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FEDERAL RADIOLOGICAL

MONITORING AND ASSESSMENT CENTER

FRMAC LABORATORY ANALYSIS MANUAL

The Federal Manual for Performing Laboratory Analyses during a Radiological Incident

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FRMAC Laboratory Analysis Manual

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FRMAC is an acronym for Federal Radiological Monitoring and Assessment Center.

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Preface

This manual is written for personnel who respond to a nuclear/radiological incident that will be called upon to provide support to ensure that samples receive appropriate laboratory analyses. Overall, this manual provides general guidance and some specific diagrams and forms. However, it is understood that site- and incident-specific operational decisions and procedures may need to be modified at the time of an incident. This manual is intended to provide guidance for laboratory analysis personnel without limiting FRMAC's ability to integrate the work with other partners or stakeholders. Some of the titles of management positions within the FRMAC have been changed in order to comply with the structure of the Incident Command System (ICS) under the National Incident Management System (NIMS).

The NNSA/NSO has the overall responsibility for maintaining the master copy of all FRMAC manuals. Please provide comments on this manual to:

U.S. Department of Energy
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Special recognition goes to the members of the FRMAC Laboratory Analysis Working Group for their work on this revision in developing a laboratory analysis community consensus and identifying the appropriate analysis methodologies.

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Acknowledgment is given to those who participated in development of the previous version of the manual. This revision is built upon those efforts.

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Acronyms and Abbreviations

AAL	Analytical Action Level
AFRAT	Air Force Radiation Assessment Team
ALI	Annual Limit of Intake
AR	Analysis Request
ARF	Analysis Request Form (see Appendix E)
BAFB	Brooks Air Force Base
BNL	Brookhaven National Laboratory
CA	Coordinating Agency
CDC	Center for Disease Control and Prevention
CDE	Committed Dose Equivalent
CEDE	Committed Effective Dose Equivalent
CM	Consequence Management
CMHT	Consequence Management Home Team
CMRT I	Consequence Management Response Team Phase I
CMRT II	Consequence Management Response Team Phase II
CMWeb	Consequence Management Website
CoC	Chain of Custody
CRCPD	Conference of Radiation Control Program Directors
DHS	U.S. Department of Homeland Security
DIL	Derived Intervention Level
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOECAP	U.S. Department of Energy Consolidated Audit Program
DOELAP	U.S. Department of Energy Laboratory Accreditation Program
DOT	U.S. Department of Transportation
DQO	Data Quality Objective
DRL	Derived Response Level
DVF	Data Verification Form
DWC	Derived Water Concentrations
EDD	Electronic Data Deliverable
eFRMAC	Electronic FRMAC data management systems
ERLN	Environmental Response Laboratory Network
EPA	U.S. Environmental Protection Agency
ES&H	Environmental Safety and Health
FAD	Functional Area Drill
FDA	Food and Drug Administration
FERN	Food Emergency Response Network
FRMAC	Federal Radiological Monitoring and Assessment Center
H&S	Health and Safety
IATA	International Air Transport Association
ICLN	Integrated Consortium of Laboratory Networks
ICS	Incident Command System
LAM	Laboratory Analysis Manager
LANL	Los Alamos National Laboratory
LCS	Laboratory Control Samples

LLNL	Lawrence Livermore National Laboratory
LoQ	Limit of Quantitation
LRN	Laboratory Response Network
MAPEP	Mixed Analyte Performance Evaluation Program
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MQO	Measurement Quality Objective
NIST	National Institute of Standards and Technology
NIMS	National Incident Management System
NNSA	National Nuclear Security Administration
NRF	National Response Framework
NRIA	Nuclear/Radiological Incident Annex
NSO	Nevada Site Office
ORNL	Oak Ridge National Laboratory
PAG	Protective Action Guides
PNNL	Pacific Northwest National Laboratory
POC	Point Of Contact
PT	Proficiency Testing
QA	Quality Assurance
QC	Quality Control
RAMS	Radiological Assessment and Monitoring System
RAP	Radiological Assistance Program
RESL	Radiological and Environmental Sciences Laboratory
RSL	Remote Sensing Laboratory
SCF	Sample Control Form
SCS	Sample Control Specialists
SNL	Sandia National Laboratories
SOP	Standard Operating Procedure
SOW	Statement of Work
TEDE	Total Effective Dose Equivalent
USDA	U.S. Department of Agriculture
WCRM	Well Characterized Reference Material

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Section 1: Introduction

When the FRMAC responds to a radiological/nuclear incident, monitoring, sampling, and radioanalytical support will arrive from a number of different agencies. The respondents providing this support will, in all likelihood, have received varying levels of training and will have experience with different monitoring, sampling, and radioanalytical equipment and procedures. It is important that an acceptable and established set of Standard Operating Procedures (SOPs) is in place to be followed by all personnel having responsibilities for processing samples and analyzing data during the incident.

This manual provides general guidance and some specific diagrams and forms to establish a common operating environment for FRMAC, and other, laboratory analysis personnel. It is understood that site- and incident-specific operational decisions and procedural parameters will need to be established and documented at the time of an incident. It is also understood that FRMAC sample tracking and analysis may be operating in an integrated or coordinated environment with other agencies and jurisdictions, including state or local agencies. This manual is intended to provide enough guidance for stand-alone use without limiting FRMAC's ability to integrate the work with other agencies and jurisdictions and laboratories.

During the Early Phase of an incident, analytical data is urgently needed to establish protective actions. FRMAC response procedures are intended for use in processing relatively large numbers of samples in the shortest possible time. In the early stages of an incident, when the impact on the health and safety of the public is not well defined, the resources dedicated to Quality Assurance (QA) activities must be sufficient to assure that appropriate radioanalytical Measurement Quality Objectives (MQOs) and thereby, assessment Data Quality Objectives (DQOs) are met. As the incident stabilizes, QA activities will evolve commensurate with the need to satisfy the evolving DQOs, which are anticipated to become increasingly rigorous and exacting. DQOs are the elements of a systematic planning approach which, when used to define the MQOs affect a balance and compromise between precise analytical determinations and the timeliness for response activities and decisions.

The Intermediate Phase will require a greater degree of data quality assurance as more rigorous analytical methodologies are employed to support longer-term exposure risk evaluations. During this phase, the role of field measurements and mobile laboratory assets may decline if they are not able to meet the more rigorous MQOs needed to satisfy the assessment DQOs and support assessment decisions. These more rigorous objectives may require the use of off-site laboratories, with greater capacity and enhanced capabilities. The role of local analytical capability may also decline depending on its capacity and ability to adapt to these intermediate phase DQOs and MQOs. Larger capacity and greater capability laboratories across the country will likely become the mainstay of the analytical effort as the incident evolves into the recovery phase. These laboratories may be geographically distant from the incident, which will increase sample management challenges. The relative role of field measurements, mobile laboratories, and off-site laboratories will depend on the radionuclides of concern for the specific incident. This manual addresses the processes and procedures for coordinating sample analyses during FRMAC operations.

These procedures are applicable to a FRMAC response to an incident and may or may not be used by the Coordinating Agency (CA) during the Late Phase (recovery) of an incident.

Section 2: Laboratory Analysis Division and Operations

The Nuclear/Radiological Incident Annex (NRIA) to the National Response Framework (NRF) addresses the response of Federal agencies to incidents involving nuclear or radioactive material. The NRIA specifically assigns U.S. Department of Energy (DOE) responsibility for on-scene analytical capability supporting assessment and indicates that this should be done in cooperation with other Federal agencies. DOE has been given the FRMAC management responsibility of such operations.

The Laboratory Analysis Manager receives direction from the FRMAC Deputy Director and provides direction to the staff supporting the Laboratory Analysis Division. Figure 2-1 shows the structure of the Laboratory Analysis Division. Complete FRMAC organization charts are available in the *FRMAC Operations Manual.* The FRMAC Laboratory Analysis Division will be staffed with personnel to carry out the functions of laboratory coordination, sample control, data entry, sample tracking, shipping, and quality control. Although these functions may initially be filled by DOE/ National Nuclear Security Administration (NNSA) personnel, responders from the various agencies will be needed to handle the large number of samples collected from a major nuclear/radiological incident. The organizational structure depicted in Figure 2-1 is used to set up and operate the FRMAC Laboratory Analysis Division.

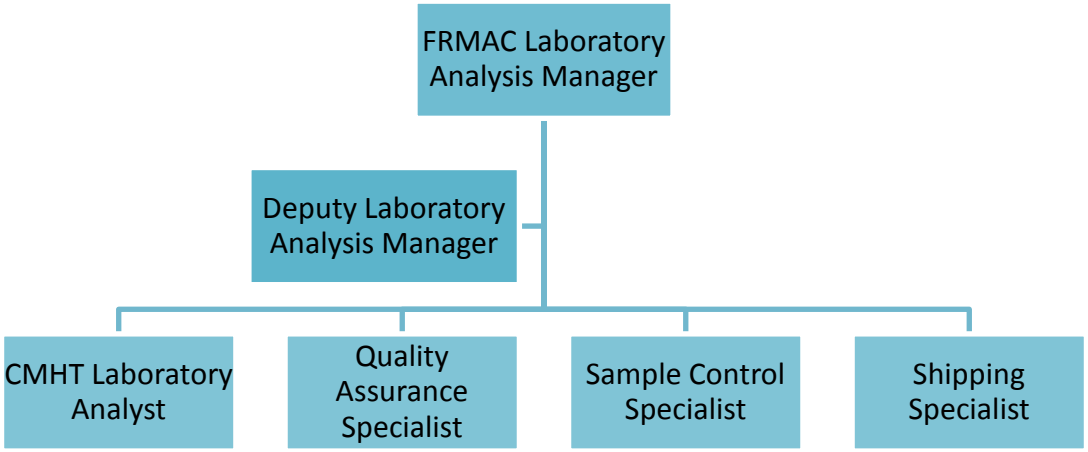

Figure 2-1. FRMAC Laboratory Analysis Division Structure

- The laboratory resources that support the FRMAC may be composed of a variety of federal, state, other government, local and commercial assets that are requested to respond to the incident.

- State or local mobile laboratory resources may arrive first on scene, and coordinate with the federal assets as they arrive.
- The DOE provides a mobile fly-away laboratory for early phase rapid analysis capability as well as ability to analyze high activity samples.
- The EPA shares responsibility with DOE for the analysis of radiological samples collected during an incident and provides support with the U.S. Environmental Protection Agency (EPA) mobile laboratories. EPA has two mobile sample preparation laboratories, two mobile radiation measurement laboratories and two mobile command posts (one based in Montgomery, AL and the other in Las Vegas, NV) which they may bring to the incident scene.
- The Air Force Radiation Assistance Team (AFRAT) also has considerable mobile laboratory capability, which they can deploy; however this capability has a primary mission of providing Health and Safety (H&S) support to the military responders but can be modified at the discretion of the gaining command.
- Civil Support Teams (National Guard) located throughout the US have responders with limited radiological analysis equipment that may be used to respond to a radiological incident.

Integration of these varied assets is key to the success of the laboratory analysis mission.

When the FRMAC responds to a radiological/nuclear incident, analytical data will be needed to establish protective actions. For example:

- Analytical results from air filters collected near the incident scene will dictate respiratory protection requirements for responders and provide a measure of airborne concentrations to which the public may be exposed.
- Analytical results from soil and surface samples (swipes) will provide a measure of surface deposition and are used to determine protective action recommendations and on-site health and safety controls.
- Alpha and gamma spectroscopy of early samples provides the quantity and limited identification of each radionuclide present (mixed or multiple sources).
- Liquid scintillation analysis indicates if there is tritium or other low energy radionuclides present.

A dedicated sample processing area with personnel that are trained to work with radiological materials will perform sample screening, splitting, packaging, and shipping.

The FRMAC Laboratory Analysis Division will be physically set up nearby but likely outside of the actual FRMAC in a convenient location where:

- communication lines can easily be run and in proximity to the hot-line where potentially externally contaminated samples are received and managed.
- adequate space for a hotline and contamination control station,
- a tent for Sample Control operations,
- a staging area and storage area,
- an acceptable area to locate the mobile and fly-away laboratories.
- access to the Radiological Assessment and Monitoring System (RAMS) and the internet

- phone or radio communication with the FRMAC and responding laboratories can be established.

The FRMAC Laboratory Analysis Manager as well as other staff will need to attend frequent meetings with FRMAC leadership to coordinate and prioritize activities.

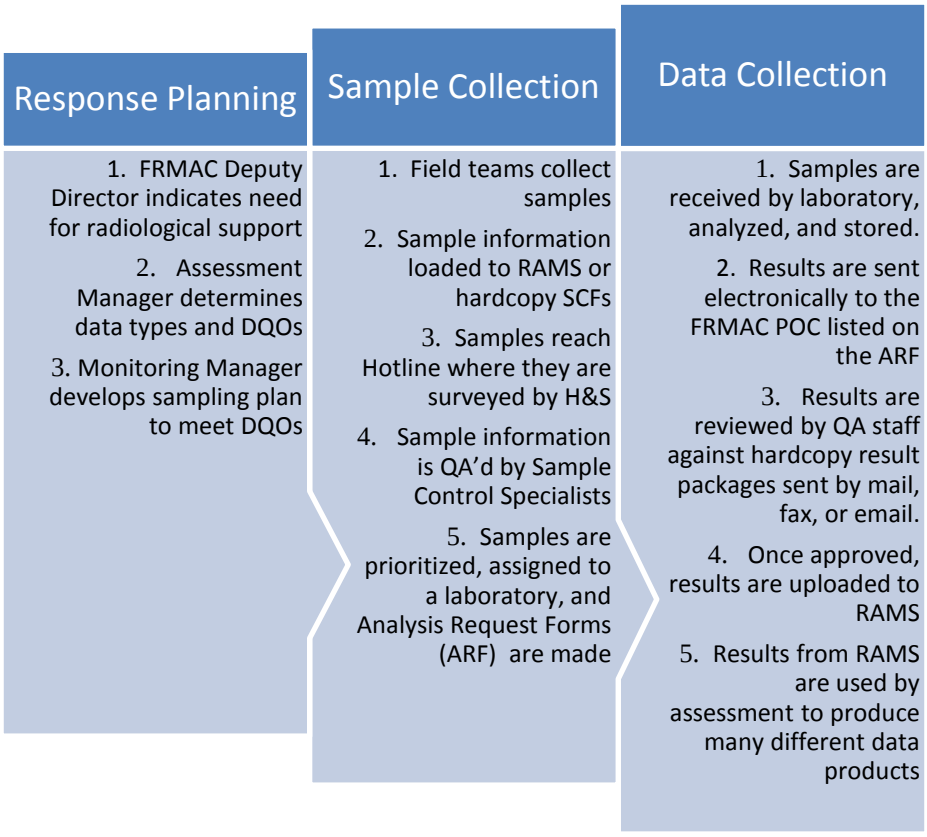

Figure 2-2: FRMAC Laboratory Analysis Process

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Section 3: Responsibilities

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3.1 Introduction

Below are brief descriptions of each of the major operational functions within the Laboratory Analysis Division. Complete job descriptions and training requirements are included in Appendix A.

3.1 FRMAC Laboratory Analysis Manager

The FRMAC Laboratory Analysis Manager maintains close coordination with the Deputy Laboratory Analysis Manager and the Quality Assurance (QA) Specialist. The Laboratory Analysis Manager communicates and interfaces with the FRMAC Deputy Director and the other FRMAC managers (mainly Assessment, Monitoring and Sampling, Health and Safety, and Support) to ensure that the Laboratory Analysis Division is appropriately resourced and that the necessary information is received from, and provided to the other FRMAC organizations. The Laboratory Analysis Manager also works with the Assessment Manager and Monitoring Manager to ensure that samples collected (and the analyses that are requested) will enable the Assessment Scientist to make the necessary decisions and meet the intent of the defined Data Quality Objectives (DQOs). The Laboratory Analysis Manager will also ensure that Measurement Quality Objectives (MQOs) sufficient to achieve the DQOs are established and communicated to the laboratories, that the laboratories provide feedback on their ability to achieve the MQOs, that the laboratory data is reviewed and approved/qualified as appropriate to ensure Assessment is advised of the quality of the data. Typically one individual is assigned to this role per shift.

3.2 Deputy Laboratory Analysis Manager

The FRMAC Deputy Laboratory Analysis Manager directs all on-site laboratory analytical activities and maintains close coordination with the FRMAC Laboratory Analysis Manager, Consequence Management Home Team (CMHT) Laboratory Analyst team member(s), Sample Control, Quality Assurance, and Shipping Specialists providing support to the FRMAC. The Deputy acts as the point of contact for queries regarding the status of a sample analyses. The Deputy ensures that the samples are submitted to the laboratories and that the reports are received and reviewed for accuracy and quality. Typically one individual is assigned to this role per shift.

3.3 Consequence Management Home Team Laboratory Analyst

The CMHT functions as a virtual extension of the FRMAC. The CMHT Laboratory Analyst functions as the FRMAC contact for laboratory information until deployed Laboratory Analysis capability arrives. The CMHT Laboratory Analyst team member is responsible for gathering available operational information to understand the developing needs for laboratory support, activating the off-site laboratories and communicating their analytical capability and capacity to the Laboratory Analysis Manager and Deputy Laboratory Analysis Manager. CMHT Laboratory Analyst will accept/review/validate the data provided by the off-site laboratories and ensure that this information is properly reviewed and entered into the Radiological Assessment and Monitoring System (RAMS) database. When the FRMAC on-site Laboratory resources are operational, the CMHT Laboratory Analyst will continue to receive/review/verify sample and

QA results from the off-site laboratories, and support the field assets as requested. Typically one individual is assigned to this role per shift. However, for a large incident this could increase to two or more individuals.

3.4 Quality Assurance Specialist

The FRMAC Quality Assurance Specialist coordinates the collection of quality assurance samples with the Monitoring Manager and the designated monitoring staff. The Quality Assurance Specialist injects Quality Control (QC) samples into the sample stream and reports results from QC samples. He/she investigates the causes of unusual quality assurance results and brings unusual results to the attention of the FRMAC Laboratory Analysis Manager and Deputy. The Quality Assurance Specialist is also responsible for reviewing/verifying/validating analytical data results from the on-site laboratories and entering them into the RAMS and ensuring proper procedures have been followed for all aspects of the sample management. Typically one individual is assigned to this role per shift. However, for a very large incident this may increase to two or more individuals.

3.5 Sample Control Specialist

The FRMAC Sample Control Specialist is responsible for receiving, inspecting, and logging samples that have been submitted, and screened by Health and Safety personnel. After confirming the sample data entry on the sample control forms or in RAMs, they place the samples in the staging area where the samples are prepared for delivery to the laboratories for analysis. Once the samples are prepared for the laboratories, they complete the Analysis Request Form (ARF) and store the samples until they are ready for transport to the laboratories. The Sample Control Specialists works closely with the Deputy Laboratory Analysis Manager, the Quality Assurance Specialist, and the Shipping Specialist. Typically two to three individuals are assigned to this role per shift. However, for a very large incident this may increase to several individuals.

3.6 Shipping Specialist

The FRMAC Shipping Specialist is responsible for packaging of samples and arranging delivery to either the on-site mobile laboratories or off-site fixed laboratories. The Shipping Specialist is responsible for ensuring the shipments meet required transportation regulations. The Shipping Specialist is specifically required to certify any shipment that will be transported under Department of Transportation (DOT) and/or International Air Transport Association (IATA) shipment regulations. The decision of whether or not a shipment is regulated will be made on available data, or data generated by an on-site mobile laboratory's analysis. The Shipping Specialist works closely with the Sample Control Specialists and Deputy Laboratory Analysis Manager. Since regulators have wide interpretations on what specific training is required to certify an individual as a "qualified shipper" (i.e., a person qualified to certify—by signature--a formal manifest) it is up to the individual responders' originating (base) organization to define what they consider to be a "qualified/certified hazardous material shipper" for their organization. Typically one individual is assigned to this role per shift. However, for a very large incident this may increase to two or more individuals.

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Section 4: Laboratory Selection Methods and Procedures

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Figures

4.1 Introduction

The CMHT Laboratory Analyst supports the Assessment and Monitoring managers with the initial development of the response Data Quality Objectives (DQO) related to sampling and analysis. Once the decision to perform sampling activities is made, the next step is to consider the type of analysis required and determine the Measurement Quality Objectives (MQOs) for the analyses. Based on the required analyses, MQOs, turn-around times, and the numbers of samples collected, the samples are assigned to on-site mobile laboratories and/or off-site laboratories for analyses. This chapter addresses the procedures used to evaluate laboratories, both prior to and during a response, for determining which laboratories will be used.

Three time phases; early, intermediate, and late, are generally accepted as being common to all responses to unplanned releases of radioactive materials.

The early phase (also referred to as the initial phase) begins at the time of release of the radioactive material and generally continues until the release has been controlled and initial protective actions have been initiated. Protective actions are generally based on the status of the situation and limited information on the type and quantities of materials present. During this phase the urgency is on obtaining some initial sampling results to understand the nature of the release. The Laboratory Analysis team will begin assessing the release and determining the likelihood of sample collection efforts and the necessary resources to support this need. This phase may last from hours to days.

The intermediate phase is the period beginning once initial protective actions have been taken and after the source releases have been brought under control and reliable environmental measurements are available for use as a basis for decisions on additional protective actions. The intermediate phase requires more rigorous data quality as longer-term exposure risks are evaluated. During this phase, the role of field measurements and mobile laboratory assets will decline if they are not able to meet the MQOs required for Assessment decisions. The relative role of field measurements, mobile laboratories, and off-site laboratories depends on the radionuclides of concern and the MQOs for the specific incident. This phase may overlap with the early phase and may last from weeks to many months.

The late phase (also referred to as the recovery phase) is the period beginning when recovery action designed to reduce radiation levels in the environment to acceptable levels for unrestricted use are commenced, and ending when all recovery actions have been completed. During this phase, DQOs generally require lower detection limits and more rigorous analyses (MQOs), and the role of off-site fixed laboratories will increase (Figure 4-1). During the recovery phase, the responsibility for laboratory analyses of environmental samples transitions from the U.S. Department of Energy (DOE) to the U.S. Environmental Protection Agency (EPA). The recovery phase may extend from months to years.

A graphical representation of how MQOs will change with each phase can be seen in Figure 4-1.

