Advantages

- Reduction in secondary waste
- Reduction in risk to workers
- Minimizes environmental impacts
- Significant cost reduction

No associated notes.

## Real-Time Measurement of Radionuclides in Soil

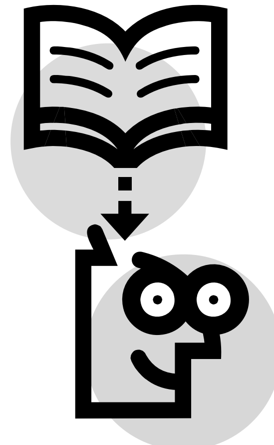
# MODULE 4:

Observations and Conclusions

No associated notes

## Learning Objectives

- Observations
  - General
  - Technical
  - Regulator/stakeholder
- Conclusions



No associated notes.

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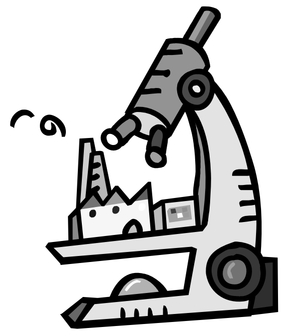
# General Observations

- Rapidly screen for a large number of contaminants at lower concentrations
- Assumptions about secular equilibrium necessary
- Technical expertise is still needed and emphasized
- Results should be looked at in context of other information



No associated notes.

75

## Technical Observations

- Three types of uncertainty affect decisions
- QA/QC can address a lot of the measurement errors
- Site-specific protocols needed due to impact of environmental conditions on measurements
- Soil type, moisture, and geometry affect measurements

The three types of uncertainty affecting decisions using environmental measurements: 1) Inferential uncertainty; 2) Analytical uncertainty; 3) spatial uncertainty.

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## Regulator/Stakeholder Observations

- Early education, involvement, and acceptance are essential
- Emphasis on QA/QC development and implementation
- Some concerns with use for final certification
- Can address concerns regarding “missing something”

Certification is synonymous with confirmation, verification, etc. Meaning the final conclusion regarding an area meeting cleanup standards.

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## Conclusions

- Can rapidly measure a number of radiological contaminants in situ
- There are numerous platforms for use
- Possibility of substantial cost savings
- Limited in ability to assess contamination at depth
- Site-specific QA/QC program necessary

Most gamma emitting radionuclides can be measured using these systems. In some cases, progeny can be measured to determine parent radionuclide concentration.

Multiple vendors now offer systems that utilize one of the two detector types on differing vehicles/platforms.

Cost savings can be realized by analytical cost reduction, excavation bounding, faster results mean faster work and less down time.

Serious limitations on the systems for evaluation contaminants at depth or below any dense surface.

Multiple parameters effect the quality of data and a rigorous site specific QA/QC program is necessary.

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## Conclusions

- Opportunity for improved risk reduction
- Greatly reduce generation of secondary wastes
- Reduction in characterization uncertainty (aerial extent and hot spots)
- A decision-making process and team must be developed that addresses and understands the systems and their limitations

Reduce risk in terms of : 1) decision making, 2) worker exposure, 3) environmental protection, etc.

No sample waste from soil cores, packaging waste, personal protective equipment (PPE), etc.

Near 100% coverage allows addressing things that might otherwise get missed in a standard sampling grid.

New technologies, faster results and emphasis on appropriate QA/QC require a specialized team that are familiar with the benefits and limitations of these technologies.

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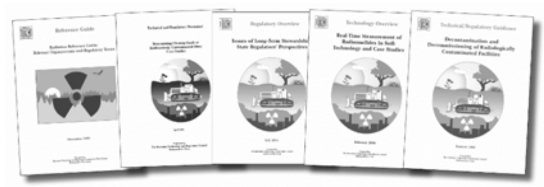
## Thank You for Participating

- Links to additional resources
  - http://www.clu-in.org/conf/itrc/radsrealtime/resource.cfm
- 2nd question and answer session



Links to additional resources:

http://www.clu-in.org/conf/itrc/radsrealtime/resource.cfm

Your feedback is important – please fill out the form at:

http://www.clu-in.org/conf/itrc/radsrealtime/

**The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:**

✓Helping regulators build their knowledge base and raise their confidence about new environmental technologies

✓Helping regulators save time and money when evaluating environmental technologies

✓Guiding technology developers in the collection of performance data to satisfy the requirements of multiple states

✓Helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations

✓Providing a reliable network among members of the environmental community to focus on innovative environmental technologies

**How you can get involved with ITRC:**

✓Join an ITRC Team – with just 10% of your time you can have a positive impact on the regulatory process and acceptance of innovative technologies and approaches

✓Sponsor ITRC's technical team and other activities