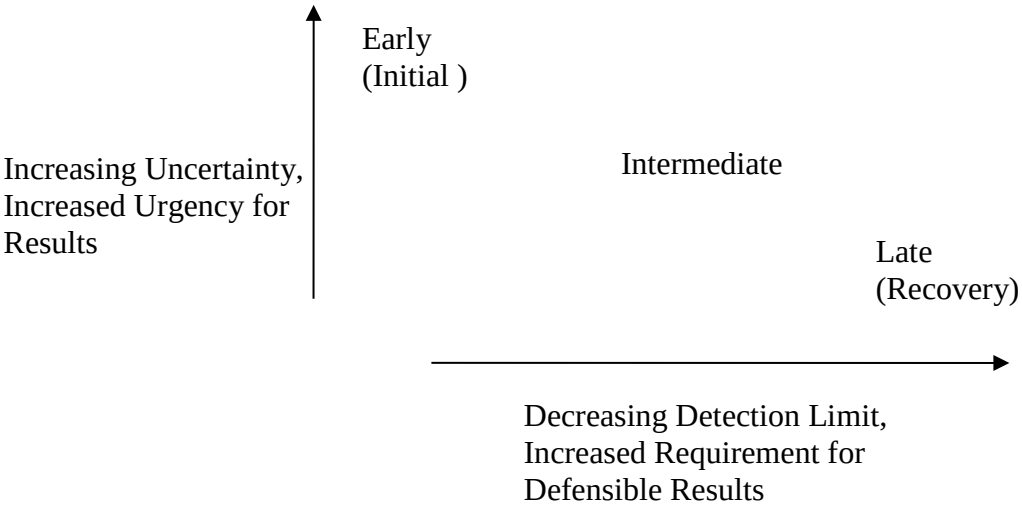

Figure 4-1. MQOs during each Phase of an Incident

It is advisable to select radioanalytical laboratories as early in the monitoring and sampling process as practical. When available, mobile laboratories can provide on-site analytical capability due to their shorter turnaround times as long as they are able to meet the necessary MQOs. Obtaining laboratory or other services may involve a specific procurement process.

It is recognized by the FRMAC that the optimum situation would be for the FRMAC to implement a managed proficiency program sending known samples to various laboratories prior to an incident to ensure those laboratories are able to quantify the radionuclides correctly. This would also make it possible to practice the exchange of samples, sample analysis, and final results. However a program of this nature is extremely expensive to implement and maintain, and is beyond the ability for the FRMAC to support. As a result, the FRMAC is assuming some risk by proceeding without such a program. The plan for mitigation of this risk is that the FRMAC will, to the extent possible, attempt to utilize laboratories that participate in proficiency testing programs such as the Mixed Analyte Performance Evaluation Program (MAPEP), are accredited, and are audited under a recognized program (e.g.; the Department of Energy Consolidated Audit Program (DOECAP)). Also, depending on the event specific situation, FRMAC may ask participating laboratories to exchange samples from the event with other laboratories or may provide control samples for analysis by each laboratory as described in Section 6.

4.2 Laboratory Evaluation and Selection

4.2.1 Purpose

Radioanalytical assets are critical to providing highly important and timely data to the FRMAC Assessment Scientists. Prior to any incident, radioanalytical assets must be identified and their capabilities and capacities evaluated. Radioanalytical assets may include a mix of Federal, State, local, and commercial assets, and may consist of mobile and fixed laboratories of potentially widely varying capabilities. A subjective rating of each of these organization's capabilities and

capacities to meet default MQOs (see Appendix B) associated with a FRMAC response should be documented. Asset identification and qualification is an ongoing process, as new organizations are created and others dissolve, merge, relocate, or reorganize.

The urgency of an incident and the need for a quick answer will determine the role of the local assets. Generally, those radioanalytical laboratories that are not impacted by the incident will be the first ones called upon. Some of these facilities may not normally analyze samples with the potential for significant levels of contamination, but because of their proximity, can still fill an analytical need during the earliest stages of an incident. On-site mobile laboratories should be used as soon as they arrive, either to provide immediate radioanalytical results, or to triage samples for distribution to off-site laboratories. If the local and on-site mobile laboratories do not have the capabilities and capacities to analyze the samples, other commercial and government laboratories should be used as soon as possible; under the condition that they have extended abilities to conduct analyses for virtually any radionuclide occurring in a wide variety of media (soil, water, and vegetation) and have a thorough quality assurance program.

The following sections provide guidance on identification, evaluation and selection of radioanalytical laboratories to provide analyses for a FRMAC response.

4.2.2 Identification of Radioanalytical Assets

The Integrated Consortium of Laboratory Networks (ICLN) was established by the U.S. Department of Homeland Security (DHS) to enhance laboratory resources. Members of the ICLN include the DOE, EPA, FDA, USDA, CDC, DoD and CRCPD. Each of these agencies has identified radioanalytical assets in both the government and commercial sectors. The ICLN should be consulted when identifying radioanalytical assets.

Laboratories included within established networks or accreditation programs should also be considered when identifying and evaluating laboratory capabilities and capacities.

- ERLN – A network of environmental radioanalytical laboratories established by the EPA. Several State laboratories are funded by the EPA to maintain capabilities for radioanalytical analyses for a nuclear or radiological incident.
- FERN – A network of radioanalytical laboratories established by the FDA to analyze for radionuclides in food and agriculture samples. Several State laboratories are funded by the FDA to maintain capabilities for radioanalytical analyses in food and agriculture samples for a nuclear or radiological incident.
- LRN – Currently the CDC is the only laboratory capable of analyzing for radionuclides in clinical samples. (The CDC plans to establish a network of laboratories capable of analyzing for radionuclides in clinical samples.)
- CRCPD – The CRCPD maintains a list of State's radioanalytical laboratories.
- NAMP – The DOE National Analytical Management Program is tasked with coordinating analytical services and capabilities for the DOE laboratories.
- DOECAP – The DOE Consolidated Audit Program maintains a list of laboratories that are audited under the program and provide services to DOE facilities.
- DOELAP – The DOE Laboratory Accreditation Program maintains a list of laboratories that provide radiobioassay services to DOE facilities (samples from the general population are considered clinical samples and are handled by the CDC).

4.2.3 Guidelines for Evaluating Laboratories

Prior to an incident, a subjective evaluation of a radioanalytical organization's capabilities and capacities to process samples for a FRMAC response should be performed and documented. This should be an ongoing process as new organizations are created and others dissolve, merge, relocate, or reorganize. Radioanalytical laboratories identified in Section 4.2.2 should be evaluated. Consider the following when making the evaluation:

- The analyses needed
- The sample matrices
- The required MQOs
- The anticipated sample contamination levels and the laboratories experience in handling these types of samples
- Timeliness of results and sample capacity based on current sample workload.

Equipment calibrations should be performed using National Institute of Standards and Technology (NIST), or other national and international standards laboratories, traceable reference radionuclide standards whenever possible. The adequacy of the facilities, instrumentation, and staff levels can be estimated by either consulting the laboratories directly or by reviewing statements of qualifications and external audit information. The following information can be received from the prospective laboratory and may provide an estimate of the laboratory's capabilities and capacities.

- Is the laboratory experienced in performing the same or similar analyses?
- Does the laboratory have satisfactory performance evaluation results from formal monitoring or accreditation programs?
    - The laboratory should be able to provide a summary of QA audits and proof of participation in inter-laboratory cross-check programs.
- Is the laboratory able to receive incident samples?
    - This criterion considers whether or not the laboratory possesses a radioactive materials handling license or permit for the samples to be analyzed. Large incidents will require more than one analytical laboratory to meet required MQOs.
- Does the laboratory provide an internal quality control review of all generated data that is independent of the data generators?
- Does the laboratory possess documented procedures, instrumentation, and qualified personnel to perform the necessary analyses?
- Are there protocols for method performance documentation and sample security/chain of custody?

Providers of radioanalytical services should have a documented QA program in place. The QA program should include:

- Laboratory organizational structure
- Personnel responsibilities and qualifications
- Written standard operating procedures and instructions
- Inter- and intra-laboratory performance analyses
- Design control to define the flow of samples through the laboratory

- A corrective action process, including verification and validation processes for corrective actions
- An internal audit program.

The Model Scope of Work provided in Appendix F is provided so that radioanalytical laboratories have an indication of (1) what they should be able to provide to FRMAC, and (2) what may be requested by FRMAC as part of a contractual mechanism for procuring radioanalytical services.

4.2.4 Guidelines for Selecting a Laboratory During a Response

This procedure includes steps to identify and select radioanalytical laboratories to meet the needs of a radiological or nuclear incident response. When possible select a laboratory that has been prequalified under section 4.2.3. A primary goal of managing laboratory resources is to obtain sufficient radioanalytical support with the fewest number of laboratories. The use of many laboratories dramatically complicates the logistical requirements for engaging laboratories, scheduling, shipping and tracking samples and data, assuring analytical quality and comparability across laboratories, evaluating data, and monitoring laboratory performance.

The following are factors that impact the decisions on selection of radioanalytical laboratories such as using an on-site verses off-site laboratory, and which off-site laboratories to use:

- Urgency of the data
- Knowledge of the materials released
- Timing of the incident
- Activity levels of samples & the laboratory's activity receipt limits and capabilities
- End use of data
- Ability to detect key radionuclides
- The analyses needed
- The sample matrices
- The required MQOs
- Cost
- The anticipated sample contamination levels and the laboratory's experience in handling these types of samples
- Timeliness of results and sample capacity based on current sample workload.

In order to gather current laboratory capability and capacity information early in an incident the procedure below may be performed before there is detailed information on the analysis needs or a statement of work.

- Utilize the documented information on radioanalytical laboratory capabilities and capacities to identify laboratories that meet potential analysis needs, taking into account the various evaluation items noted, and the location of the laboratories relative to the incident. The following guidelines should be considered when selecting laboratories:
    - Radioanalytical laboratories should be contacted based on their subjective capabilities and capacities rating for the analyses required.
    - Radioanalytical laboratories with larger capacities should be utilized first. This will decrease the logistical requirements for scheduling and tracking samples and

data, assuring analytical quality and comparability across laboratories, evaluating data, and monitoring laboratory performance.
    - Assign samples to radioanalytical laboratories to best utilize their documented capabilities and capacities. Many laboratories may have competing priorities for the analyses of environmental, food and clinical samples, and may be supporting other organizations besides FRMAC.
    - Ensure that the selected radioanalytical laboratory can meet the required MQOs and turn-around times.
- Contact the identified laboratories and verify their current radioanalytical capabilities and capacities. Document this information for use during the incident. This function is performed by the CMHT Laboratory Analyst personnel for the off-site laboratories, and by the Deputy Laboratory Analysis Manager for the on-site mobile laboratories. Use the Laboratory Questionnaire in Appendix E to verify:
    - Current contact information including:
        - Name of contact and alternate contact
        - Telephone number of contact and alternate contact
        - Fax number of contact and alternate contact
        - Email address for contact and alternate contact
        - Shipping address.
    - Acceptance limits on sample activity or dose
    - Required MQOs can be met
    - Required turn-around times can be met.

During the early phase of an incident, it is anticipated that sampling will be minimal, activity levels may be high and MQOs will be achievable under short turn-around times.

- If available, during the early phase of an incident, utilize on-site mobile laboratories or local laboratories, which have the capability to accept the samples, meet the MQOs, and provide short turn-around times for the analyses.
- If on-site mobile laboratories or local laboratories are not available, contact off-site laboratories for the analyses, keeping in mind to evaluate the maximum activity levels acceptable by the laboratories.

As additional monitoring resources arrive on the scene, sampling activities will increase. By the third day, most on-site mobile laboratories should be available.

- On-site mobile laboratories should be used for generally non-complex (e.g.; direct count) analyses that require short turn-around times and to triage samples that will be sent to off-site laboratories.
- If the capacity or capabilities of the on-site mobile laboratories are exceeded, off-site laboratories with extended capabilities should be contacted, keeping in mind the maximum activity levels that each laboratory can accept.

The following figure depicts, given general capabilities and capacities, a laboratory asset-type's role in supporting a FRMAC response. "1", indicates the first choice; "2", the second choice; and, "3", the third choice.

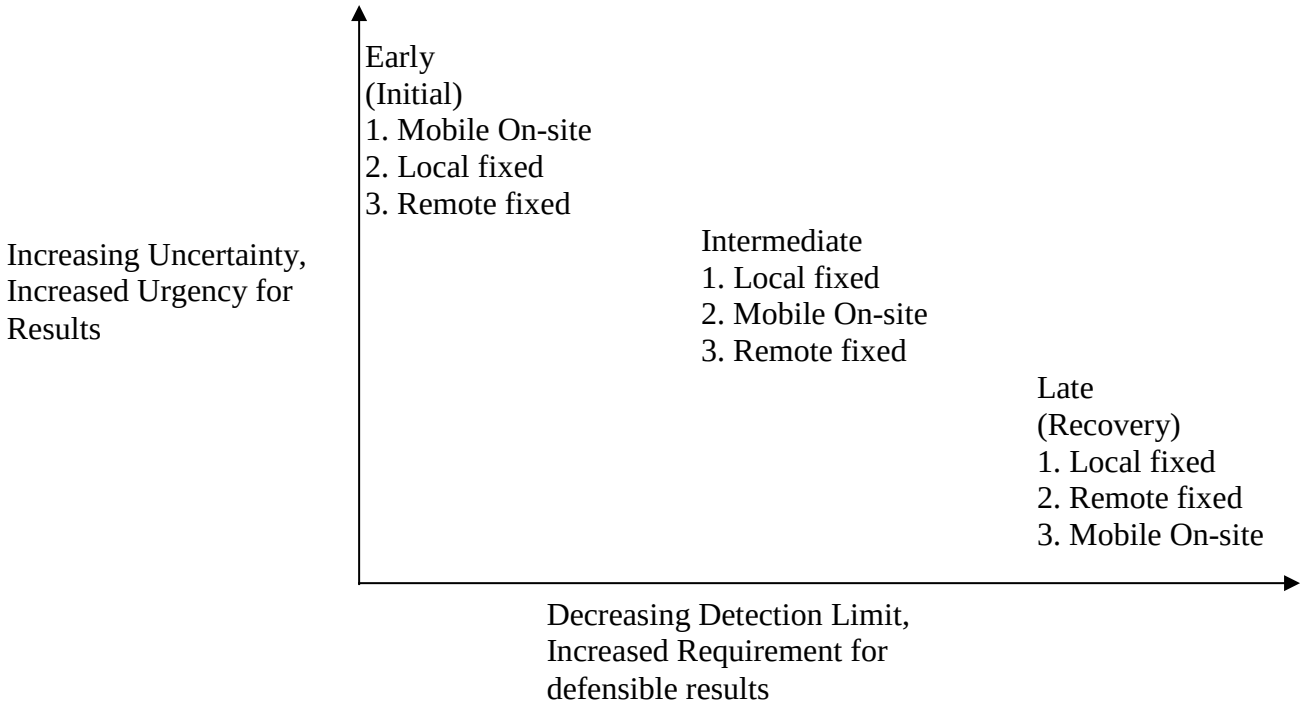

Figure 4-2. Phase-related MQOs & Laboratory Asset Role

4.2.5 Records

Information on the identification of radioanalytical assets is maintained by the FRMAC Laboratory Analysis Working Group. Contact information for the various radioanalytical laboratories is stored in the Radiological Assessment and Monitoring System (RAMS) database.

Information on the subjective evaluation of laboratory capabilities and capacities is also maintained by the FRMAC Laboratory Analysis Working Group. This information is stored on a secure web-server (CMWeb) with limited access and will be managed at its appropriate sensitivity level. This information may only be used by the FRMAC Laboratory Analysis Division to make decisions regarding laboratory selection and activation and the distribution of samples during an incident.

The completed Laboratory Questionnaire is maintained by the Deputy Laboratory Analysis Manager and/or the CMHT Laboratory Analyst personnel.

Section 5: Sample Control Process and Procedures

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Sample tracking encompasses the identification of samples, their location, and the individuals responsible for their custody and transfer of custody. This covers the entire process from collection of the samples to final holding or disposal. The process begins with the collection of the sample, its identification, and determination of appropriate analysis. These essential elements are crucial to relating the analytical result to a sampling location. Tracking samples from collection to receipt at the analytical laboratory is accomplished by utilizing a documented Chain-of-Custody (CoC) process. Samples received by the laboratory are then tracked by the analytical laboratory's internal tracking procedures and correlated to the CoC documentation.

CoC documentation for each sample is important. There must be sufficient evidence to demonstrate that the integrity of the sample is not compromised from the time it is collected to the time it is analyzed. Hence, the sample should either be under the complete control of the FRMAC or secured and protected from any activity that could change the true value of the results or the nature of the sample. Ensuring that a clear transfer of the custodial responsibility is well documented and no questions exist as to who is responsible for the sample at any time is critical to ensure the validity of the analysis.

All samples leaving the incident site should be accompanied by an Analysis Request Form (ARF). This form documents sample custody from the FRMAC to the laboratory. The individuals relinquishing the sample and those receiving the sample must sign and date the record. The record should include a list of samples, the number of samples in the shipment container, and the analysis requested for each sample. In addition, the requested MQOs for the samples and any other requirements will be defined.

A protected and secure sample storage area (building, trailer, shed) with adequate shelving and refrigeration (if necessary) for the samples collected during the incident should be requested by the FRMAC Laboratory Analysis Manager or CMHT Laboratory Analyst personnel. The area must be secured when sample control personnel are not present. This area is to accommodate samples awaiting analysis, and those returned from laboratories following analysis. The samples must be clearly marked and an inventory must be maintained of the samples in storage. The inventory is accomplished with the RAMS database. The sample storage area must be environmentally controlled to prevent spoilage or deterioration of samples. Samples may be destroyed only at the direction of the FRMAC Laboratory Analysis Manager after consultation with the Incident Commander and Coordinating Agency. Figure 5-1 depicts the Laboratory Analysis Division's process flow.

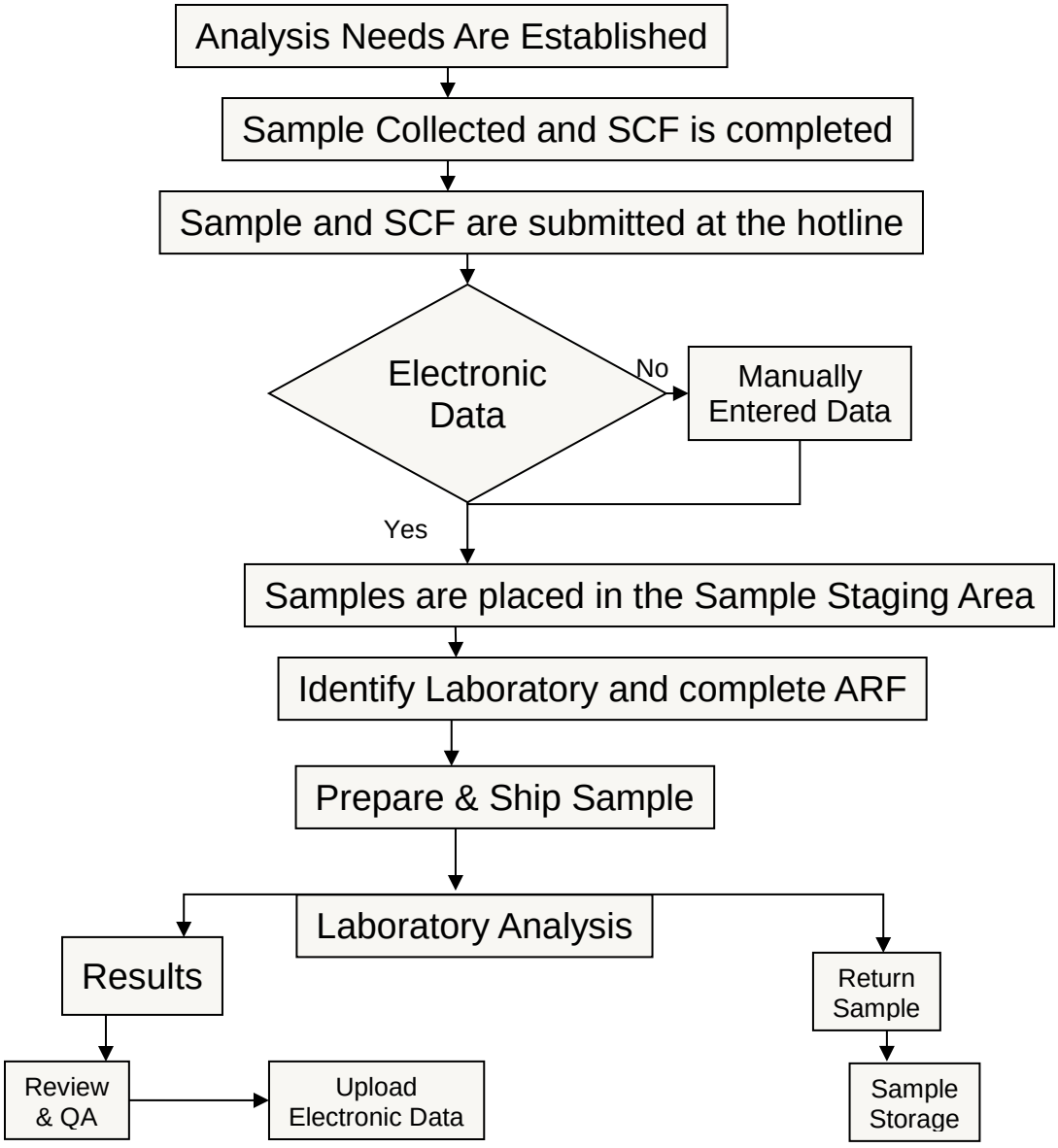

Figure 5-1. Laboratory Analysis Process Flow Diagram

5.1 Sample Control Setup and Operation

Upon arrival, Laboratory Analysis personnel will assist Health and Safety Personnel in establishing a hotline or contamination control station, including a Sample Control Receipt Area, which is sufficient to support sample control needs. A Health and Safety Technician should be assigned to hotline operations. All samples placed at the sample receipt table must be surveyed and additional contamination control will be implemented, as needed, prior to hand-off to the Sample Control Specialists (SCS).

A point of contacts board/list (that contains the Laboratory Analysis Manager, Deputy Laboratory Analysis Manager, Quality Assurance Specialist, CMHT, Shipping Specialist, and eFRMAC contact information) is posted in the sample control tent and updated as needed.

The FRMAC facility may be established by the time that the Laboratory Analysis personnel and assets have arrived on-scene. Consequently, there will be limited options for setting up the Sample Receipt (usually co-located with Hotline operations), Sample Control (staging, storage) and mobile laboratory operations. Additionally, depending on incident-specific situations and sampling decisions, there may be a need to establish forward-staged Sample Receipt locations, from which samples are brought back to a central Sample Control location. However, within existing limitations, the sample control tent housing data entry and other sample control activities should be set-up in close proximity to the sample control receipt area. It should also be located near the FRMAC Command and Control to permit a working connection with the FRMAC RAMS database and also assist in the communication between the FRMAC divisions. Close proximity for these assets will improve communication and sample delivery. If data entry cannot be co-located near FRMAC Command and Control then alternate methods (wireless) will need to be utilized to ensure remote connection to the RAMS database. Consideration should also be given for an area large enough and with electric power to accommodate mobile laboratories that will be setting up in the same vicinity. See Section 7 for additional logistical requirements.

5.1.1 Safety Activities

The FRMAC H&S Division is assigned the responsibilities for the health and safety of all personnel involved in FRMAC operations. The H&S Division assigns a hotline staff member to perform contamination surveys of all samples received by the FRMAC. The H&S Division develops H&S plans for each deployment that identifies hazards associated with the incident and methods to mitigate those hazards. Field teams are briefed daily on work hazards and controls as well as activities to be conducted that day prior to starting work. The Laboratory Analysis Manager or Deputy may be required to attend H&S briefings.

The Laboratory Analysis Manager or Deputy meets with Laboratory Analysis personnel and on-site laboratories to discuss plan of the day items such as expected sampling, situational awareness, and health and safety issues of concern.

5.2 Sample Receipt, Login, and Chain of Custody

All samples associated with the FRMAC operation are received through the sample control receipt line. Samples are received from field monitoring personnel, surveyed, and logged in. The sample CoC is established at the point when the sample is collected via electronic tablet or by hardcopy methods. The CoC is then transferred to Laboratory Analysis when the samples are submitted at the hotline and documented on the SCF form. Sample priorities and paperwork are checked and samples are placed in a storage area awaiting analysis where they are segregated by activity, priority, media, collection location, or any other pertinent parameter. A sample is defined as being in custody if any of the following conditions are met:

- It is within someone's possession
- It is within someone's view, after being in someone's possession

- It was in someone's possession and then was secured with a custody seal to prevent tampering and placed in a secure area
- It is placed in a designated secure area.

A sample storage area of sufficient size must be set up near the sample control area. This area should be protected from rain, intense sun, freezing, and other intense weather conditions and must be secure so that samples cannot be stolen or tampered with. The FRMAC Laboratory Analysis Manager or CMHT Laboratory Analyst personnel should arrange for this area during arrival and set-up. Since samples may contain a variety of matrices, ice chests, refrigeration, and/or freezers (for ice) should be available for milk, fluid, and/or food samples. Chain-of-custody paperwork should be kept with the samples in this storage area.

Note: *Samples received at the Hotline must be surveyed and verified as being free of removable radiological contamination before handling.*

5.2.1 FRMAC Sample Receipt Process

1. Have field monitoring personnel upload tablet data to RAMS via the docking stations if data has not already been uploaded remotely
2. Record survey readings on the outside of the sample container and on the Sample Control Form (SCF).
3. Place any samples that are determined to be externally contaminated in a plastic bag and seal the sample inside. Have the hotline staff member perform another contamination survey on the newly packaged sample. Complete a Non Conformance Form indicating the status of the sample and submit it to the Deputy Laboratory Analysis Manager for resolution.
4. If the field monitoring personnel collected the sample information in the tablet, ensure the Tablet Box is checked if using the Sample Control Form (see Appendix E).
5. Have the submitter of a non-FRMAC sample complete a Sample Control Form and place a FRMAC barcode on the sample. If the submitter was not involved in sample collection, contact the Laboratory Analysis Manager or Deputy for direction on proceeding.
6. Survey the Sample Control Form and place it in a plastic bag if it is found to be contaminated and initiate a Non Conformance Form for resolution by the Deputy Laboratory Analysis Manager.
7. Ensure that the correct barcode label identifying the sample is affixed to the Sample Control or Analysis Receipt Form.
8. Check the security seal on the original sample container to be sure it is intact. Note any discrepancies on the Sample Control or Receipt Form.
9. Weigh the sample (exceptions are air filters and swipes) and record the weight in grams on the Sample Control or Receipt Form.
10. Ensure that all of the required sample control information is correct. Sign for custody of the samples before releasing the sample collection personnel.

5.2.2 eFRMAC Sample Login Process

1. Verify that the sample and information on the SCF or Receipt form is in RAMS (see Appendix D). The following is the minimum amount of information needed to process the sample for analysis.
    - SCF number
    - Collection Team ID
    - Contact Dose Rate (from Health and Safety personnel)
    - Sample Type Identified (Air, Milk, Soil, Water, or Other)Sample Location
    - Sample Collection Time
    - Sample Volume (air samples)

Note: *If sample type is air, then filter size and flow information or total volume must be provided.*

2. If the sample information is complete in RAMS, place a "green sticker" on the upper right hand corner of the SCF or Receipt Form. Do not cover the barcode label with the sticker. The green sticker indicates that no additional information is needed to be entered into RAMS.
3. If the sample does not exist in RAMS, ensure the minimum amount of information is collected on the SCF or Receipt Form.
4. If the missing information becomes available, input the information into RAMS and place a "green sticker" on the upper right hand corner of the SCF(s) or Receipt Forms. If it is not available, you will need to enter the information into RAMS at a later time (see Appendix D). File the SCF with the other "incomplete SCFs".
5. If the minimum information is not available, file a FRMAC Sample Non-Conformance Form for the sample and place it in the appropriate storage location (see Appendix E).
6. Have the individual who brought the sample(s) sign and date the "relinquished by" line located on the bottom of the form(s).
7. Fill in "sent to storage" on the received by line, sign and date the "relinquished by" line and send the sample to the appropriate storage area.
8. Tear off the top copy of the form (which will always remain with the sample) and provide it along with the sample to the Shipping Specialist for placement into storage.
9. Record the sample information into the hardcopy FRMAC Sample Control Logbook.
10. Retain the copy of the SCF (and any Non-Conformance Forms) in the Sample Control Area.

5.2.3 Manual Sample Login Process

1. If the RAMS database is not operational, have the field monitoring team member fill in the minimum required information onto the SCF (either from the information contained on the tablet or by process knowledge) or on the Receipt Form. The following is the minimum amount of information needed to process the sample for analysis.
    - SCF number
    - Collection Team ID
    - Contact Dose Rate (from Health and Safety personnel)
    - Sample Type Identified (Air, Milk, Soil, Water, or Other)
    - Sample Collection Time

- Sample Volume (air samples)

Note: *If sample type is air, then filter size and flow information or total volume must be provided.*

2. Follow steps 4 through 10 in section 5.2.1.

5.3 Preparing an Analysis Request

The Deputy Laboratory Analysis Manager groups the samples, defines their priority, and defines the laboratory to which the samples and the associated documentation will be sent.

5.3.1 eFRMAC Process

1. Retrieve an Analysis Request Form (ARF) number from the hardcopy Analysis Request Log.
2. Complete an Analysis Request Form in RAMS for the batch of samples being sent to a laboratory (see Appendix E). Make sure to include the desired MQOs on the form. Each Analysis Request Form shall have only one laboratory specified.

   Note: *Analysis Request Forms are prepared for sending samples to both on-site and off-site laboratories.*

3. Attach one copy of the barcode from each sample SCF or Receipt Form(s) to the original Analysis Request Form printed from RAMS (use back of form if necessary).
4. Create a folder with the Analysis Request Form number and the laboratory that will be performing the analysis written on the tab.
5. Make a copy of the Analysis Request Form and place it in the folder along with the copy of the SCF or Receipt form(s).
6. Place a "green sticker" in the upper right hand corner on the copy of the Analysis Request Form. The green sticker indicates that no additional information is needed to be entered into RAMS.
7. Once the Analysis Request Form is complete provide the original form to the Shipping Specialist for shipment/delivery to the laboratory.
8. If there are any SCF items requiring entry into RAMS (indicated by "No green sticker" on paperwork) pertaining to the Analysis Request Form, place the folder in a bin so that the items can be addressed in RAMS when it becomes available.
9. If there are no items in the folder requiring entry into RAMS, (indicated by "green stickers" on all the paperwork) place the folder in the filing cabinet to await results from the laboratory.

5.3.2 Manual Process

1. Retrieve an Analysis Request Form (ARF) number from the hardbound Analysis Request Log.
2. Complete a hardcopy FRMAC Analysis Request Form (see Appendix E) for the batch of samples being sent to a laboratory. Make sure to include the desired MQOs on the form. Each Analysis Request Form shall have only one laboratory specified.

Note: *Analysis Request Forms are prepared for sending samples to both on-site and off-site laboratories.*

3. Follow steps 3 through 9 in section 5.3.1.

5.4 Sample Shipping

All samples being shipped for radiological analysis must be characterized adequately for shipping purposes, packaged, and labeled before transport. The primary concern is the possibility of spills, leaks, or breakage of the sample containers. In addition to the loss of samples and cross-contamination, the possible release of hazardous material poses a threat to the safety of persons handling and transporting the package. All applicable U.S. Department of Transportation (DOT) and International Air Transport Association (IATA) regulations shall be followed when shipping samples to laboratories for radiological analysis.

Sample control personnel will provide a completed Analysis Request Form (ARF) for each batch of samples needing shipment for radiological analysis.

1. Retrieve the samples from sample storage.
2. Visually inspect each sample container for indication of leaks or defects in the sample container.
3. Ensure that proper environmental controls have been applied to the sample to ensure adequate sample condition is maintained.

   Note: *The FRMAC does not have the ability to transport or carry acids (sample preservatives) in the field. However, other Federal Agency sampling protocols may require the use of acids in their sample collection processes. The presence of preservatives is indicated to the laboratory on the Analysis Request Form.*

4. If a problem is noticed that does not allow for the analysis of the sample, complete a FRMAC Sample Non Conformance Form (see Appendix D to complete an electronic NCF or Appendix E if RAMS is unavailable and a hardcopy must be created). If the sample cannot be shipped to the laboratory, attach a copy of the FRMAC Sample Non Conformance Form to the sample's SCF or Receipt Form and return the sample to sample storage along with its SCF. A copy of the FRMAC Sample Non Conformance Form must be provided to sample control personnel so that they may notify the appropriate personnel. Sample Control Specialists must also remove the sample from the ARF in the RAMS database and change its status to "hold" since the sample will not be sent to the laboratory for analysis.
5. If the samples are acceptable, sign and date the "relinquished by" section of the ARF form. Make a copy for the file folder associated with the Analysis Request located in the sample control tent. Once this form is received, Sample Control Specialists need to update the sample status in RAMS (if applicable) as "sent to lab" (see Appendix D). If sending the samples to an on-site laboratory making the copy of the form and changing the sample status in RAMS can be completed once the paperwork is received from the on-site laboratory.

6. Include the original, signed and dated Analysis Request Form, identifying each sample in the package. It is good practice to place this form in a plastic bag to prevent it from becoming wet or contaminated in case of a spill during shipment. Multiple packages of samples may be covered by a single ARF that reflects each package.
7. Ensure the ARF adequately meets the information requirements for the receiving laboratory before sending samples to off-site laboratories.
8. Seal the package and apply CoC tape in such a manner that it must be torn (broken) in order to open the package; you may also apply CoC tape to each individual sample if applying tape to the external package creates a problem during shipment.
9. If samples are sent on-site to the mobile laboratories, have the mobile laboratory personnel sign and date the "received by" line of the ARF form and provide a copy to the Sample Control Specialists located in the Sample Control Tent. The Sample Control Specialist will update the sample status in RAMS to "sent to lab" (see Appendix D).
10. If samples are sent off-site for analysis, the carrier is responsible for complying with all applicable federal, state, and local regulations.
11. Discuss the custody objectives with the shipper to ensure that the objectives are met. For example, if the samples are sent by mail and the originator of the sample requires a record that the shipment was delivered, the package should be registered with return receipt requested. If, on the other hand, the objective is to simply provide a written record of the shipment, a certificate of mailing may be less expensive and appropriate.
12. Provide copies of all shipping documents to the Sample Control Specialists for retention in the file associated with the Analysis Request Form.

5.4.1 Packaging Guidance

If a custody seal was in place upon receipt but has been broken during handling prior to shipment, contact the Deputy Laboratory Analysis Manager to determine how to proceed. As long as the sample has been maintained in a secure location, it is expected that a new initialed seal may be placed on the container, in which case this action must be documented.

1. Place each sample in an appropriate secondary container that will help prevent breakage during transit. This packaging also provides for secondary containment if the samples break in transit. If the primary sample container is glass, package the sample with enough cushion material to avoid breaking in transit. Any liquid sample should be packaged with absorbent material if the primary container leaks in transit.
2. Place samples in an ice chest, or suitable strong, tight container.
3. Surround samples with blue ice packs, or other temperature preservation material as necessary.
4. Cushion with a suitable absorbent material if shipping sludge or liquid matrices.
5. Affix orientation labels on the front and back of the container, for all liquid sample shipments.
6. Weigh the shipping container rounding to the nearest pound.
7. Document Transfer of Custody to Carrier:
    a. Sign and enter the date and time (carrier estimated pickup time) on the area of the form designated for relinquishing samples.
    b. Enter the shipping date and time and the name of the carrier and the tracking number.
    c. Make the necessary copies of the original CoCs for the file.

d. Place the original CoC and any other associated paperwork in a plastic bag affixed to the outside of the first container.
e. If this is a multiple package shipment, make as many COC copies as there are additional packages, stamp each "copy", place in a Ziploc® bag and include on each additional container.
f. Seal the shipping container(s) by wrapping each end twice with strapping tape or an equivalent tape.
g. Place initialed and dated custody seals on the strapping tape across front and back diagonal corners of the shipping container(s), ensuring the seals cover the lid-body junction of the container.
h. Transfer the shipping container(s) to the carrier.

5.5 Laboratory Data Deliverables

5.5.1 Purpose

Sample information and analytical results are managed in hardcopy format using standard filing practices, with electronic records managed in RAMS, which provides electronic management of sample chain-of-custody, shipment, analytical results, quality assurance, data review, and electronic transfer of analytical results.

Analyses requests are initiated by the Deputy Laboratory Analysis Manager. Samples sent to radioanalytical laboratories are accompanied by an Analysis Request Form. This form is either electronically generated using RAMS or manually created if RAMS is unavailable. An example of an Analysis Request Form is provided in Appendix E. The required MQOs and the format for the Electronic Data Deliverable (EDD) will also be provided to the radioanalytical laboratories. The required MQOs and EDD may be provided separately to the radioanalytical laboratories via email.

Radioanalytical laboratories analyzing samples for FRMAC must provide both hardcopy and electronic results as soon as available, in order for Laboratory Analysis to verify the electronic data prior to loading and processing the data in RAMS. If electronic results are provided ahead of hardcopy reports, care must be taken to ensure the electronic records are correct, since many laboratories may be:

- more experienced with producing hardcopy results (instrument or Laboratory Information Management System print-outs) as opposed to electronic deliverables,
- relatively inexperienced with the FRMAC EDD format and data value expectations, and
- generating the EDD by manual data entry, which under schedule demands increases the likelihood of errors.

On-site mobile laboratories should submit the EDD and paper copies of the analysis results to the FRMAC QA Specialist. Off-site laboratories should email the EDD to the CMHT and e-mail (via PDF or other format), mail and/or fax paper copies to the CMHT.

5.5.2 Electronic Data Deliverables

Analytical results are required to be reported using the EDD format provided. The EDD is a Microsoft Excel worksheet which contains columns labeled with the required fields. An

example of the EDD along with an explanation of the information required is included in Appendix C.

Upon completion of the analyses, the radioanalytical laboratory must complete the EDD. On-site laboratories will provide the EDD file along with paper copies of the analytical results to the Quality Assurance Specialist. Off-site laboratories will email the EDD file to the CMHT. Paper copies of the results shall be sent by e-mail (via pdf or other format), mail or faxed to the CMHT. The QA Specialist and CMHT Laboratory Analyst personnel will review, verify, and validate the data (see Section 6), upload the results to RAMS and qualify the electronic records in accordance with the review protocols.

5.5.3 Records

Laboratory analysis records are maintained by the QA Specialist at the FRMAC and the CMHT. At a minimum these sample records shall include:

- Copies of the Sample Control Forms
- A copy of the Analysis Request Form
- A copy of the shipping paperwork.

Analytical Results Records

- The EDD file submitted by the radioanalytical laboratories
- Paper copies of the analytical results submitted by the radioanalytical laboratories
- The completed Data Verification Review form (Appendix E)
- FRMAC non-conformance form (if applicable)

Sample Record files are created at the FRMAC.The QA Specialist is responsible for transferring the Sample Records for samples sent to off-site laboratories to the CMHT. The QA Specialist retains the sample records for samples sent to the on-site mobile laboratories until analyses are completed and results are reviewed, uploaded to RAMS, verified, and validated. The Analytical Results Records are assembled at the end of the process. The Analytical Result Records are then combined with the Sample Records and maintained at the CMHT.

5.5.4 Electronic Records

All sample information and analytical results are maintained in the RAMS database. EDD files received from radioanalytical laboratories shall be uploaded to a secure file server.

5.6 Samples Returned from the Laboratories

When samples are returned from either the off-site or on-site laboratories, the following steps are to be taken:

1. Sign the form as having received the sample on the Analysis Request Form that is associated with the samples.
2. Retrieve the SCF or Receipt Form(s) from the folder located in the Sample Control Tent.
3. Provide the ARF to Sample Control Specialists so they can update the sample status in RAMS. Change the sample status of the samples in RAMS as “Received from Lab” (see

Appendix D) and file the paperwork in the appropriate folder. If RAMS is unavailable place the ARF in a bin to update in RAMS when it becomes available.

4. Place the sample(s) in storage along with their original SCF or Receipt Forms.

5.7 Sample Retention and Disposal

This section describes the retention, management, and eventual disposal of analytical samples generated during a radiological incident. Samples may be retained both by radioanalytical laboratories (for potential reanalysis) and the FRMAC/Coordinating Agency (for both reanalysis, and evidentiary purposes). All sample aliquots, including those returned from laboratories, must be secured and appropriately maintained until disposal is authorized by appropriate leadership.

The purpose of this requirement is to ensure the proper management of unused portions of potentially hazardous and radioactive analytical samples taken during a radiological incident, both at the locations of off-site and on-site laboratories, and at the site of the incident response itself. It is assumed that the majority of samples will be maintained briefly at the laboratory, and then returned to the response organization. This document does not address the disposal of process waste generated during the analytical process. Adequate facilities and procedures for managing such waste shall be assured before samples are sent to any analytical facility.

The FRMAC Laboratory Analysis Manager has primary responsibility for sample retention and disposal decisions. The task of sample archiving may be delegated to Sample Control Specialists. In a large-scale response, the CMHT Laboratory Analyst personnel may communicate sample retention and disposal requirements to off-site laboratories.

- Off-site and contract laboratories shall retain all unused portions of analytical samples for at least 60 days, but no more than 1 year, after all analyses are complete. Unused samples shall be stored in a manner which allows rapid retrieval of any sample container, and all storage areas shall have sufficient access controls to ensure the chain-of-custody of the samples at all times.
- All laboratories performing analytical work for FRMAC shall either have appropriate waste handling procedures that comply with all applicable regulatory requirements, or shall be capable of returning all unused samples to the Coordinating Agency exercising authority over any response.
- Any sample disposal performed by the laboratories shall comply with all applicable regulations and requirements. The SCF or Receipt Form(s) (in the special remarks section) shall indicate the disposition of the sample (either disposal or return) as well as the sample status changed in RAMS as “disposed.”
- Samples being returned shall be shipped in accordance with applicable DOT requirements and the Analysis Request Form shall accompany the samples.
- Unused samples that are returned to the FRMAC shall be retained by the FRMAC until written authorization for disposal is provided by the Coordinating Agency exercising authority over the response.
    - Samples authorized for disposal by the Coordinating Agency will be disposed of in accordance with all applicable regulatory requirements.
    - Unused samples shall be stored in a manner which allows rapid retrieval of any sample container, and all storage areas shall have sufficient access controls to

ensure that the Coordinating Agency has physical control and custody of the samples at all times.
    - Ultimate responsibility for final sample disposition is held by the Coordinating Agency.
- Copies shall be kept of all communications from the Coordinating Agency authorizing sample disposal.
- Copies shall be kept of all communications from off-site and on-site laboratories assuming responsibility for sample disposal.

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Section 6: Laboratory Data Quality Control

6.1 Purpose

The primary purpose of the FRMAC is to provide Incident Command with a common operating picture of the environmental radiation conditions for planning incident response activities. If a release of radioactive materials impacts a large area, the monitoring process will require a significant amount of time to acquire the data. Every effort must be made to assure that the data are of adequate quality and quantity to support decision-makers. Quality assurance processes affecting laboratory data take place at a number of steps: developing default and incident-specific DQOs and MQOs, pre-qualification of laboratories, incident real-time evaluation of laboratory capabilities and capacities, sample collection, sample receipt, sample preparation for analysis, sample analysis, and data review. Each of these steps is important in obtaining data of a known quality on which decisions may be made. This chapter will describe how quality control (QC) samples and data review processes support this objective.

In order to ensure consistent results amongst analytical laboratories, default gamma libraries specific to various types of radiological/nuclear incidents were developed. Use of these suggested libraries ensures that laboratories are reporting the same radionuclides, based on the same gamma energy lines, abundances and half-live assumptions. The suggested libraries may be modified by the FRMAC Laboratory Analysis Working Group (LAWG) to meet the needs of a specific incident. Such modifications will be provided to the radioanalytical laboratories involved in the analyses of incident samples.

6.2 Quality Control Samples

6.2.1 Purpose

Numerous types of QC samples are available at various points in the environmental monitoring process to support evaluations of different aspects of the effort. Quality control samples which might be used include the following types:

- **Field QC samples:** samples generated in the field to assist in evaluating some aspect of the field conditions or operations. This may include field replicates and field blank samples.
- **Split samples:** samples generated by Laboratory Analysis by aliquoting a portion of the homogenized field sample, and submitting the aliquots independently, to be analyzed either by the same laboratory or different laboratories.
- **Blind Quality Control Samples:** these samples are reference materials which are prepared in various matrices, and are submitted to the laboratory for analysis.
- **Laboratory QC samples**: samples generated by the laboratory either from matrices similar to the field samples (blanks, laboratory control sample, etc.) or from field samples (replicates, spikes, etc.).

With these options, decisions on which QC samples are to be implemented need to be made strategically and judiciously to ensure that the Laboratory Analysis Division's, and thereby the FRMAC's mission, is achieved without overburdening resources. See Appendix F, Model Scope of Work, for guidelines on types and frequencies of laboratory QC samples.

When reviewing data, if differences between observed and known values for laboratory control samples arise that are outside acceptable tolerances or control limits, the potential causes should be investigated thoroughly to indicate areas where important details of the analytical process may have been overlooked. Often a laboratory's observed values agree with the known value within acceptable tolerances, but are biased high or low. Careful documentation of the laboratory's performance in this regard can assist in characterizing the fluctuations of a measurement system or analytical method. Like other performance indicators, large or sudden changes in bias require scrutiny. Care must be used when evaluating results associated with complex and variable matrices. In general, aqueous samples tend to be less affected than other media like soils or heterogeneous materials. However, multi-phase fluids, high solid content, and brackish or saline waters may be more problematic.

6.2.2 Procedure

The procedure below uses a multi-faceted approach to cover a range of possible situations. The Laboratory Analysis Manager and Deputy are responsible for communicating with the other FRMAC divisions and laboratories in order to determine how much emphasis is placed on each facet of the approach.

Collection and analysis of QC samples is useful. This provides information on the sample collection processes, and indicates accuracy and precision of analytical methods. It is generally accepted that variability is more influenced by contaminant distribution in the environment, sampling techniques, and sample processing than the analytical methods employed. The quality assurance program must address this in the process of evaluating laboratory data. Early in an incident, QC samples may not be readily available or it may be determined that processing field samples is a higher priority. At this stage, it is especially important to have pre-qualification information, to communicate with supporting laboratories to understand their capabilities and capacities, and to obtain results from the laboratories recent participation in PT programs.

If a decision is made that samples are to be collected for evaluating background or local reference levels of contaminant, the Laboratory Analysis Manager in coordination with Assessment Scientists and the Monitoring Manager, establish the agreed upon sampling locations that are thought to be at background level for each radionuclide and sample media of concern. This may initially be based on plume models or air dispersion calculations. The purpose of these background locations is to have convenient sampling locations to which field teams may be sent to collect background samples. Once more information is available, establish additional reference sampling locations with elevated levels of contamination.

Whenever possible, prior to collecting and submitting any samples for an incident , each field team should be assigned to collect at least one sample at the background or reference locations and to complete the paperwork and submit these samples to the sample receiving line. If there are problems with the sample collection procedures or the paperwork completion, the field team must be referred to the Monitoring Manager for additional training or resolution of problems.

Reference or background samples shall be submitted as samples to laboratories, but the analysis priority will depend on the current workload and backlog of samples. Reference and background sampling locations will be periodically assigned to each field team.

Results from these background and reference samples will be used to estimate the overall variability of the sampling, sample processing and analysis. They will also be used to check for cross-contamination during collection of samples.

Gathering laboratory information

The CMHT Laboratory Analyst and the Deputy Laboratory Analysis Manager will perform the following at the incident site with the on-site mobile laboratories;

- Obtain capability and capacity information from the laboratory (see Chapter 4), and obtain the latest results for PT program samples that have been analyzed by the laboratory.
- Request copies of laboratory results for instrument performance information and internal QC samples and review the results. Note any potential problems and bring them to the attention of the Laboratory Manager as needed.
- Verify the sample geometries used for the types of samples to be sent to the laboratory and request current versions of their procedures for sample processing and analysis.
- As applicable, provide the laboratory with the radionuclides, and suggested gamma energy lines, abundances and half-lives to be used for gamma analyses.

Field QC samples include field replicates and blanks (field, equipment) and are options for evaluating contaminant distribution in the environment, reproducibility of the sampling process, and to determine if radionuclide contamination is introduced by the sampling process. If field QC samples are collected, in addition to the usual sample receiving protocol, the following actions must be completed:

- Define the data quality objectives for collecting the samples and the intended use of the data.
- Appropriately Identify and associate the samples in RAMS and on the hardcopy paperwork
- Submit the associated field QC samples associated with the incident samples to the same laboratory as the incident samples for analysis.

Split samples are generated by Laboratory Analysis by aliquanting a portion of a homogenized field sample, and submitting the aliquots for independent analysis. The subsequent data will provide a measure of precision. The data use approach should be established up-front (e.g., control limits, actions on imprecise data). The sample splitting process must ensure that the homogenizing and aliquanting is:

- performed in an acceptable area, as determined by the Laboratory Analysis Manager and the H&S Manager.
- performed by qualified personnel in accordance with accepted procedures and that they are using the appropriate equipment (e.g., personal protective equipment, glove box, tools).
- fully and clearly documented both on hardcopy records and in RAMS.

Blind Quality Control samples are reference materials prepared in matrices similar to those collected in the field, and may be sent alone or included with batches of field samples sent to the laboratory for analysis. Laboratory performance on PT samples is an indicator of the

laboratory's ability to determine the analyte in the matrix. Programs administering these types of samples are well-established in the industry as a necessary and important tool in monitoring performance of laboratories, as well as providing a basis for method evaluation and laboratory certification and accreditation. The value of PT programs and samples is unquestionable as part of a pre-qualification strategy (Chapter 4), and is also considered integral to evaluating laboratory performance real-time during an incident. Early in an incident the availability and importance of introducing PT samples is a challenge that the Laboratory Analysis Manager and FRMAC Leadership need to consider. There is the trade-off between the value added as compared to the resources needed to support this effort. As the incident matures there will be more and more desire to implement formal PT samples to help ensure the defensibility of the data. Implementing the real-time PT sample strategy needs to be done while considering the following; (1) laboratories will routinely provide certain preparation and/or instrument quality control data, (2) PT samples may not be a reasonable match (either matrix, contaminants, or concentrations) to incident samples, (3) PT sample analysis demands resources that might otherwise be spent analyzing Consequence Management (CM)/FRMAC samples, and (4) use of PT sample data to evaluate laboratory performance on FRMAC samples, and qualify associated field sample data, may not be straight-forward or definitive (5) what actions are taken if a laboratory fails a PT sample.

The PT sample process will involve:

- ensuring an adequate inventory of samples is brought with, and maintained during the response.
- labeling samples in accordance with transportation and H&S requirements.
- storing samples in an appropriately secured and posted (if necessary) location, both prior to shipment to a laboratory, and when received back from the laboratory, as determined by the H&S Manager.
- logging the samples in the RAMS and clearly indicating that these are PT samples, so as not to confuse them and associated data with actual field samples.
- submitting PT samples to the laboratories as considered necessary to ensure data quality.
- evaluating the data for acceptable performance:
    - If samples from an established program are being used (e.g.; DOE Mixed Analyte Performance Evaluation Program), then the administering organization's grading criteria applies
    - If no criteria are established, the equation below may be used (Z_{CRM}):

$$Z_{CRM} = \frac{x - d}{\sqrt{u_c^{\,2}(x) + u_c^{\,2}(d)}}$$

where:

$\underline{x}$ is the measured value,

$\underline{d}$ is the certified value, and

$\underline{u_c^{\,2}(x)}$ and $\underline{u_c^{\,2}(d)}$ are the squares of the 1 standard deviation of the x and d values, respectively.

Warning limits for Z_{CRM} are +/- 2 standard deviations and the control limits are +/- 3 standard deviations.

- investigating with the laboratory unacceptable performance to determine causes and corrective action.
- appropriately qualifying associated field samples, which may be limited to the affected laboratory batch, or may affect all samples of a certain matrix, or analyzed by a specific method or laboratory.

Laboratory QC samples include those generated from field samples and those from matrices similar to field samples but free of the radionuclides of interest, to the extent possible. The laboratory generates replicates from field samples by taking aliquots of the homogenized sample to process either as a laboratory replicate (similar to a split), or to spike with known amounts of a standard reference material (matrix spike, matrix spike replicate). Evaluation of laboratory generated QC samples is typically performed using prepared samples consisting of media equivalent to a routine analytical sample which is either free of, or contains a known, measurable amount of the analyte of interest. Upon completion of the analysis, the results are compared to the known or accepted value, and the agreement is evaluated using a predetermined criterion.

Laboratory performance:

- **Blanks** assist in monitoring for contamination introduced by the laboratory. Ideally, no target analytes should be present in a laboratory blank at detectable concentrations. If that is not possible (e.g., for naturally occurring radionuclides), those radionuclides should be well-characterized and tracked.

  In addition to comparison of the value to the detection limit (critical level, depending on Assessment DQOs and associated MQOs), the numerical performance indicator for a blank sample used to monitor for unexpected contamination is:

$$Z_{Blank} = \frac{x}{u_c(x)}$$

  where:

  $\underline{x}$ denotes the measured blank activity and

  $\underline{u_c}(x)$ denotes the 1 standard deviation of the x values

  Recommended warning limits for Z_{Blank} are +/-2 standard deviations and control limits are +/-3standard deviations which produce confidence levels of 95% and 99% respectively.

- **Replicate sample** evaluation typically is performed using multiple analysis of the same sample (blanks, spikes, blinds, reference materials, performance evaluation samples, etc.), and evaluating the analyses relative to a statistically based criterion. The reproducibility of analytical results should be evaluated by replicates to establish this uncertainty component.

All analytical batches should be evaluated with respect to precision, whether by using replicates or matrix spike duplicates. Precision is measured by quantifying the difference between the results of a repeated measurement against an acceptance criterion. Limits are placed on the criterion, and data for any batch in excess of the criterion require investigation and corrective action, as appropriate. The numerical performance indicator for duplicates, often referred to as the duplicate error ratio, or Z, is:

$$Z_{Duplicate} = \frac{x_1 - x_2}{\sqrt{u_c{}^2(x_1) + u_c{}^2(x_2)}}$$

where:

$\underline{x_1}$ and $\underline{x_2}$ denote the two measured activity concentrations and

$\underline{u_c{}^2(x_1)}$ and $\underline{u_c{}^2(x_2)}$ are the squares the 1 standard deviation of the x and d values, respectively.

Recommended warning limits for $Z_{Duplicate}$ are +/- 2 standard deviations and control limits are +/- 3 standard deviations.

- **Matrix spike** samples are an indication of the ability of the analytical process to determine the radionuclide in the matrix. Acceptance criteria should be established by the laboratory based on their historical performance for determining a specific radionuclide in a given matrix.
- **Laboratory Control Samples (LCS)** provide information similar to that gained from matrix spike samples, except that a LCS is prepared from an artificial matrix and should therefore be free from effects which might be encountered in spikes performed on field samples. Acceptance criteria, as with matrix spikes, should be based on historic laboratory performance.

Note: *Laboratory Analysis must communicate with the Assessment and Monitoring Divisions if QC samples from field samples will be performed, since additional sample volumes will be required to support all analyses. The necessary sample volume/mass is dependent on the detection levels needed to satisfy Assessment's DQOs, and the amount needed by the laboratory to achieve the associated MQOs.*

6.2.3 Records

The following records shall be created and retained:

- Documents supporting the sample handling/splitting procedure
- Known values for PT samples, the grading criteria, and grading results
- Laboratory reports and associated data evaluation forms
- Communications directing the laboratory concerning deficiencies and corrective actions.

6.3 Laboratory Data Review

FRMAC not only conducts extensive monitoring and sampling but it adds value to those measurements by performing numerous checks on quality to assure construction of a valid, internally consistent data set. In all phases of a response, data quality processes are commensurate with the need to make decisions on data of known quality. Quality assurance rigor applied during the early phase will generally be less stringent than those during later phases. This is due primarily to the laboratory's ability to satisfy assessment early-phase objectives relatively easily when compared with later-phase objectives. That is, laboratory gross analyses (gamma, alpha, and beta) and higher detection limits may support decisions to evacuate or shelter-in-place; whereas later decisions will demand isotopic analyses at lower detection limits to make decisions on whether to remediate or condemn property, quarantine crops, etc.. Prior to the arrival of Laboratory Analysis assets all ground-based radiation data (e.g., exposure rates, sampling results, and isotopic concentrations of deposited activity) are first screened for completeness and obvious discrepancies by the monitoring manager. The data are then reviewed again by FRMAC Assessment for consistency by conducting peer comparisons (nearest neighbors, model trends, and ratios of collocated measurements). Once the Laboratory Analysis assets arrive, laboratory data are treated by a similar process to assure validity. Analysis results received from laboratories are first reviewed by Laboratory Analysis. Assessment then reviews them for consistency with related measurements. Similarly, other quantities such as the radionuclide mix and re-suspension factors are validated by analysis of multiple data sources with special attention to spatial variations and temporal changes.

Data integrity is vital. Therefore, three types of safeguards are utilized:

- The first safeguard is construction and protection of the data archive which captures all of the environmental radiological data acquired by or furnished to the FRMAC. Every data point acquired by FRMAC must be traceable to an individual instrument, survey team, calibration, and procedure. Most of FRMAC's data are managed in electronic format.
- The second safeguard is to secure all electronic data in RAMS. Access to the RAMS database and privileges within the system are controlled; certain critical transactions are tracked. Most importantly, the RAMS database is maintained on mirrored servers in real time. One server is located in the field and the other server at the Remote Sensing Laboratory (RSL) in Las Vegas.
- The third safeguard is a chain-of-custody, which is used for all samples, from collection to post-analysis storage and disposition.

6.3.1 Purpose

The purpose of laboratory data review is to provide a systematic approach to evaluate analytical results along with the data deliverables that support the results as well as to ensure those data are appropriately qualified as to the quality of the record, and that the data are appropriately labeled to indicate whether the data have been reviewed, and that the quality of the data are known to Assessment for their use in decision making.

This procedure covers the review of laboratory data, values, and reports. Depending on Assessment DQOs and laboratory MQOs, data review can be a lengthy and involved process. Consequently, it is vital that Assessment:

- Establish as early as possible their DQOs.
- Be in constant communication with Laboratory Analysis to ensure the validity of data.

6.3.2 Procedure

The data review process will primarily evaluate the laboratory performance in providing data that meets FRMAC needs, as defined through the Analysis Request and other documents. However, there will be cases where the FRMAC sampling data affect the laboratory products (e.g.; air volumes provided to the lab, with the laboratory providing activity per volume of air). While all reasonable efforts are made to ensure the sampling data are correct at the point of sample receipt (Chapter 5), unresolved issues need to be considered as potential contributing factors.

Initially, the electronic data is loaded into RAMS with a preliminary status meaning that the data record has not been reviewed. Once the Data Verification Form (DVF) (Appendix E) is complete, the data status will be advanced to "V" which indicates that the record has been verified. This status, in and of itself, does not indicate the quality of the record – only the status of the data record in relation to the review process.

The DVF identifies elements which are reviewed on the hardcopy and in the electronic data deliverable (EDD). These elements are considered essential to evaluating the data, and must be completed prior to marking the data as "V" and available for further Assessment Scientist use. These elements may be expanded or contracted, depending on several factors (e.g.; investigation of an unacceptable item, complexity of the analysis, etc.), but will be documented and appropriately signed-off. Ideally, automated review will be performed for some or all of the RAMS data elements and a completion report that identifies any issues will be produced. Actions taken if an item is not acceptable will vary depending on the effect on data quality or defensibility and the need for the impacted data. However, all actions must be signed by the Laboratory Analysis Manager or designee.

Rationale for each checklist item:

- *Issues identified prior to analysis that affect the data* – were any sampling or sample handling concerns resolved prior to the laboratory receiving the samples? If so, that will need to be considered for the effect on the data.
- *Custody records continuous and complete* – do the documented custody transfers indicate continuous custody? If not, this may invalidate the associated data.
- *Requested radionuclides were reported* – were the radionuclides entered on the Analysis Request form reported?
- *Correct SCF Sample ID numbers* – are the FRMAC sample numbers accurately reported?
- *Correct reporting units* – did the laboratory report the data in the units requested?
- *Uncertainty reported (1 or 2-sigma indicated)* – this checks for whether an uncertainty was reported with the result, and if the laboratory indicated whether it was at 1 or 2 sigma.
- *Detection and Quantitation Limits met* – was the required detection limit (entered on the Analysis Request) achieved?
- *Electronic data compare correctly against Hardcopy* – do the EDD data match what is provided on the hardcopy report? The hardcopy should be considered to present the

correct values in cases where they disagree after consultation with the laboratory that analyzed the samples.

- *Hardcopy deliverable level is correct (1 or 4) and complete* – was the type of data package requested of the laboratory provided? Level 1 is considered a preliminary report and consists of FRMAC results and chain-of-custody, whereas the Level 4 report includes the laboratory QA/QC data, sample preparation documents, calibration data, standard traceability, etc. (See model S.O.W. in Appendix F*)*
- *QC data meet requirements* – do the QC sample data results fall within acceptable criteria? Those items in Appendix E are default conditions, and may be adjusted, if authorized by the Laboratory Analysis Manager.

When complete, the checklist shall be signed and filed according to the coordinating agency's record management plan.

6.4 Recordkeeping

Procedure: Any radiological incident that requires a FRMAC response has substantial probability of leading to criminal and/or civil litigation. As such, the maintenance of associated records is crucial. The FRMAC shall be responsible for records retention until control of the incident is assumed by the Coordinating Agency. At this time, the Coordinating Agency will assume responsibility for the records.

Retention: All records that relate to a FRMAC response shall be capable of maintaining these records for at least 75 years.

Storage: Records shall be stored in a manner that allows reasonably rapid retrieval, protection from damage due to environmental conditions, and maintains positive control and custody over all information.

Disposition/Disposal: The Coordinating Agency in charge of an incident response shall determine if and when records may be disposed.

6.5 References

- National Environmental Laboratory Accreditation Program, Chapter 5, Quality Systems, Revision 15, National Environmental Laboratory Accreditation Council, May 2001.
- Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP), Chapter 18, NUREG-1576, EPA 402-B-04-001A, NTIS PB2004-105421. July 2004.

Section 7. Logistical Requirements

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The CMRT deploys in three phases – CMRT I, CMRT II and CM Augmentation in accordance with timelines established in the FRMAC Operations Manual. The main body of staffing for CMRT I and II will deploy out of RSL – Nellis AFB, Las Vegas, NV. CM Augmentation staffing will deploy largely from the other National Laboratories supporting FRMAC. Each phased-response element deploys with an equipment package and personnel who are qualified and trained to support the technical needs of the response. Laboratory Analysis initial equipment and personnel deploy during CMRT II with one FRMAC Laboratory Analysis Manager and three Sample Control Specialists. A CM Augmentation phase of personnel and laboratory equipment will be deployed from the National Laboratories to augment DOE staff once a FRMAC is established, or as determined necessary to meet the CMRT/FRMAC mission.

During an incident, the CMHT is activated as well as the CMRT. Members of the team come from four different laboratories: RSL, Sandia National Laboratories (SNL), Lawrence Livermore National Laboratory (LLNL), and Los Alamos National Laboratory (LANL). RSL is the base of operations for the CMHT, providing direct interactions with logistical personnel, physical control, and general facilitation of the communication bridge line activities and data entry support.

7.1 Laboratory Analysis Capability

The FRMAC Laboratory Analysis Division will integrate into the FRMAC and set up operations at the location identified during the initial logistics request made to the state or local agency, as described in the Operations Manual. Once on the scene, the main operational considerations driving set-up include: (1) the need to interact and communicate with the FRMAC Operational Manager, and other divisions receiving and providing support to Laboratory and Sample Control Operations, (2) location near the mobile laboratories, some of which may have already set up operations, and (3) receiving samples from the Field Teams, which is usually collocated with the Hotline operations. Depending on the incident, all Laboratory Analysis operations may be setup and located in close proximity to the FRMAC, be entirely staged in a forward deployed location(s) nearer the Hotline location, or may be setup in both locations.

The FRMAC Laboratory Analysis Division will be physically set up and located outside of the FRMAC Command and Control in a nearby location where communication lines can easily be run and radioactive materials can be handled. Adequate space is needed for: Hotline operations, contamination control, sample control operations, sample storage / staging area, and the mobile and fly-away laboratories. One or more DRASH tents are needed for Sample Control. To operate effectively, access to the RAMS and the internet must be provided. Phone or radio communication with the FRMAC and off-site laboratories must also be installed. The FRMAC Laboratory Analysis Manager as well as other staff may need to attend frequent meetings with FRMAC leadership to coordinate and prioritize activities.

7.1.1 Equipment Load Out

The basic factors determining the required Laboratory Analysis equipment to be deployed during a CM response are: (1) load limits (space and/or weight), (2) Laboratory Analysis equipment priority relative to other CMRT II equipment, and (3) consideration of what can/cannot be obtained at the incident location within a reasonable amount of time.

The equipment inventories and deployment box information are maintained in the Asset Readiness Management System, and are stored at the RSL-Nellis facility. The inventories are reviewed periodically and updated as necessary to ensure Laboratory Analysis deploys with materials suitable to support the mission.

7.1.2 On-Site Equipment Needs

The table below indicates the types of items the Laboratory Analysis Division will need. While some are maintained in the Laboratory Analysis deployment boxes, the others need to be obtained from within other FRMAC organizations or external to FRMAC. The numbers of items, if provided, are an estimate of what might be needed, but will obviously vary depending on incident-specific demands. The primary task once CMRT II personnel arrive on site is to assess the operational needs and take appropriate action to obtain the necessary resources. FRMAC and ICS Logistics support is tasked to fulfill these needs.

Table 7-1. Types of Items Needed by Laboratory Analysis Operations

Item
Bags • Boot 15x24 (10) • Bubble 6 x 8½ (100) • Ziploc® 9 x 12 (400)
Board, dry erase, white (2) and markers
Calculators, scientific (2 regular and 2 HP type (i.e., reverse polish)) and batteries
Chairs (12)
Clips, binder (assorted sizes)
Communications • Short Range Radios (3) • Telephones access (2) • Network access to RAMS and e-mail
Computers, laptop (8) and peripheral devices (power cords, mouse, barcode readers, USB cables, printers/copiers (2))
Container security seals (3 boxes)
Dots, Self-adhesive, Green ¾" round (5 packages)
Envelopes, padded 9½ x 14 (25)
Filing supplies (collapsible, foldable) • Baskets (8) • Bins (6) • Boxes (2) • Trays, photo, stackable (6)
First Aid Kits (1)
Forms • Analytical Request (200) • Sample Control Forms (100)
Gloves, Latex, Medium, Large, Extra Large (1 box each)
Ice Chest • 12 qt (4) • 24 qt (2) • 48 qt (2)
Kimwipes® (5 boxes)
Log Books (5)
Paper • Pads (6) • Reams (2)
Pens • Black (12) • Highlighter, Yellow (4) • Sharpe Fine Point (4) • Sharpe Ultra Fine Point (4)
Power • Access to 110V/20a, if available • Generator (1) if access to line power is not available – more if communications equipment is installed and requires power and cooling (A/C). • Extension cords and power strips (6)

Item
Print/Copy/Fax Machine (1) and replacement cartridges
Reference materials • Brown and Firestone Gamma reference book (2) • Transportation regulations (DOT, IATA) • Nuclide Navigator (1 copy) • Blue Spectra book for Fission Products and other spectra (1 copy)
Rings, notebook (12)
Rope, nylon, white (1/4") (50')
Safety Glasses (6 pair)
Scales, calibrated • Sample, grams to 2nd decimal point (1) • Shipments, up to 50 pounds (1) • Wind shields
Scissors (4)
Shelves, plastic, for sample storage (2 units)
Refrigeration units (1-3) (if needed)
Signs, large for general location posting • "Sample Receiving" • "Sample Control" • "Sample Storage"
Signs, small for process posting • "Non-Conformance" • "To Be Shipped" • "Refrigerated" • "Returned from Lab" • "Elevated Activity" • "Elevated Activity Non-Conformance" • "Externally Contaminated"
Stamp, "COPY", self-inking (3)
Staplers (3)
Tables, 6ft (8)
Tape • Dispensers (2) • Duct (2 rolls) • Radioactive Material (1 roll) • Strapping (12 rolls)
Tent • DRASH (1, 2 if load space is available) • Pop-Up (2)
Transportation Labels • Cargo Aircraft Only (1 roll) • Fragile (1 roll) • Orientation (1 roll) • Radiological White I • Radiological Yellow II • Radiological Yellow III
Vehicles

Item
• Sedan or SUV (minimum 2, but dependent on set-up and carrier service)

7.1.3 Required Facility

Laboratory operations facility and space needs are initially considered and addressed as part of the Logistics requests made via ICS to state and local supporting agencies at the time the CMRT I is deployed.

CMRT II will deploy with a minimum of one DRASH tent, but may need additional facility space to house other assets and capabilities (fly-away laboratory, sample storage) as part of augmentation roll-out. In lieu of tents, other facilities in the vicinity need to be considered, as long as (1) the space is suitable for operations (secure, utilities, proximity to FRMAC, etc.), and (2) there is no conflict with co-located or adjacent operations.

7.2 Other Required Support

7.2.1 Hotline Support

FRMAC Laboratory Analysis operations require that the samples brought to the Hotline are free of loose or removable radiological contamination before sample receipt can accept sample(s). The FRMAC H&S Division provides the resources for required radiological and potentially for industrial hygiene surveys and must be established prior to samples being received by Laboratory Analysis.

7.2.2 Sample Transport Support

Sample transport needs are generally determined by: (1) Laboratory Analysis proximity to the supporting laboratories, (2) courier services provided by the on-scene mobile laboratories, (3) other courier services such as UPS®, FedEx®, etc., and (4) whether samples are determined to be regulated under DOT/ IATA. Accordingly, sample transport may be as simple as hand-carrying the container to the on-site mobile laboratory, or as complex as a fully regulated shipment sent via air transport.

7.2.3 Sample Shipments

FRMAC Laboratory Analysis operations require that a qualified shipper (as defined by the base organization) be available to perform shipments of samples that are determined to be regulated under DOT or IATA. Shipments determined to be unregulated do not fall under any particular packaging to package and ship samples to off-site laboratories.

“Samples” as defined by 40 CFR Part 261.4 paragraph (d) and as used here are not considered “waste” and therefore not subject to requirements under 40 CFR Parts 124, 261 through 268, or 270. However, they must be managed according to 49 CFR Parts 100 to 185 and other applicable transportation requirements.

Appendix A. Detailed Position Descriptions and Training

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Table A-1. Laboratory Analysis Training Requirements

Description	Frequency	Laboratory Manager & Deputy Laboratory Manager	CMHT -LA	QA Specialist	Sample Control Specialist	Shipping Specialist
Required Training						
Hands-On Training Event or equivalent	3 years	X	X	X	X	X
EOTA CMP-101DW: Operations Overview for CM	1 time	X	X	X	X	X
EOTA CMP-104DW: H&S Orientation Course	1 time	X		X	X	X
ICS 100: Introduction to ICS	1 time	X	X	X	X	X
ICS 200: ICS for Single Resources and Initial Action Incidents	1 time	X	X	X	X	X
IS 700: NIMS	1 time	X	X	X	X	X
IS 800.b: National Response Framework (NRF), Introduction	1 time	X	X			
Rad Worker I	Current	X		X	X	X
LA 100: Sample Control Training or equivalent	3 years	X	X	X	X	X
LA 200: Laboratory Operations Training or equivalent	3 years	X	X	X		
LA 300: Laboratory Manager Training or equivalent	3 years	X	X			
Qualified Hazardous Shipper as defined by individual's base/originating organization	Current					X
Optional Training						
ICS 300: Intermediate ICS	1 time	X	X			
EOTA CMP105DW: Analysis Leadership Training	1 time	X	X			

A.1 FRMAC Laboratory Analysis Position Descriptions

The FRMAC Laboratory Analysis Position Descriptions are located in the Laboratory Analysis Division folder at the following URL:
http://www.nv.doe.gov/nationalsecurity/homelandsecurity/frmac/manuals.aspx

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Appendix B. Data Quality Objectives

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B.1 Protective Action Guides

A Protective Action Guide (PAG) is the projected dose from an unplanned release of radioactive material indicates that specific actions to reduce or avoid the projected dose (i.e., a protective action) are warranted. Protective actions may include, but are not limited to, evacuation of the public or sheltering in place. The PAG does not imply an acceptable level of risk for normal (non-incident conditions). It also does not represent the boundary between safe and unsafe conditions; rather, it is the approximate level at which protective actions warrant consideration.

Three time phases—early, intermediate and late—are generally accepted as being common to all unplanned releases of radioactive materials. The early phase begins at the time of release of the radioactive material and generally continues until the release has been controlled. During this phase, protective actions are generally based on the status of the situation and limited information on the type and quantities of materials present. This phase may last from hours to days.

The intermediate phase is the period beginning after the source releases have been brought under control and reliable environmental measurements are available for use as a basis for decisions on additional protective actions. It extends until these additional protective actions are terminated. This phase may overlap the early phase and may last from weeks to many months.

The late phase (also referred to as the recovery phase) is the period beginning when recovery action designed to reduce radiation levels in the environment to acceptable levels for unrestricted use are commenced, and ending when all recovery actions have been completed. This period may extend from months to years.

The decisions required during each of the time phases determine the sample matrices that are collected and the analysis requirements. The key objective during the early and intermediate phases of an incident is to ensure that the population is not exposed to harmful levels of radiation and that critical infrastructure is available for use. Samples are collected to determine the types of radionuclides and concentration/activity present, the extent of the contamination, and to determine if population monitoring is necessary. As the incident progresses additional samples may be collected to determine if food products need to be embargoed. During the late phase, samples are collected to determine if areas or structures may be released for unrestricted use.

FRMAC uses PAGs established by federal agencies (DHS, EPA, FDA) to perform evaluations of radiological conditions. Table B-1 and B-2 provide recommended PAGS for evacuation or sheltering in place for different time phases during an incident. Table B-2 provides recommended guidance on dose limits for workers performing incident services. Issues specific to an incident may warrant selection of different values for the PAGs.

Table B-1. Protective Action Guides (PAGs)

	Worker	**Early Phase**	**First Year**	**Second Year**	**50 Year**
Total Effective Dose	1000 mRem	1000 mRem	2000 mRem	500 mRem	5000 mRem
Exposure Period	8 hours	4 days (96 hours)	365 days	365 days	50 years

Table B-2. Guidance on Dose Limits for Workers Performing Incident Services

Dose Limit (rem)	**Activity**	**Condition**
5	All	
10	Protecting valuable property	Lower dose not practical
25	Lifesaving or protection of large populations	Lower dose not practical
>25	Lifesaving or protection of large populations	Only on a voluntary basis to persons fully aware of the risks involved

The PAGs provided in Table B-1 are applicable to environmental exposures due to combined external and inhalation exposures. In addition, radionuclide concentration limits for drinking water and food as regulated by the U.S. Environmental Protection Agency (EPA) and U.S. Food and Drug Administration (FDA) are applicable.

EPA Derived Water Concentrations (DWCs) consider the PAGs in Table B-1 as well as risk-based factors. During the late, or recovery phase, applicable drinking water regulations (CFR 141.66) for radionuclides may apply.

Table B-3. Maximum Contaminant Levels (MCLs) for Radionuclides in Drinking Water

Analyte	MCL
Gross Alpha (excluding radon and uranium)	15 pCi/L
Ra-226 + Ra-228	5 pCi/L
Uranium	30 μg/L
Tritium	20,000 pCi/L
Sr-90	8 pCi/L
Other man-made[1]	4 mRem/year
[1]The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water must not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year (mRem/yr).	

FDA Derived Intervention Levels represent the activity concentrations of radioactive materials found in food that, in the absence of any intervention, could lead to an individual receiving a dose equal to the appropriate PAG if consumed over one year.

Table B-4. FDA PAGs

The more limiting of • 5 mSv CEDE (500 mRem), or • 50 mSv (5 Rem) committed dose equivalent to individual tissue or organ

For clinical samples, the Center for Disease Control (CDC) uses the Annual Limit of Intake (ALI) to determine if medical intervention is required. The ALI is the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. The CDC should be consulted for guidance on clinical samples.

Table B-5. Basis for Annual Limit of Intake (ALI) Values

The more limiting of • 0.05 Sv CEDE (5 rem), or • 0.5 Sv (50 Rem) committed dose equivalent to individual tissue or organ

B.2 Derived Response Levels and Derived Intervention Levels

The PAG recommendations are given in terms of projected dose equivalent. It is often more convenient to utilize specific radionuclide concentrations upon which to initiate protective action. FRMAC uses Derived Response Levels (DRLs) or Derived Intervention Levels (DILs) to relate measured quantities in the environment to the appropriate regulatory limits. DRLs are calculated values (*e.g.*, radionuclide concentrations) that correspond to a PAG or DIL. The DRL is the level of activity in a sample that if an individual is exposed to for an extended period of time would lead to a dose equivalent to the PAG or DIL. DRLs are surrogates for the PAG or DIL and can be compared directly to the measured or calculated concentration.

The FRMAC Laboratory Analysis Division uses DRLs or DILs obtained from the Assessment Division to calculate Analytical Action Levels (see Section B.3). Calculations of DRLs and DILs can be complex and are documented in the EPA Protective Action Guidance Manual and the FRMAC Assessment Manual. The FRMAC Assessment Scientists should be consulted for calculation of DRLs and DILs. The CDC should be consulted for guidance on clinical samples.

DRLs and DILs calculated by the Assessment Division may consider plume dose or exclude plume dose depending on the situation. Tables of default Analytical Action Levels and Critical Levels (L_C) for both models are provided. It is up to the Assessment Division to give guidance on which set of defaults to use early in an event.

Tables for Analytical Action Levels and Critical Levels (L_C) are based on the most conservative time phase DRLs provided by the FRMAC Assessment Division.

B.3 Analytical Action Levels

The Analytical Action Level (AAL) is the value that will cause the decision maker to choose a course of action. For the purpose of determining if the activity in a sample would cause a PAG to be exceeded, the AAL is equal (or directly proportional) to the DRL or DIL. It is desirable to express the AALs in terms of activity concentration in samples submitted to the laboratory. Table B6 shows the methods for determining AALs based on DRLs or DILs.

Short Term Deposition DRLs are the minimum (most conservative) of the DRLs for the Early Phase and 1st Year Time Phases. Long Term Deposition DRLs are the minimum (most conservative) of the DRLs for the Early Phase, 1st Year, 2nd Year, and 50 Year Time phases as well as the $Milk\_DRL_{area}$.

Table B-6. DRL to AAL Conversions

Matrix	Source DRL Type	DRL Units	Conversion from DRL to AAL	AAL Units
Air	Deposition DRL "Short Term"	$\mu Ci/m^2$	AAL = Dp_DRL * Resuspension Factor ($1E\text{-}06\ m^{-1}$ Default)	$\mu Ci/m^3$
Food	DIL	$\mu Ci/kg_{wet}$	AAL = DIL	$\mu Ci/kg_{wet}$
Forage	$Milk\_DRL_{mass}$	$\mu Ci/kg_{wet}$	AAL = $Milk\_DRL_{mass}$	$\mu Ci/kg_{wet}$
Milk	DIL	$\mu Ci/kg_{wet}$	AAL = DIL	$\mu Ci/kg_{wet}$
Soil "Short Term"	Deposition DRL "Short Term"	$\mu Ci/m^2$	AAL = Dp_DRL * Sample Size ($0.01\ m^2$ Default)	µCi/sample
Soil "Long Term"	Deposition DRL "Long Term"	$\mu Ci/m^2$	AAL = Dp_DRL * Sample Size ($0.01\ m^2$ Default)	µCi/sample
Water (Cow) Drinking Water	$Milk\_DRL_{water}$ EPA Guidelines	µCi/l	AAL = $Milk\_DRL_{water}$	µCi/l pCi/l

To determine the appropriate AAL for each sample matrix, obtain the value for the DRL Type shown in Column 2 from the Assessment Division and convert to the AAL according to the methods shown in Column 4. For clinical samples contact the CDC to determine the MQOs. Default AALs, calculated from the most conservative default DRLs and DILs from the Assessment Division are shown in Tables B-7 and B-8.

Table B-7. Default Analytical Action Levels (AAL) by sample type and nuclide EXCLUDING Plume Dose

	Air ($\mu Ci/m^3$)	Food ($\mu Ci/kg_{wet}$)	Forage ($\mu Ci/kg_{wet}$)	Milk ($\mu Ci/kg_{wet}$)	ST Soil (µCi/Sample)	LT Soil (µCi/Sample)	Water (µCi/L)	Tap Water (pCi/L)
DRL Type APPLIED	**Dp_DRL "Short Term"**	**DIL**	**$Milk\_DRL_{mass}$**	**DIL**	**Dp_DRL "Short Term"**	**Dp_DRL "Long Term"**	**$Milk\_DRL_{water}$**	**EPA guidelines**
Am-241	1.8E-06	5.4E-05	7.5E-01	5.4E-05	1.8E-02	1.0E-02	6.2E-01	Contact FRMAC Assessment for appropriate value
Ba-140	1.6E-04	1.9E-01	9.0E+00	1.9E-01	1.6E+00	1.2E-01	7.5E+00	
Ce-141	2.3E-03	1.9E-01	1.4E+02	1.9E-01	2.3E+01	2.0E+00	1.2E+02	
Ce-144	1.8E-04	1.3E-02	9.4E+00	1.3E-02	1.8E+00	1.3E-01	7.8E+00	
Cf-252	4.4E-06	1.0E-04	1.4E+00	1.0E-04	4.4E-02	1.9E-02	1.2E+00	
Cm-242	3.1E-05	5.1E-04	5.4E-01	5.1E-04	3.1E-01	7.5E-03	4.5E-01	
Cm-244	3.1E-06	5.4E-05	5.6E-02	5.4E-05	3.1E-02	7.8E-04	4.7E-02	
Co-60	1.1E-05	2.0E-02	1.4E+00	2.0E-02	1.1E-01	1.9E-02	1.2E+00	
Cs-134	1.8E-05	2.5E-02	6.6E-02	2.5E-02	1.8E-01	9.2E-04	5.5E-02	
Cs-136	2.0E-04	3.1E-01	9.2E-01	3.1E-01	2.0E+00	1.3E-02	7.6E-01	
Cs-137	4.2E-05	3.7E-02	9.7E-02	3.7E-02	4.2E-01	1.3E-03	8.1E-02	
Gd-153	3.9E-04	3.6E-01	2.5E+02	3.6E-01	3.9E+00	3.3E+00	2.1E+02	
I-129	9.3E-04	1.5E-03	3.5E-03	1.5E-03	9.3E+00	2.4E-05	2.9E-03	
I-131	1.8E-03	4.6E-03	1.3E-02	4.6E-03	1.8E+01	8.8E-05	1.1E-02	
I-132	1.3E-02	4.3E+01	1.9E+08	4.3E+01	1.3E+02	1.3E+02	1.6E+08	
I-133	4.9E-03	1.9E-01	2.2E+00	1.9E-01	4.9E+01	1.5E-02	1.8E+00	
I-134	2.9E-02	4.4E+02	3.1E+19	4.4E+02	2.9E+02	2.9E+02	2.5E+19	
I-135	4.4E-03	3.2E+00	1.1E+03	3.2E+00	4.4E+01	7.9E+00	9.5E+02	
Ir-192	9.9E-05	7.9E-02	8.4E+02	7.9E-02	9.9E-01	9.9E-01	7.0E+02	
La-140	9.1E-04	1.8E+00	4.3E+03	1.8E+00	9.1E+00	9.1E+00	3.6E+03	
Mo-99	5.2E-03	3.9E+00	8.0E+01	3.9E+00	5.2E+01	1.1E+00	6.7E+01	
Nb-95	2.1E-04	3.2E-01	1.7E+04	3.2E-01	2.1E+00	2.1E+00	1.4E+04	
Np-237	5.1E-07	1.1E-04	4.5E-01	1.1E-04	5.1E-03	5.1E-03	3.7E-01	
Np-239	9.8E-03	7.6E-01	5.7E+03	7.6E-01	9.8E+01	7.9E+01	4.7E+03	
P-32	4.2E-03	1.3E-01	1.9E-01	1.3E-01	4.2E+01	2.6E-03	1.6E-01	
Pm-147	2.5E-02	3.0E-01	2.1E+02	3.0E-01	2.5E+02	2.9E+00	1.7E+02	
Po-210	4.4E-05	4.2E-05	2.6E-03	4.2E-05	4.4E-01	3.6E-05	2.1E-03	
Pu-238	1.6E-06	6.8E-05	1.3E+00	6.8E-05	1.6E-02	1.6E-02	1.1E+00	
Pu-239	1.5E-06	5.9E-05	1.1E+00	5.9E-05	1.5E-02	1.5E-02	9.3E-01	
Pu-241	7.6E-05	3.3E-03	6.2E+01	3.3E-03	7.6E-01	7.6E-01	5.1E+01	
Ra-226	5.3E-06	5.5E-05	8.8E-04	5.5E-05	5.3E-02	1.2E-05	7.3E-04	
Ru-103	2.9E-04	1.8E-01	1.2E+03	1.8E-01	2.9E+00	2.9E+00	1.0E+03	
Ru-106	8.7E-05	1.2E-02	7.7E+01	1.2E-02	8.7E-01	5.2E-01	6.4E+01	
Sb-127	1.9E-03	8.5E-01	1.0E+03	8.5E-01	1.9E+01	1.4E+01	8.5E+02	
Sb-129	9.6E-03	7.7E+01	1.4E+08	7.7E+01	9.6E+01	9.6E+01	1.2E+08	
Se-75	1.5E-04	5.5E-02	2.9E-01	5.5E-02	1.5E+00	4.0E-03	2.4E-01	
Sr-89	1.5E-03	3.8E-02	2.9E-01	3.8E-02	1.5E+01	4.0E-03	2.4E-01	
Sr-90	1.7E-04	4.3E-03	3.2E-02	4.3E-03	1.7E+00	4.4E-04	2.7E-02	
Sr-91	6.3E-03	2.9E+01	7.1E+03	2.9E+01	6.3E+01	6.3E+01	5.9E+03	
Te-129m	1.2E-03	4.0E-02	1.9E+00	4.0E-02	1.2E+01	2.7E-02	1.6E+00	
Te-131m	1.5E-03	1.8E+00	2.6E+02	1.8E+00	1.5E+01	3.5E+00	2.1E+02	
Te-132	5.7E-04	1.2E-01	8.4E+00	1.2E-01	5.7E+00	1.2E-01	7.0E+00	
Tm-170	1.9E-03	5.6E-02	3.9E+01	5.6E-02	1.9E+01	5.5E-01	3.3E+01	
U-234	8.5E-07	1.4E-03	7.3E-02	1.4E-03	8.5E-03	1.0E-03	6.1E-02	
U-235	4.2E-07	1.5E-03	7.8E-02	1.5E-03	4.2E-03	1.1E-03	6.5E-02	
U-238	1.1E-06	1.6E-03	8.2E-02	1.6E-03	1.1E-02	1.1E-03	6.8E-02	
Y-91	1.2E-03	3.3E-02	3.5E+01	3.3E-02	1.2E+01	4.8E-01	2.9E+01	
Yb-169	5.7E-04	2.4E-01	1.7E+02	2.4E-01	5.7E+00	2.4E+00	1.4E+02	
Zr-95	3.8E-05	1.1E-01	4.2E+03	1.1E-01	3.8E-01	3.8E-01	3.5E+03	

1 – All AALs are based on quantities developed in the FRMAC Assessment Manual. For values where multiple Time Phases may be applicable, the most conservative value was chosen. ICRP 60 dosimetry model is used in the default calculations.

2 – Water AAL from the Water DRL calculated by determining the radionuclide concentration that would produce a dose equal to the FDA PAG. Water DRL method to be included in the FRMAC Assessment Manual at a future date

3-- The Values presented here represent the critical level Lc, this value is taken to be 10% of the AAL

4—"Short Term Dp_DRLs" are the minimum (most conservative) of the Dp_DRLs for the Early Phase and 1st Year Time Phases.

5—" Long Term Dp_DRLs" are the minimum (most conservative of the Dp_DRLs for the Early Phase, 1st Year, 2nd Year, 50 Year Time Phase, and the $Milk\_DRL_{area}$

Table B-8. Default Analytical Action Levels (AAL) by sample type and nuclide INCLUDING Plume Dose

	Air ($\mu Ci/m^3$)	Food ($\mu Ci/kg_{wet}$)	Forage ($\mu Ci/kg_{wet}$)	Milk ($\mu Ci/kg_{wet}$)	ST Soil (µCi/Sample)	LT Soil (µCi/Sample)	Water (µCi/L)	Tap Water (pCi/L)
DRL Type APPLIED	**Dp_DRL "Short Term"**	**DIL**	**$Milk\_DRL_{mass}$**	**DIL**	**Dp_DRL "Short Term"**	**Dp_DRL "Long Term"**	**$Milk\_DRL_{water}$**	**EPA guidelines**
Am-241	2.0E-08	5.4E-05	7.5E-01	5.4E-05	2.0E-04	2.0E-04	6.2E-01	Contact FRMAC Assessment for appropriat e value
Ba-140	1.5E-04	1.9E-01	9.0E+00	1.9E-01	1.5E+00	1.2E-01	7.5E+00	
Ce-141	4.9E-04	1.9E-01	1.4E+02	1.9E-01	4.9E+00	2.0E+00	1.2E+02	
Ce-144	3.6E-05	1.3E-02	9.4E+00	1.3E-02	3.6E-01	1.3E-01	7.8E+00	
Cf-252	5.2E-08	1.0E-04	1.4E+00	1.0E-04	5.2E-04	5.2E-04	1.2E+00	
Cm-242	3.3E-07	5.1E-04	5.4E-01	5.1E-04	3.3E-03	3.3E-03	4.5E-01	
Cm-244	3.4E-08	5.4E-05	5.6E-02	5.4E-05	3.4E-04	3.4E-04	4.7E-02	
Co-60	1.1E-05	2.0E-02	1.4E+00	2.0E-02	1.1E-01	1.9E-02	1.2E+00	
Cs-134	1.8E-05	2.5E-02	6.6E-02	2.5E-02	1.8E-01	9.2E-04	5.5E-02	
Cs-136	2.0E-04	3.1E-01	9.2E-01	3.1E-01	2.0E+00	1.3E-02	7.6E-01	
Cs-137	4.2E-05	3.7E-02	9.7E-02	3.7E-02	4.2E-01	1.3E-03	8.1E-02	
Gd-153	3.9E-04	3.6E-01	2.5E+02	3.6E-01	3.9E+00	3.3E+00	2.1E+02	
I-129	1.8E-04	1.5E-03	3.5E-03	1.5E-03	1.8E+00	2.4E-05	2.9E-03	
I-131	6.4E-04	4.6E-03	1.3E-02	4.6E-03	6.4E+00	8.8E-05	1.1E-02	
I-132	2.0E-04	4.3E+01	1.9E+08	4.3E+01	2.0E+00	2.0E+00	1.6E+08	
I-133	1.5E-03	1.9E-01	2.2E+00	1.9E-01	1.5E+01	1.5E-02	1.8E+00	
I-134	8.6E-07	4.4E+02	3.1E+19	4.4E+02	8.6E-03	8.6E-03	2.5E+19	
I-135	1.1E-03	3.2E+00	1.1E+03	3.2E+00	1.1E+01	7.9E+00	9.5E+02	
Ir-192	9.9E-05	7.9E-02	8.4E+02	7.9E-02	9.9E-01	9.9E-01	7.0E+02	
La-140	4.4E-04	1.8E+00	4.3E+03	1.8E+00	4.4E+00	4.4E+00	3.6E+03	
Mo-99	1.2E-03	3.9E+00	8.0E+01	3.9E+00	1.2E+01	1.1E+00	6.7E+01	
Nb-95	2.1E-04	3.2E-01	1.7E+04	3.2E-01	2.1E+00	2.1E+00	1.4E+04	
Np-237	5.7E-09	1.1E-04	4.5E-01	1.1E-04	5.7E-05	5.7E-05	3.7E-01	
Np-239	1.3E-03	7.6E-01	5.7E+03	7.6E-01	1.3E+01	1.3E+01	4.7E+03	
P-32	4.7E-04	1.3E-01	1.9E-01	1.3E-01	2.8E+00	2.6E-03	1.6E-01	
Pm-147	2.8E-04	3.0E-01	2.1E+02	3.0E-01	1.8E-04	2.8E+00	1.7E+02	
Po-210	4.5E-07	4.2E-05	2.6E-03	4.2E-05	1.6E-04	3.6E-05	2.1E-03	
Pu-238	1.8E-08	6.8E-05	1.3E+00	6.8E-05	8.4E-03	1.8E-04	1.1E+00	
Pu-239	1.6E-08	5.9E-05	1.1E+00	5.9E-05	9.8E-04	1.6E-04	9.3E-01	
Pu-241	8.4E-07	3.3E-03	6.2E+01	3.3E-03	2.9E+00	8.4E-03	5.1E+01	
Ra-226	9.8E-08	5.5E-05	8.8E-04	5.5E-05	2.9E-01	1.2E-05	7.3E-04	
Ru-103	2.9E-04	1.8E-01	1.2E+03	1.8E-01	5.7E+00	2.9E+00	1.0E+03	
Ru-106	2.9E-05	1.2E-02	7.7E+01	1.2E-02	4.3E+00	2.9E-01	6.4E+01	
Sb-127	5.7E-04	8.5E-01	1.0E+03	8.5E-01	1.5E+00	5.7E+00	8.5E+02	
Sb-129	4.3E-04	7.7E+01	1.4E+08	7.7E+01	2.4E+00	4.3E+00	1.2E+08	
Se-75	1.5E-04	5.5E-02	2.9E-01	5.5E-02	1.2E-01	4.0E-03	2.4E-01	
Sr-89	2.4E-04	3.8E-02	2.9E-01	3.8E-02	9.6E+00	4.0E-03	2.4E-01	
Sr-90	1.2E-05	4.3E-03	3.2E-02	4.3E-03	2.3E+00	4.4E-04	2.7E-02	
Sr-91	9.6E-04	2.9E+01	7.1E+03	2.9E+01	5.9E+00	9.6E+00	5.9E+03	
Te-129m	2.3E-04	4.0E-02	1.9E+00	4.0E-02	3.0E+00	2.7E-02	1.6E+00	
Te-131m	5.9E-04	1.8E+00	2.6E+02	1.8E+00	2.1E+00	3.5E+00	2.1E+02	
Te-132	3.0E-04	1.2E-01	8.4E+00	1.2E-01	2.1E+00	1.2E-01	7.0E+00	
Tm-170	2.1E-04	5.6E-02	3.9E+01	5.6E-02	5.3E+00	5.5E-01	3.3E+01	
U-234	1.0E-08	1.4E-03	7.3E-02	1.4E-03	3.8E-01	1.0E-04	6.1E-02	
U-235	4.7E-09	1.5E-03	7.8E-02	1.5E-03	4.7E-05	4.7E-05	6.5E-02	
U-238	1.4E-08	1.6E-03	8.2E-02	1.6E-03	1.4E-04	1.4E-04	6.8E-02	
Y-91	2.1E-04	3.3E-02	3.5E+01	3.3E-02	2.1E+00	4.8E-01	2.9E+01	
Yb-169	5.3E-04	2.4E-01	1.7E+02	2.4E-01	5.3E+00	2.4E+00	1.4E+02	
Zr-95	3.8E-05	1.1E-01	4.2E+03	1.1E-01	3.8E-01	3.8E-01	3.5E+03	

1 – All AALs are based on quantities developed in the FRMAC Assessment Manual. For values where multiple Time Phases may be applicable, the most conservative value was chosen. ICRP 60 dosimetry model is used in the default calculations.

2 – Water AAL from the Water DRL calculated by determining the radionuclide concentration that would produce a dose equal to the FDA PAG. Water DRL method to be included in the FRMAC Assessment Manual at a future date

3-- The Values presented here represent the critical level Lc, this value is taken to be 10% of the AAL

4—"Short Term Dp_DRLs" are the minimum (most conservative) of the Dp_DRLs for the Early Phase and 1st Year Time Phases.

5—" Long Term Dp_DRLs" are the minimum (most conservative of the Dp_DRLs for the Early Phase, 1st Year, 2nd Year, 50 Year Time Phase, and the $Milk\_DRL_{area}$

B.4 Measurement Quality Objectives

The Data Quality Objectives (DQO) process described in the EPA "Guidance on Systematic Planning using the Data Quality Objectives Process[2]" and Appendix B to the "Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)[3]" is used to determine performance or acceptance criteria. These criteria serve as a basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of a study. The outcome of this process is typically tolerable limits on the probability or chance (risk) of making an erroneous decision. Based on these limits, specific MQOs can be determined. The MQOs are generally expressed as a required measurement uncertainty (φ_{MR}) at the AAL or a required threshold for detection (L_C).

The measured value and the measurement uncertainty are used to determine if a measurement exceeds a PAG. If the measured value plus 1.645 times the measurement uncertainty does not exceed the AAL, then one can state that the result does not exceed the AAL, and thus the PAG, at a 95% confidence level (5% false positive rate). The required measurement uncertainty at the AAL is based on tolerable limits on the probability or chance (risk) of making an erroneous decision. Small tolerable limits translate to small required uncertainties at the AAL. Small uncertainties generally increase the time and costs for analyses. Therefore, the need for small uncertainties must be balanced against the time and costs for performing the analyses and the capabilities of the radioanalytical laboratories. The required measurement uncertainty at the AAL should be agreed upon between the FRMAC Assessment Division and the Laboratory Analysis Division based upon assessment needs and laboratory capabilities. These required uncertainties may be adjusted during the response to incident as the increased time and costs for performing analyses are balanced against the need for lower tolerable limits on the probability or chance (risk) of making an erroneous decision. During the early phase of an incident, measurement uncertainties of up to 25 % may be tolerated. A default value of 10% is used if no value is provided.

The Critical Level (L_C)[4], is used to determine the presence or absence of a radionuclide in a sample. If a result exceeds the L_C, one can state that the result is different from the background at the 95% confidence level (5% false negative rate). The L_C is set at a level where values below this level are of minimum statistical concern. The values for uncertainty should be agreed upon between the FRMAC Assessment Division and the Laboratory Analysis Division based upon assessment needs and laboratory capabilities. The absence of a radionuclide above 10% of the AAL implies that the radionuclide contributes less than 10% of the PAG. During the early phase of a response to an incident, L_Cs of up to 25% may be tolerated. A default value of 10% of the AAL is used if no value is provided.

A detailed discussion on the Critical Level (Critical Value) is found in the *"Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP), Part II Chapter 20"*[5]. L_C is calculated as: $L_C = k\sigma_B$

where:

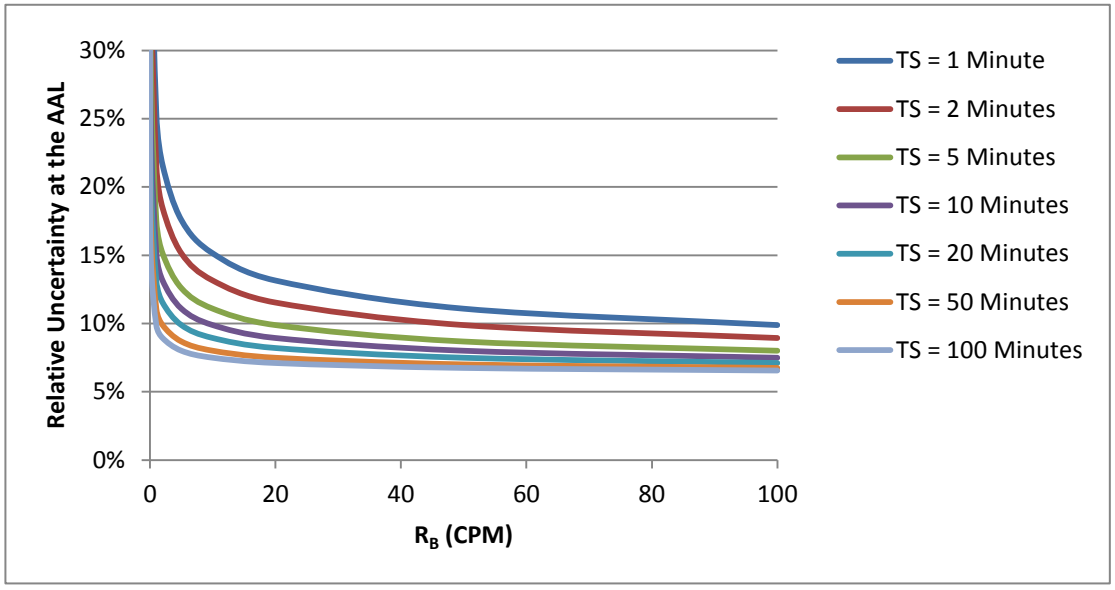
k = is the normal deviate for a 1-sided confidence level (1.645 the 95% confidence level)

σ_B = standard deviation of the background

While it is desirable for laboratories to demonstrate that the required measurement uncertainty at the AAL is met, in practice this is a difficult task. Since most radioanalytical laboratories provide measurements for environmental level samples, MQOs are typically expressed in terms of a required Minimum Detectable Activity (MDA) or Critical Level (L_C) rather than a required measurement uncertainty at an AAL. Figure B-1 and Table B-9 demonstrate the relationship between the ratio of the L_C to AAL and the counting uncertainty at the AAL for various background count rates and count times. The data assumes a well-known background ($T_B >> T_S$, where T_B = background count time and T_S = sample count time).

Figure B-1. Relative Uncertainty at the Analytical Action Level for L_C/AAL = 10%

(Well-known Background, $T_B >> T_S$)



T_B =background count time

T_S= sample count time

The results indicate that requiring an L_C of 10% of the AAL will provide an uncertainty at the AAL of approximately 10% for most typical background count rates and count times. For higher count rates and longer count times the percent uncertainty at the AAL will be less than 10%. However, for very low background count rates and short count times the percent uncertainty at the AAL will be greater than 10%. Tables B-10 and B-11 shows the default L_Cs obtained by setting the L_C at 10% of the AAL.

Table B-9. Relative Uncertainty at the Analytical Action Level for L_C/AAL = 10%

(Well-known Background, $T_B >> T_S$)

	T_S (min.)						
R_B (CPM)	1	2	5	10	20	50	100
0.001	138.8%	116.7%	92.9%	78.2%	65.8%	52.5%	44.3%
0.01	78.2%	65.8%	52.5%	44.3%	37.4%	29.9%	25.4%
0.1	44.3%	37.4%	29.9%	25.4%	21.6%	17.6%	15.1%
1	25.4%	21.6%	17.6%	15.1%	13.1%	11.1%	9.9%
2	21.6%	18.5%	15.1%	13.1%	11.5%	9.9%	8.9%
5	17.6%	15.1%	12.6%	11.1%	9.9%	8.7%	8.0%
10	15.1%	13.1%	11.1%	9.9%	8.9%	8.0%	7.5%
20	13.1%	11.5%	9.9%	8.9%	8.2%	7.5%	7.1%
50	11.1%	9.9%	8.7%	8.0%	7.5%	7.0%	6.7%
100	9.9%	8.9%	8.0%	7.5%	7.1%	6.7%	6.6%

$$\frac{\sigma_{R_{AAL}}}{R_{AAL}} = \frac{R_{L_C}}{R_{AAL}} \frac{1}{k} \sqrt{\left(\frac{R_{AAL}}{R_{L_C}}\right)\left(k\sqrt{\frac{1}{R_B T_S}}\right)+1}$$

$$k = 1.645$$

$$\frac{R_{L_C}}{R_{AAL}} = 10\%$$

where:

$\frac{\sigma_{R_{AAL}}}{R_{AAL}}$ = relative uncertainty at the Analytical Action Level

R_{L_C} = count rate at the Critical Level (L_C)

R_{AAL} = count rate at the Analytical Action Level

R_B = background count rate

T_S = sample count time

k = normal deviate for a 1-sided confidence level (1.645 the 95% confidence level)

Table B-10. Default Critical Levels (L_c) by sample type and nuclide EXCLUDING Plume Dose

	Air ($\mu Ci/m^3$)	Food ($\mu Ci/kg_{wet}$)	Forage ($\mu Ci/kg_{wet}$)	Milk ($\mu Ci/kg_{wet}$)	ST Soil (μCi/Sample)	LT Soil (μCi/Sample)	Water ($\mu Ci/L$)	Tap Water (pCi/L)
DRL Type APPLIED	**Dp_DRL "Short Term"**	**DIL**	**$Milk\_DRL_{mass}$**	**DIL**	**Dp_DRL "Short Term"**	**Dp_DRL "Long Term"**	**$Milk\_DRL_{water}$**	**EPA guidelines**
Am-241	1.8E-07	5.4E-06	7.5E-02	5.4E-06	1.8E-03	1.0E-03	6.2E-02	Contact FRMAC Assessment for appropriate value
Ba-140	1.6E-05	1.9E-02	9.0E-01	1.9E-02	1.6E-01	1.2E-02	7.5E-01	
Ce-141	2.3E-04	1.9E-02	1.4E+01	1.9E-02	2.3E+00	2.0E-01	1.2E+01	
Ce-144	1.8E-05	1.3E-03	9.4E-01	1.3E-03	1.8E-01	1.3E-02	7.8E-01	
Cf-252	4.4E-07	1.0E-05	1.4E-01	1.0E-05	4.4E-03	1.9E-03	1.2E-01	
Cm-242	3.1E-06	5.1E-05	5.4E-02	5.1E-05	3.1E-02	7.5E-04	4.5E-02	
Cm-244	3.1E-07	5.4E-06	5.6E-03	5.4E-06	3.1E-03	7.8E-05	4.7E-03	
Co-60	1.1E-06	2.0E-03	1.4E-01	2.0E-03	1.1E-02	1.9E-03	1.2E-01	
Cs-134	1.8E-06	2.5E-03	6.6E-03	2.5E-03	1.8E-02	9.2E-05	5.5E-03	
Cs-136	2.0E-05	3.1E-02	9.2E-02	3.1E-02	2.0E-01	1.3E-03	7.6E-02	
Cs-137	4.2E-06	3.7E-03	9.7E-03	3.7E-03	4.2E-02	1.3E-04	8.1E-03	
Gd-153	3.9E-05	3.6E-02	2.5E+01	3.6E-02	3.9E-01	3.3E-01	2.1E+01	
I-129	9.3E-05	1.5E-04	3.5E-04	1.5E-04	9.3E-01	2.4E-06	2.9E-04	
I-131	1.8E-04	4.6E-04	1.3E-03	4.6E-04	1.8E+00	8.8E-06	1.1E-03	
I-132	1.3E-03	4.3E+00	1.9E+07	4.3E+00	1.3E+01	1.3E+01	1.6E+07	
I-133	4.9E-04	1.9E-02	2.2E-01	1.9E-02	4.9E+00	1.5E-03	1.8E-01	
I-134	2.9E-03	4.4E+01	3.1E+18	4.4E+01	2.9E+01	2.9E+01	2.5E+18	
I-135	4.4E-04	3.2E-01	1.1E+02	3.2E-01	4.4E+00	7.9E-01	9.5E+01	
Ir-192	9.9E-06	7.9E-03	8.4E+01	7.9E-03	9.9E-02	9.9E-02	7.0E+01	
La-140	9.1E-05	1.8E-01	4.3E+02	1.8E-01	9.1E-01	9.1E-01	3.6E+02	
Mo-99	5.2E-04	3.9E-01	8.0E+00	3.9E-01	5.2E+00	1.1E-01	6.7E+00	
Nb-95	2.1E-05	3.2E-02	1.7E+03	3.2E-02	2.1E-01	2.1E-01	1.4E+03	
Np-237	5.1E-08	1.1E-05	4.5E-02	1.1E-05	5.1E-04	5.1E-04	3.7E-02	
Np-239	9.8E-04	7.6E-02	5.7E+02	7.6E-02	9.8E+00	7.9E+00	4.7E+02	
P-32	4.2E-04	1.3E-02	1.9E-02	1.3E-02	4.2E+00	2.6E-04	1.6E-02	
Pm-147	2.5E-03	3.0E-02	2.1E+01	3.0E-02	2.5E+01	2.9E-01	1.7E+01	
Po-210	4.4E-06	4.2E-06	2.6E-04	4.2E-06	4.4E-02	3.6E-06	2.1E-04	
Pu-238	1.6E-07	6.8E-06	1.3E-01	6.8E-06	1.6E-03	1.6E-03	1.1E-01	
Pu-239	1.5E-07	5.9E-06	1.1E-01	5.9E-06	1.5E-03	1.5E-03	9.3E-02	
Pu-241	7.6E-06	3.3E-04	6.2E+00	3.3E-04	7.6E-02	7.6E-02	5.1E+00	
Ra-226	5.3E-07	5.5E-06	8.8E-05	5.5E-06	5.3E-03	1.2E-06	7.3E-05	
Ru-103	2.9E-05	1.8E-02	1.2E+02	1.8E-02	2.9E-01	2.9E-01	1.0E+02	
Ru-106	8.7E-06	1.2E-03	7.7E+00	1.2E-03	8.7E-02	5.2E-02	6.4E+00	
Sb-127	1.9E-04	8.5E-02	1.0E+02	8.5E-02	1.9E+00	1.4E+00	8.5E+01	
Sb-129	9.6E-04	7.7E+00	1.4E+07	7.7E+00	9.6E+00	9.6E+00	1.2E+07	
Se-75	1.5E-05	5.5E-03	2.9E-02	5.5E-03	1.5E-01	4.0E-04	2.4E-02	
Sr-89	1.5E-04	3.8E-03	2.9E-02	3.8E-03	1.5E+00	4.0E-04	2.4E-02	
Sr-90	1.7E-05	4.3E-04	3.2E-03	4.3E-04	1.7E-01	4.4E-05	2.7E-03	
Sr-91	6.3E-04	2.9E+00	7.1E+02	2.9E+00	6.3E+00	6.3E+00	5.9E+02	
Te-129m	1.2E-04	4.0E-03	1.9E-01	4.0E-03	1.2E+00	2.7E-03	1.6E-01	
Te-131m	1.5E-04	1.8E-01	2.6E+01	1.8E-01	1.5E+00	3.5E-01	2.1E+01	
Te-132	5.7E-05	1.2E-02	8.4E-01	1.2E-02	5.7E-01	1.2E-02	7.0E-01	
Tm-170	1.9E-04	5.6E-03	3.9E+00	5.6E-03	1.9E+00	5.5E-02	3.3E+00	
U-234	8.5E-08	1.4E-04	7.3E-03	1.4E-04	8.5E-04	1.0E-04	6.1E-03	
U-235	4.2E-08	1.5E-04	7.8E-03	1.5E-04	4.2E-04	1.1E-04	6.5E-03	
U-238	1.1E-07	1.6E-04	8.2E-03	1.6E-04	1.1E-03	1.1E-04	6.8E-03	
Y-91	1.2E-04	3.3E-03	3.5E+00	3.3E-03	1.2E+00	4.8E-02	2.9E+00	
Yb-169	5.7E-05	2.4E-02	1.7E+01	2.4E-02	5.7E-01	2.4E-01	1.4E+01	
Zr-95	3.8E-06	1.1E-02	4.2E+02	1.1E-02	3.8E-02	3.8E-02	3.5E+02	

1 – All AALs are based on quantities developed in the FRMAC Assessment Manual. For values where multiple Time Phases may be applicable, the most conservative value was chosen. ICRP 60 dosimetry model is used in the default calculations.

2 – Water AAL from the Water DRL calculated by determining the radionuclide concentration that would produce a dose equal to the FDA PAG. Water DRL method to be included in the FRMAC Assessment Manual at a future date

3-- The Values presented here represent the critical level Lc, this value is taken to be 10% of the AAL

4—"Short Term Dp_DRLs" are the minimum (most conservative) of the Dp_DRLs for the Early Phase and 1st Year Time Phases.

5—" Long Term Dp_DRLs" are the minimum (most conservative of the Dp_DRLs for the Early Phase, 1st Year, 2nd Year, 50 Year Time Phase, and the $Milk\_DRL_{area}$

Table B-11. Default Critical Levels (L_c) by sample type and nuclide INCLUDING Plume Dose

	Air ($\mu Ci/m^3$)	Food ($\mu Ci/kg_{wet}$)	Forage ($\mu Ci/kg_{wet}$)	Milk ($\mu Ci/kg_{wet}$)	ST Soil (μCi/Sample)	LT Soil (μCi/Sample)	Water ($\mu Ci/L$)	Tap Water (pCi/L)
DRL Type APPLIED	**Dp_DRL "Short Term"**	**DIL**	**$Milk\_DRL_{mass}$**	**DIL**	**Dp_DRL "Short Term"**	**Dp_DRL "Long Term"**	**$Milk\_DRL_{water}$**	**EPA guidelines**
Am-241	2.0E-09	5.4E-06	7.5E-02	5.4E-06	2.0E-05	2.0E-05	6.2E-02	Contact FRMAC Assessment for appropriate value
Ba-140	1.5E-05	1.9E-02	9.0E-01	1.9E-02	1.5E-01	1.2E-02	7.5E-01	
Ce-141	4.9E-05	1.9E-02	1.4E+01	1.9E-02	4.9E-01	2.0E-01	1.2E+01	
Ce-144	3.6E-06	1.3E-03	9.4E-01	1.3E-03	3.6E-02	1.3E-02	7.8E-01	
Cf-252	5.2E-09	1.0E-05	1.4E-01	1.0E-05	5.2E-05	5.2E-05	1.2E-01	
Cm-242	3.3E-08	5.1E-05	5.4E-02	5.1E-05	3.3E-04	3.3E-04	4.5E-02	
Cm-244	3.4E-09	5.4E-06	5.6E-03	5.4E-06	3.4E-05	3.4E-05	4.7E-03	
Co-60	1.1E-06	2.0E-03	1.4E-01	2.0E-03	1.1E-02	1.9E-03	1.2E-01	
Cs-134	1.8E-06	2.5E-03	6.6E-03	2.5E-03	1.8E-02	9.2E-05	5.5E-03	
Cs-136	2.0E-05	3.1E-02	9.2E-02	3.1E-02	2.0E-01	1.3E-03	7.6E-02	
Cs-137	4.2E-06	3.7E-03	9.7E-03	3.7E-03	4.2E-02	1.3E-04	8.1E-03	
Gd-153	3.9E-05	3.6E-02	2.5E+01	3.6E-02	3.9E-01	3.3E-01	2.1E+01	
I-129	1.8E-05	1.5E-04	3.5E-04	1.5E-04	1.8E-01	2.4E-06	2.9E-04	
I-131	6.4E-05	4.6E-04	1.3E-03	4.6E-04	6.4E-01	8.8E-06	1.1E-03	
I-132	2.0E-05	4.3E+00	1.9E+07	4.3E+00	2.0E-01	2.0E-01	1.6E+07	
I-133	1.5E-04	1.9E-02	2.2E-01	1.9E-02	1.5E+00	1.5E-03	1.8E-01	
I-134	8.6E-08	4.4E+01	3.1E+18	4.4E+01	8.6E-04	8.6E-04	2.5E+18	
I-135	1.1E-04	3.2E-01	1.1E+02	3.2E-01	1.1E+00	7.9E-01	9.5E+01	
Ir-192	9.9E-06	7.9E-03	8.4E+01	7.9E-03	9.9E-02	9.9E-02	7.0E+01	
La-140	4.4E-05	1.8E-01	4.3E+02	1.8E-01	4.4E-01	4.4E-01	3.6E+02	
Mo-99	1.2E-04	3.9E-01	8.0E+00	3.9E-01	1.2E+00	1.1E-01	6.7E+00	
Nb-95	2.1E-05	3.2E-02	1.7E+03	3.2E-02	2.1E-01	2.1E-01	1.4E+03	
Np-237	5.7E-10	1.1E-05	4.5E-02	1.1E-05	5.7E-06	5.7E-06	3.7E-02	
Np-239	1.3E-04	7.6E-02	5.7E+02	7.6E-02	1.3E+00	1.3E+00	4.7E+02	
P-32	4.7E-05	1.3E-02	1.9E-02	1.3E-02	2.8E-01	2.6E-04	1.6E-02	
Pm-147	2.8E-05	3.0E-02	2.1E+01	3.0E-02	1.8E-05	2.8E-01	1.7E+01	
Po-210	4.5E-08	4.2E-06	2.6E-04	4.2E-06	1.6E-05	3.6E-06	2.1E-04	
Pu-238	1.8E-09	6.8E-06	1.3E-01	6.8E-06	8.4E-04	1.8E-05	1.1E-01	
Pu-239	1.6E-09	5.9E-06	1.1E-01	5.9E-06	9.8E-05	1.6E-05	9.3E-02	
Pu-241	8.4E-08	3.3E-04	6.2E+00	3.3E-04	2.9E-01	8.4E-04	5.1E+00	
Ra-226	9.8E-09	5.5E-06	8.8E-05	5.5E-06	2.9E-02	1.2E-06	7.3E-05	
Ru-103	2.9E-05	1.8E-02	1.2E+02	1.8E-02	5.7E-01	2.9E-01	1.0E+02	
Ru-106	2.9E-06	1.2E-03	7.7E+00	1.2E-03	4.3E-01	2.9E-02	6.4E+00	
Sb-127	5.7E-05	8.5E-02	1.0E+02	8.5E-02	1.5E-01	5.7E-01	8.5E+01	
Sb-129	4.3E-05	7.7E+00	1.4E+07	7.7E+00	2.4E-01	4.3E-01	1.2E+07	
Se-75	1.5E-05	5.5E-03	2.9E-02	5.5E-03	1.2E-02	4.0E-04	2.4E-02	
Sr-89	2.4E-05	3.8E-03	2.9E-02	3.8E-03	9.6E-01	4.0E-04	2.4E-02	
Sr-90	1.2E-06	4.3E-04	3.2E-03	4.3E-04	2.3E-01	4.4E-05	2.7E-03	
Sr-91	9.6E-05	2.9E+00	7.1E+02	2.9E+00	5.9E-01	9.6E-01	5.9E+02	
Te-129m	2.3E-05	4.0E-03	1.9E-01	4.0E-03	3.0E-01	2.7E-03	1.6E-01	
Te-131m	5.9E-05	1.8E-01	2.6E+01	1.8E-01	2.1E-01	3.5E-01	2.1E+01	
Te-132	3.0E-05	1.2E-02	8.4E-01	1.2E-02	2.1E-01	1.2E-02	7.0E-01	
Tm-170	2.1E-05	5.6E-03	3.9E+00	5.6E-03	5.3E-01	5.5E-02	3.3E+00	
U-234	1.0E-09	1.4E-04	7.3E-03	1.4E-04	3.8E-02	1.0E-05	6.1E-03	
U-235	4.7E-10	1.5E-04	7.8E-03	1.5E-04	4.7E-06	4.7E-06	6.5E-03	
U-238	1.4E-09	1.6E-04	8.2E-03	1.6E-04	1.4E-05	1.4E-05	6.8E-03	
Y-91	2.1E-05	3.3E-03	3.5E+00	3.3E-03	2.1E-01	4.8E-02	2.9E+00	
Yb-169	5.3E-05	2.4E-02	1.7E+01	2.4E-02	5.3E-01	2.4E-01	1.4E+01	
Zr-95	3.8E-06	1.1E-02	4.2E+02	1.1E-02	3.8E-02	3.8E-02	3.5E+02	

1 – All AALs are based on quantities developed in the FRMAC Assessment Manual. For values where multiple Time Phases may be applicable, the most conservative value was chosen. ICRP 60 dosimetry model is used in the default calculations.

2 – Water AAL from the Water DRL calculated by determining the radionuclide concentration that would produce a dose equal to the FDA PAG. Water DRL method to be included in the FRMAC Assessment Manual at a future date

3-- The Values presented here represent the critical level Lc, this value is taken to be 10% of the AAL

4—"Short Term Dp_DRLs" are the minimum (most conservative) of the Dp_DRLs for the Early Phase and 1st Year Time Phases.

5—" Long Term Dp_DRLs" are the minimum (most conservative of the Dp_DRLs for the Early Phase, 1st Year, 2nd Year, 50 Year Time Phase, and the $Milk\_DRL_{area}$

During the late, or recovery phase, if drinking water regulations (CFR 141.25) are applied, the required detection limits are given in Table B-12.

Table B-12. Required Detection Limits for Drinking Water Samples

Analyte	**Detection Limit[1]**
Gross Alpha	3 pCi/L
Ra-226	1 pCi/L
Ra-228	1 pCi/L
Uranium	1 μg/L
Tritium	1,000 pCi/L
Sr-89	10 pCi/L
Sr-90	2 pCi/L
I-131	1 pCi/L
Cs-134	1 pCi/L
Gross Beta	4 pCi/L
Other Radionuclides	1/10 of the applicable limit

[1]See CFR 141.25 for detailed description

B.5 References

1. Turbo FRMAC 2009, Sandia National Laboratories
2. Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4, February 2006, EPA/240/B-06/001
3. MARLAP, Volume 1, Appendix B, The Data Quality Objectives Process
4. Currie, L.A., "Limits for Qualitative Detection and Quantitation Determination, Application to Radiochemistry," Analytical Chemistry, Vol. 40, No. 3, March 1968
5. MARLAP, Volume 2, Chapter 20, Detection and Quantification, NUREG-1576, EPA 402-B-04-001C, NTIS PB2004-105421, July 2004

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Appendix C: Electronic Data Deliverables

The off-site laboratory must provide specifically formatted electronic files containing sample information and results so that it can be uploaded to RAMS by FRMAC Laboratory Analysis personnel. Table C1 contains the descriptions of each field in this Electronic Data Deliverable.

Table C-1: Description of the Electronic Data Deliverable

Field	Description	Example	Example	Example	Acceptable Entries	Detailed Description
Analysis Request #	Generated by RAMS when a shipment is created. This could be pre-populated the EDD sent to the lab	ISCM11	ISCM11	ISCM11	Must match (case-sensitive) the Analysis Request number that the result is for	Tracking number that refers to a collection of samples sent to a laboratory for analysis
Sample #	SCF # for FRMAC samples, and "LABQC" for laboratory samples. This value determines whether the data are parsed to the FRMAC Sample Data Table (SCF...) or the Lab QC Table (LABQC).	SCF12345	LABQC	LABQC	If result is for a submitted sample, this field must match the case-sensitive Sample ID as it is printed on the Analysis Request. If the result is an internal Quality Control Sample, this field must be unique among all samples analyzed by the laboratory.	Tracking number that refers to a single physical sample. If result is an internal laboratory QC sample, this field must be generated by the laboratory and be unique among all samples analyzed by the laboratory. If the result is a duplicate of a sample record, the sample # must match the original Sample # followed by "dup" (ex. SCF-001dup will be a duplicate result of sample SCF-001)
Nuclide	The radionuclide being reported for this sample.	Cs-137	Cs 137	CESIUM 137	Alpha-numeric radionuclide identifier. Most common representations of the nuclide names are compatible. (See examples)	Analyte for which quantified results are being requested
Result	The value or percent recovery obtained from the analysis	-0.02	5%	0.6	Floating-point number (scientific notation)	The quantity of analyte as discovered by laboratory
Uncertainty	The combined standard uncertainty associated with the Result. Not applicable to % Recovery data	0.03		0.08	Floating-point number (scientific notation)	The uncertainty of the result at the sigma level indicated by Unc Sigma
Unc Sigma	The value associated with the Uncertainty sigma	2		2	integer	The number of standard deviations that the value in the uncertainty field represents (ex. 1,2, or 3 sigma)
MDA	The smallest amount of a radionuclide in a sample that will be detected with a probability β of non-detection (Type II error) while accepting a probability α of erroneously deciding that a positive (non-zero) quantity of analyte is present in an appropriate blank sample (Type I error). The probabilities are both set at 0.05.	0.05		0.05	Floating-point number (scientific notation)	The smallest amount of a radionuclide in a sample that will be detected with a probability β of non-detection (Type II error) while accepting a probability α of erroneously deciding that a positive (non-zero) quantity of analyte is present in an appropriate blank sample (Type I error). The probabilities are both set at 0.05. (95% symmetrical confidence level)
Critical Level (Lc)	The smallest amount of a radionuclide that will be statistically above background at the 95% confidence level	0.025		0.0025	Floating-point number (scientific notation)	The smallest amount of a radionuclide that will be statistically above background at the 95% confidence level

Unit	Unit of measurement for the Result, Uncertainty, and MDA, with the exception of % Recovery Results	pCi	%	pCi	Alpha-numeric, this must match the syntax of the required critical level's unit	The unit of measurement that applies to the Result, Uncertainty, MDA, and critical level
Dry Mass (kg)	The net mass of the sample after a drying treatment	0.005	0.5	1.75	Floating-point number (scientific notation) always in kg	The net mass of the sample after a drying treatment
Wet Mass (kg)	The net mass of the sample before a drying treatment	0.008	0.75	2	Floating-point number (scientific notation) always in kg	The net mass of the sample before a drying treatment
Reported Wet/Dry?	The type of mass used in calculating the activity concentration of the sample	Wet	Dry	N/A	Wet, Dry, (null, if both wet mass and dry mass are left blank)	The type of mass (wet or dry) used in calculating the activity concentration of the sample
Lab Qualifier	Result qualifier assigned by the laboratory performing the analysis	U			Single Letter: A - Result is acceptable and above the required Lc J - Result is to be considered "Estimated" U - Result is acceptable and less than the required Lc R - Result is Rejected from a QA standpoint	A qualifier assigned to the result by the laboratory (ex. Not Detected, Estimated, Rejected, *null "Acceptable"*)
QC Batch ID	Identifies a group of samples (FRMAC and Lab) that are processed as part of the same batch (preparation or analysis). The is the primary key connecting FRMAC sample data to Laboratory QC sample data, if those data are stored in separate tables.	abc123	QC123456	QAC	Alpha-numeric	A unique identifier chosen by the laboratory that links samples under QC batches. A QC batch shall not exceed 20 samples including laboratory control samples and any blanks, spikes, or duplicates required under the analytical method used for the analysis. This number must be unique for any batch of samples analyzed by the laboratory.
Result Type	Indicates the type of result and whether it is associated with a FRMAC sample or Lab sample; - FRMAC: "Sample", "Sample Dup", "MS", "MSD", "LR" - Lab: "MBlk", "LCS", "LCSD"	Sample	LCS	MBlk	Choose from the following: Lab Control Sample Matrix Blank Matrix Spike Method Blank Sample Sample Duplicate	Indicates what type of result is reported
% Recovery	Used as a trackable QC value. This value is required for results of type: LCS, LCSD, MS, MSD	95%	95%	80%	Value in percentage format	the value of the tracer recovery for results of type "Lab Control Sample" or "Matrix Spike"
Analysis Method	Determinative technique used; "Gamma", "LSC", "GPC", "Alpha Spec"	Gamma Spectroscopy	Alpha Spectroscopy	Liquid Scintillation Counting	Must match the analysis method on the Analysis Request for samples: Alpha Spectroscopy Gamma Spectroscopy Gas Proportional Counting ICP-MS Liquid Scintillation Counting Other Radon Compensating Alpha/Beta	The name of the analysis method used in determining the result. This must match the method referred to on the Analysis Request Form
Comments	Text field available to the laboratory to describe, explain quality affecting issues associated with this record.	Batch QC failed, but the sample is considered to be unaffected. Data are reported as-is.	Recovery outside +/- 25%	Result > MDA	Alpha-numeric Text (250 characters or less)	Text field available to the laboratory to describe, explain quality affecting issues associated with this record. (See analysis instruction sheet for specific commenting requirements)
Upload Settings	Indicates wheter the result should **replace** or **append** to results for the same nuclide and sample that already exist in the RAMS	R	A	R	NULL, A, R	This field instructs the upload software to overwrite (R) or append (NULL, or A)

The off-site laboratory will receive an email automatically when an Analysis Request Form is generated in RAMS. This email will include a link to the FRMAC Laboratory Analysis Web Portal where laboratories will be able to download the FRMAC Electronic Data Deliverable (EDD) template. Table C2 represents what the completed deliverable may look like. Upon completion of the sample analysis, the on-site and off-site laboratories will fill in the EDD (See Table C2) and either post it to the FRMAC Laboratory Analysis Web Portal (for off-site laboratories) or deliver it to the FRMAC directly (on-site laboratories) for uploading into RAMS.

Table C-2. Sample EDD

Analysis Request #	Sample #	Nuclide	Result	Uncertainty	Unc Sigma	MDA	Critical Level (Lc)	Unit	Dry Mass (kg)	Wet Mass (kg)	Reported Wet/Dry	Lab Qualifier	QC Batch ID	Result Type	% Recovery	Analysis Method	Comments	Upload Settings
ARF-0001	SCF00001	Cs-137	-0.02	0.03	2	0.05		pCi	0.5	0.75	Wet	U	abc123	Sample		Gamma	Batch QC passed internal standards	R
ARF-0001	SCF00002	Am-241	0.05	0.005	2	0.02	0.01	pCi	0.5	0.75	Wet	U	QCBATCH01	Sample		Alpha Spec	Result > MDA	A
ARF-0003	SCF00003	H-3	20	0.002	2	0.05	0.025	dpm	0.005	N/A	N/A	U	cba321	Sample		H3 by LSC	Result > MDA	A
ARF-0004	SCF00004	H-3	0.001	0.02	2	0.05	0.025	dpm	N/A	N/A	N/A	U	cba321	MBlk		H3 by LS	Result < Critical Level	R
ARF-0005	SCF12345	Mn-54	0.001	0.03	2	0.01	0.005	pCi	0.5	0.75	Dry	U	zyx123	Sample		Gamma	Not Detected	R
ARF-0001	SCF00001d	Cs-137	0.002	0.03	2	0.015	0.005	pCi	0.5	0.75	Wet	U	abc123	Sample dup		Gamma	Duplicate of sample SCF00001	
ARF-0001	LCS090720	Cs-137	25	2	2	0.015	0.005	uCi	N/A	N/A	N/A	U	abc123	LCS	0.950	Gamma	LCS for QC batch abc123 gamma spec	
ARF-0001	MS090720	Am-243	63	5	2	0.015	0.04	pCi	N/A	N/A	N/A	U	QCBATCH01	MS	0.85	Alpha Sp	MS for QC batch QCBATCH01 alpha sp	

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Appendix D: RAMS Operations

The Radiological Assessment and Monitoring System (RAMS) is an online database that the FRMAC uses to store field instrument and sample information during a radiological response. Currently RAMS is being developed to meet the ever-growing needs of the FRMAC. During this period of development the RAMS process is changing. In efforts to avoid having outdated information in this document, RAMS operations job aids that are applicable to laboratory analysis functions will be posted online. The most current job aides can be found at the following address in CMweb:

Manuals and Documents » **USA** » **CMweb** » **Events**
FY2012 » **Lab Analysis - Training and Forms** » **Manuals and Documents**

Note that you must have been granted access to the NNSA CMweb utility in order to access these job aids.

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Appendix E: FRMAC Laboratory Analysis Forms

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E.1 Sample Control Form

SAMPLE CONTROL FORM & CHAIN OF CUSTODY | **SCF -**

☐ TABLET - Sample information entered on Tablet

Sampling Information (*to be filled out by the Field Team*)

Field Team:	Collector's Name:	Home Org:
Longitude:	Location Description:	
Latitude:		
Collection Date:	Collection Time (24hr):	Area Exposure Rate: / Contact Dose Rate:
Collection Comments:		

Sample Type (use only once)

Air	Sampler ID #	Type:	Filter size & Type: ☐ Paper ☐ Cartridge ☐ 2" ☐ 4" ☐ Other	
	Date/Time ON:	Date/Time OFF:	**OR**	Total Volume: units:
	Start Flow Rate & units	Stop Flow Rate & units		
	Additional Air Filter Media, Provide Sample #			
Milk	☐ Stored Feed ☐ Pasture ☐ Other:			
	Milking Date:	Milking Time:	Number of Animals	
Soil	Depth of soil sample: cm	Vegetation collected with soil sample? ☐	If "YES" check box if "NO" leave blank	
	Sample surface area: cm²			
Water	☐ Surface ☐ Ground / Well ☐ Potable / Tap ☐ Other:			
Other	☐ Vegetation ☐ Food ☐ Instrument ☐ Swipe ☐ Other	Description:		
	Sample Area (cm): L W H			

Sample Receiving (*to be filled out by sample control & hotline technician*)

Processing Priority: ☐ Urgent ☐ Duplicate ☐ Split ☐ Composite ☐ Blank		
Receipt Contact Dose Rate uR/hr:	☐ **Contamination Check:** Forms and sample bags surveyed.	Weight of Sample gram
Analysis Requested:		
Remarks/Special Instructions		

Custody Transfer (Signatures)

Relinquished By:	Date/Time	Received By:	Date/Time
Relinquished By:	Date/Time	Received By:	Date/Time
Relinquished By:	Date/Time	Received By:	Date/Time
Relinquished By:	Date/Time	Received By:	Date/Time

Original with Sample **Copy to Sample Control** **October 2011**

E.2 RAMS Sample Receipt Form

PLACE HOLDER FOR FUTURE DEVELOPMENT

E.3 FRMAC Sample Non-Conformance Form

Sample Number: _____

Form Completed By: _____ Date/Time: _____

Check applicable boxes.

	Incomplete Sample Information		Containers received broken or leaking
	Issue with Matrix		Insufficient sample received
	Other		

Problems/Observations:

Resolution/Correction Action:

Approved by: _____ Date/Time: _____

E.4. Data Verification Review

DATA VERIFICATION FORM			
Incident:		Analysis Request #:	
Laboratory:			
Item	**RAMS**	**Hardcopy**	**Comments**
Issues identified prior to analysis that affect the data			
Custody records continuous and complete	N/A		
Requested radionuclides were reported			
Correct SCF Sample ID numbers			
Correct reporting units			
Uncertainty reported (1 or 2-sigma indicated)			
Detection and Quantitation Limits met			
Electronic data compare correctly against Hardcopy			
Hardcopy deliverable level is correct (1 or 4) and complete	N/A		
QC data meet requirements (defaults below are subject to change) LCS +/- 25% Blank < 2*CSU Duplicate DER ≤ 3 MS +/- 40%			
Approved by (sign & date):			

E.5. FRMAC Analytical Request Form

Analysis Request #_____

FRMAC ANALYTICAL REQUEST FORM

Page_____ of_____

Event:	***Report & Turnaround Information***	***Sample Information***
Laboratory POC:	Send Report To:	*Sample Hazards/Comments/Additional Information:*
	Phone: Fax: Email:	
Phone: Fax: Email:	Turnaround: ( ) A.S.A.P. ( ) Date_____	

Sample Management Information

Samples submitted are associated with a signed S.O.W. ( ) yes ( ) no

Analysis entered here agree with the S.O.W. ( ) yes ( ) no ( ) N/A

If not , identify the variation_____

Laboratory I.D. used for analysis_____

Sample I.D.	Sample Date/Time	Matrix	Volume/ Weight	Preservative	Contact Dose Rate	Isotope	Required L_c	Analysis Method	Comments

Custody Transfer

Relinquished by: (print)	Signature	Date/ time	Received by: (print)	Signature	Date/ time

E.6 Initial Laboratory Questionnaire

Laboratory Information Summary

Laboratory Name: _____ Contact Name: _____

_____ Contact Phone/Fax Number: _____

Shipping Address: _____ Contact Email Address: _____

_____ Alternate Contact: _____

_____ Alternate Phone/Fax Number: _____

_____ Alternate Email Address: _____

_____

Please specify the maximum activity levels your laboratory can accept.

	CPM	uCi	mR	Other
Per Sample				
Total				

Please specify typical Lc for a 10 minute count.

		Counting Geometry	Am-241	Cs-137	Gross Alpha	Gross Beta	Units	Samples / Day	Expected TAT for first sample
Gamma Spectroscopy	Soil						µCi/Sample		
	Air						µCi/Sample		
	Swipes						µCi/Sample		
	Water						µCi/L		
	Vegetation						µCi/Sample		
Proportional Counting	Soil						µCi/Sample		
	Air						µCi/Sample		
	Swipes						µCi/Sample		
	Water						µCi/L		
Radon-compensating Alpha/Beta Counter	Air						µCi/Sample		
	Swipes						µCi/Sample		
Liquid Scintillation	Water						µCi/L		
	Air						µCi/Sample		
	Swipes						µCi/Sample		

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Appendix F: Model Scope of Work

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The following section is a model scope of work for contractual purposes. All of the provisions of the document are negotiable but should be used to insure that FRMAC and contract laboratory personnel fully understand the performance expectations of the other party.

F.1 General Information

This document defines the required MQOs for radiological analysis of samples collected by the DOE/NNSA Consequence Management (CM/FRMAC) program during a response for incidents involving radioactive materials. This document applies to both on-site and off-site laboratories.

The laboratory's POC for any administrative or technical issue is the FRMAC CMHT Laboratory Analyst (off-site laboratory) or Deputy Laboratory Analysis Manager (on-site laboratory).

- Three time phases, early (or initial), intermediate, and late (or recovery), are generally accepted as being common to all unplanned releases of radioactive materials.
- Samples are collected during the early or initial phase of a response and may contain high radiation levels with unknown isotopes. The required turn-around time for early phase samples are on the order of hours, detection limits are higher, and analytical methods are simple and rapid. The laboratory is required to be on a high level of readiness and be able to deploy on a short notice. It is expected that most laboratories providing early phase sample analysis support will be mobile laboratories or off-site laboratories that are geographically close to the location of the incident and capable of operating 24 hours a day.
- Intermediate phase samples require a higher level of data quality. The required turnaround times are on the order of a few days, detection limits are lower than the early phase samples, and the analytical methods may be more complicated, including simple digestions. It is expected that most laboratories providing intermediate phase sample analysis support will be off-site laboratories.
- Late or recovery phase samples are for site characterization and remediation. These samples require the highest level of data quality and legal defensibility. The required turn-around times are on the order of a few weeks, detection limits may be very low, and the analytical methods are more complicated, including full radiochemical procedures. It is expected that all laboratories providing sample analysis support during the late phase will be off-site laboratories.

It is expected that all support for early or initial phase samples will be provided by local laboratories that maintain a high level of readiness. This may include both mobile and off-site laboratories. During the intermediate and late or recovery phase, laboratory support will extend to Federal, State and commercial laboratories. Each stated requirement below shall apply to all samples from all phases unless exempted.

The majority of the samples are air filters of various sizes, swipes, and environmental samples (soil, vegetation, food, and water). The samples may also include bioassay specimens (urine, feces, tissue, or blood), and other ad hoc samples such as pieces of machinery.

Each sample is individually tamper-sealed and is assigned a unique sample number.

The type of processing required for each sample is specified on the Analysis Request Form (ARF) provided to the laboratory with each sample shipment.

Prior to submitting samples for analysis, FRMAC may perform a QA audit of the laboratory. In addition, the laboratory could be subject to periodic quality assurance audits. If requested by FRMAC, the laboratory shall allow the FRMAC representatives access for purposes of performing quality assurance audits at any time.

FRMAC may submit blind or other audit samples to determine compliance with the Measurement Quality Objectives (MQOs).

For off-site laboratories, analysis results or any other written communication of information relating to the processing of samples shall be sent to the FRMAC CMHT at the designated location. On-site mobile laboratories shall provide results or any other written communication to the Deputy Laboratory Analysis Manager at the field location.

Disposal of reagent solutions and process waste shall conform to the applicable federal, state, and local regulations. Unused sample portions and residues shall not be disposed of without previous written authorization of the submitting organization.

F.2 Technical Criteria

F.2.1 Sample Receiving, Storage, and Handling

- Sample shipments originate from FRMAC in the field. The samples may be cooled pending transport and are shipped to the laboratory.
- Each shipment is accompanied by an ARF listing designated POC, the samples in the shipment, and specifying the radionuclide(s) and desired analysis for each sample in the shipment. To expedite the paper work, the form will serve both as the (CoC) and sample analysis request form, and will take precedence over any laboratory forms.
- The laboratory shall have procedures for sample receiving, radiation screening, processing, storage, and login.
- The laboratory shall inspect each sample upon receipt and indicate on the CoC form the condition of the sample upon arrival and whether the tamper seal(s) were intact.
- The CoC form shall then be signed on behalf of the laboratory.
- The laboratory shall record its login number(s) on the ARF and fax a copy to the FRMAC POC. The cooler(s) in which the samples were shipped shall be returned separately. If the coolers are contaminated in transport, the receiving laboratory shall dispose of the coolers in accordance with applicable state and federal regulations.
- The laboratory shall have a designated area for storing samples. The laboratory shall maintain a system to store samples and remaining sample fractions such that a sample can be retrieved from storage in a timely manner.
- The laboratory shall, throughout all steps of the handling, storage, and analysis process, use containers, handling procedures, etc. to prevent loss, degradation, or contamination of samples.
- The laboratory shall store all remaining portions of an analyzed sample until directed by FRMAC Leadership, which may include the Coordinating Agency, EPA Senior Official, and the state.

- The laboratory shall have a documented process for positive sample control and custody during the various processing steps (i.e., the samples will either be under direct control of a laboratory employee or kept in a secure location). The laboratory shall make arrangements with the FRMAC for the return of the sample(s).

F.2.2 Sample Preparation and Chemistry

- The laboratory shall have detailed procedures for preparing samples, including any required radiochemistry, for all the requested analyses.
- The laboratory shall document the calibration and maintenance of various items such as fume hoods, pipettes, balances, and other equipment used during sample processing.
- At a minimum, each batch of samples that are processed together shall include a blank (reagent or matrix, as appropriate) and a Laboratory Control Sample. Some analyses may require the use of other QC samples such as but not limited to matrix duplicates, matrix spike/matrix spike duplicates, etc. as applicable to the method. In consideration of FRMAC needs, some or all may be waived by the Laboratory Analysis Manager, Deputy Manager, or CMHT Laboratory Analyst. The requirements shall be outlined in the analysis request's documentation.
    - Matrix spike and matrix spike duplicates are not required if an isotopic tracer or chemical carrier is used in the analysis. They are also not required for gross alpha, gross beta, and gamma analysis.
- The laboratory shall analyze a blank sample with each batch to determine the existence and magnitude of contamination problems or NORM in accordance with their normal procedures.
- The laboratory shall analyze a LCS and blank with each batch to monitor the overall performance of all steps in the analysis, including the sample preparation. Batches shall include no more than 20 samples. The laboratory shall use LCS and blanks with matrices as similar as possible to that of the samples (applicable to intermediate and late or recovery phase samples only).
- The LCS shall be spiked at a level to provide a counting uncertainty of less than 10% at the 2-sigma confidence level (applicable to intermediate and late or recovery phase samples only).
- Chemical recovery of individual samples subject to chemical process and separation shall be established by means of spiking with tracer quantities of other radioisotopes of the same element or carrier quantities of the inactive isotope of the same or a chemically similar element (applicable to intermediate and/or recovery samples only).
- All samples that require the addition of a tracer shall be tracer-spiked prior to sample preparation unless this is impossible for a technically feasible reason.

F.2.3 Counting Systems

- Requirements for instrument calibration shall be documented and ensure that instruments are capable of producing acceptable quantitative data. The laboratory shall use standards that are traceable to a national standards laboratory (e.g. NIST) for calibrations. Standards used solely for energy calibration do not need to be traceable. For routine instrument checks, non-traceable standards may be used as long as they are not used for determining sample results.

- The laboratory shall have instrument/equipment-specific procedures for calibration, routine instrument checks, system maintenance, sample counting, data analysis, and report generation.
- The laboratory shall document performance indicators for each instrument/equipment on control charts that shall be made available to FRMAC upon request.
- The laboratory shall establish technically defendable warning and control limits for each control chart.
- When control limits for a performance indicator are exceeded, the instrument/equipment shall not be used for counting samples until the problem is investigated, documented, and resolved.
- The laboratory shall maintain records for each instrument/equipment documenting repairs, software upgrades, and any other actions that affect the instrument/equipment.

F.2.3.1 Alpha Spectroscopy System (Alpha Spec)

- Energy versus channel calibration shall be performed at the established frequency identified in the laboratory's QA Manual.
- Resolution shall be established when a routine performance check indicates an out of statistical control change in system resolution.
- Efficiency calibration for each counting geometry shall be performed at the established frequency identified in the laboratory's QA Manual.
- Detector backgrounds shall be established according to the laboratory's QA Manual.

F.2.3.2 Gamma Spectroscopy System (Gamma Spec)

- Energy versus channel calibration shall be performed at the established frequency identified in the laboratory's QA Manual.
- Resolution versus energy calibration shall be performed at the established frequency identified in the laboratory's QA Manual or when the routine performance check indicates an out of statistical control change in system resolution.
- Efficiency calibration (efficiency versus energy) for each counting geometry shall be performed at the established frequency identified in the laboratory's QA Manual or when the routine performance check indicates an out of statistical control change in efficiency.
- Detector background shall be established according to the laboratory's QA Manual.
- At a minimum the gamma library shall include the radionuclides provided by the FRMAC, and should include the associated gamma energy lines, abundances and half-lives provided by the FRMAC Laboratory Analysis Division.

F.2.3.3 Gas Proportional Counters

- A plateau curve shall be performed at the established frequency identified in the laboratory's QA Manual, or when the routine performance checks indicate an out of statistical control change in response.
- Gross counting systems shall be efficiency calibrated for each alpha and beta counting geometry at the established frequency identified in the laboratory's QA Manual or when the routine performance check indicates an out of statistical control change in efficiency.
- Self-absorption (Attenuation) curves shall be performed at the established frequency identified in the laboratory's QA Manual or when the routine performance check indicates an out of statistical control change in efficiency.
- Detector background shall be established as indicated in the laboratory's QA Manual or when the routine performance check indicates an out of statistical control change in background.

F.2.3.4 Radon-compensating Alpha/Beta Counters

- Counting systems shall be efficiency calibrated for each alpha and beta counting geometry at the established frequency identified in the laboratory's QA Manual or when the routine performance check indicates an out of statistical control change in efficiency.
- Detector background shall be established as indicated in the laboratory's QA Manual or when the routine performance check indicates an out of statistical control change in background.

F.2.3.5Liquid Scintillation Counters

- For Liquid Scintillation Counters with alpha/beta separation capability, and if used for alpha/beta counting, the optimum pulse shape discriminator setting shall be performed at the established frequency identified in the laboratory's QA Manual or when the routine performance check indicates an out of statistical control change in performance.
- Efficiency quench curves shall be performed at the established frequency identified in the laboratory's QA Manual for each radionuclide and cocktail type to be counted or when the routine performance check indicates an out of statistical control change in efficiency.
- Background quench curves shall be established as identified in the laboratory's QA manual for each radionuclide to be counted unless matrix or batch blanks are used for background subtraction.

F.2.3.6 Kinetic Phosphorescence Analysis

- Background shall be established.
- The unit shall be calibrated with a minimum of three standards with concentrations spanning the range of interest.
- The background and calibration standards shall be analyzed after the samples are analyzed to verify system stability.

F.2.3.7 Inductively Coupled Plasma Mass Spectrometry

- Background for each isotope shall be established.

- The unit shall be calibrated for each isotope with a minimum of three standards with concentrations spanning the range of interest. For multi-isotope analysis, the calibration curve for another isotope that is close in mass (within 25 amu) to the target isotope may be used.
- The background and calibration standards shall be analyzed to verify system stability.

F.2.4 Data Analysis and Review

- The laboratory shall have procedures for analyzing raw data and reviewing data.
- The reported Critical Level (L_C), Minimum Detectable Activity (MDA) or other agreed to data limit shall meet the stated MQO. The limit shall be calculated in accordance with MARLAP or equivalent standard.
- LCS results for intermediate phase and late or recovery phase samples shall not contain a relative bias less than -25% or greater than +25% at 10 times the required L_C. For gross alpha and beta measurements and early phase samples, analytical results shall not contain a relative bias less than -50% or greater than +50% at 10 times the required L_C.
- The relative bias for LCSs shall be demonstrated.
- Blank analysis results shall be assessed to determine the existence and magnitude of contamination problems, if any. Procedures shall be in place for evaluation of the data if problems exist with any blank. If the tracer recovery for a sample is less than 30%, and if possible, the laboratory shall reprocess the sample or analyze an additional sample aliquot, if available. If another sample aliquot is not available, the laboratory shall immediately notify FRMAC so that they may consider re-sampling or a modification of procedures to provide additional sample volume in the future (applicable to intermediate and late or recovery phase samples only).
- The laboratory shall meet the L_C or MDA requirement for the analysis method and may compensate for low chemical recovery by increasing the count time.
- The LCS serves as a monitor of the overall performance of all steps in the analysis, including the sample preparation. All LCS results shall fall within the control limits stated above. The laboratory should try to spike at or near the action level or level of interest for the project.
- The combined standard uncertainty shall include all uncertainties associated with the analysis (i.e., combined counting and established instrument/equipment and sample preparation uncertainty).

F.2.4.1 Gamma Spectroscopy

- The laboratory shall identify and quantify all significant full energy peaks. The analysis gamma library shall at a minimum contain the radionuclides provided by the FRMAC, and should include the gamma energy lines, abundances and half-lives provided.
- For radioisotopes that are found, the laboratory shall report an activity, uncertainty, MDA and/or L_C (Critial Level) for the isotope.
- For target radionuclides that are not identified in the peak search and identification, the L_C (Critical Level) and MDA for that radionuclide shall be reported.
- The laboratory shall maintain the ability to re-evaluate the analytical results of all of the samples for one year following submission of the final analytical results to the FRMAC.

F.2.5 Delivery and Reporting of Results

- Results of analyses shall remain confidential and shall not be released to any third party, used to provide examples of the laboratory's work, or in any other way to provide data that would violate the confidentiality of sample results.
- The turn-around-time shall start when the sample arrives at the laboratory's facility and the laboratory has complete instructions for the analysis of the sample and ends when the results are reported to the FRMAC.
- The FRMAC POC shall be notified immediately of completion of early phase samples using the methods defined during the incident. The hardcopy results of intermediate and late or recovery phase samples shall be mailed, uploaded electronically, or faxed to the FRMAC POC. Electronic data deliverables of the results shall be made sent via email, or uploaded to the webportal to the FRMAC POC.
- Results for each Sample Group shall be submitted together (Data Package).
- The following minimum information shall be provided in the analysis report:
    - The FRMAC Sample Number.
    - The Laboratory's Sample Number.
    - The type of sample (2″ AF, Water, Urine, etc.).
    - The volume of the sample
    - The analysis aliquot type and quantity
    - The type of analysis performed on the sample (alpha spectroscopy, liquid scintillation, etc.). This shall be the same as that listed on the Analysis Request Form.
    - The radionuclide(s) specified for analysis on the Analysis Request Form.
    - The Results
        - The measured activity shall be reported in the units as the specified critical level units listed on the Analysis Request Form.
    - The total propagated uncertainty at the 1 or 2 sigma level reported in the same units as the result.
    - The recovery of the radio-tracer, if applicable.
    - The sample-specific MDA and/or L_C in the same units as the result.
- Electronic deliverable formats will be supplied by the FRMAC Deputy Laboratory Analysis Manager or CMHT.

Each set of results submitted to the FRMAC for normal samples shall be accompanied by a narrative report that includes for each sample the following information as applicable (this requirement is waived for initial and rush samples):

- The result of associated blank(s).
- The result of associated Laboratory Control Sample(s).
- The procedures used for sample analysis.
- A commentary explaining any problems encountered during the analysis of the samples.

The laboratory shall submit periodic quality assurance reports that include:

- A list of all instrumentation, process, and other quality-related problems as well as a brief description of how the problem was resolved.

- A commentary explaining any unusual problems or anomalies encountered by the laboratory (key personnel changes, funding issues, organizational changes, etc.).

Whenever the laboratory determines that a correction needs to be made to a previously reported result, the following is required:

- The corrected result and the reason for the change shall be promptly reported via telephone to the FRMAC POC.
- The previous and revised result and the reason for the change shall be documented by memo within five business days to FRMAC.
- The laboratory shall immediately notify the FRMAC by telephone if the analysis requested for a sample cannot be performed due to special circumstances such as unacceptable sample, lost sample, no sample received, invalid analysis, etc.

F.2.6 Quality Assurance

- The laboratory shall maintain a Quality Assurance (QA) Program.
- The laboratory QA Manual shall contain, or point to, procedures for implementation of the QA requirements and shall be maintained current.
- Written procedures shall be developed and implemented for all steps in each analytical process.
- Preparation, identification, and use of procedures shall be controlled (i.e., changes are reviewed, approved, and documented via a change history)
- Procedures shall be reviewed and revised as needed on a periodic basis, as stated in the laboratory's QA Manual.
- The following specific QA requirements shall be included in the laboratory's QA Manual:
    - Positive identification and control measures shall be used to assure that samples and other critical items are identifiable at all stages of the analysis and traceable to their source and the resultant data.
    - Measuring and test equipment shall be controlled and calibrated to assure the accuracy and reliability of required data. Traceability to the NIST or other recognized standards agencies shall be maintained.
    - Nonconforming materials, components, or parts (including samples and data) shall be reported, analyzed, controlled, and corrected or disposed of in accordance with procedures in the laboratory's QA Manual. Evidence that QA and QC activities were performed shall be documented, reported to the FRMAC as requested, and preserved.
    - The laboratory shall maintain a formal internal QA audit program. In addition, audits may be scheduled by FRMAC on an as-needed basis.
    - Staff shall receive QA and job-specific training appropriate to their responsibilities. All training, whether specific to QA or in other areas related to the work, shall be documented and accurate records kept.

The quality assurance program shall include:

- The analysis of blank and spiked samples with each batch of samples processed at one time.

- At least five percent of the total number of samples analyzed shall be quality control samples prepared by the laboratory to demonstrate compliance with accuracy and precision requirements (applicable to intermediate and late or recovery phase samples only).
    - The quality control samples shall have, insofar as possible, matrix, volume, and other relevant characteristics of the actual samples being analyzed (applicable to intermediate and late or recovery phase samples only).
    - A system of reviewing and analyzing the results of these samples shall be maintained to detect current problems due to contamination, calibration, calculations, inadequate procedures, or other causes.

Documented and laboratory-validated analytical methods shall be used whenever possible with all deviations tested and documented. FRMAC reserves the right to request specific analytical methods.

- The laboratory shall assure that its facilities and equipment are constructed and operated to minimize the possibility of cross-contamination.
- The laboratory shall provide FRMAC reasonable access to all facilities and data for the purpose of verification of performance as well as to ensure that the conditions of this Statement of Work are being met.
- The laboratory shall participate in sample comparison programs to ensure ability to properly measure known samples.

F.2.6.1 Software QA Activities

- All computer software, including modifications, that has the potential to affect the quality of analyses shall be tested and documented.

F.2.7 Records Management

The laboratory shall have a records management program for all record material and data generated by the analyses processes.

The records management program shall have as a minimum:

- Written procedures for handling laboratory records and data throughout their life cycle.
- A system for rapid retrieval of records.
- Written records retention and disposition schedules which meet all federal, state, and local legislative and regulatory requirements. These records shall include:
    - Laboratory Organization Chart
    - Key Personnel Qualifications
    - Any applicable Laboratory Certifications or Accreditations
    - Audit Reports from the last 3 years
    - Performance Testing Sample Results for the last 3 years
    - Procedures
        - Quality Assurance Plan
        - Sample Receiving, Handling, Custody, and Waste Disposal Procedures
        - Instrument Calibration Procedures

        - Sample Preparation Procedures
        - Sample Counting Procedures
        - Data Quality Review including Discrepancy Resolution
        - Data Reduction and Reporting
    - Validation Documentation
    - Data Files
    - Sample Receipt and Chain-of-Custody (for all analyses)
    - Continuing Calibration Data
        - QC Charts
    - Standards Data
        - Certificates
        - Prep Sheets
        - Verifications
    - Calibration Data Packages (by analysis type)

The laboratory shall keep all records pertaining to the analysis of FRMAC samples (including QA/QC records and program and policy manuals in effect at the time of sample analysis) for a minimum of five years from the reporting date of the sample results.

The laboratory shall give FRMAC prior notice of its intent to dispose of any records pertaining to the analysis of FRMAC samples.

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Appendix G: Bibliography and References

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Appendix H: Glossary

Accuracy	The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator.
Affected Sample Result	A sample result that is considered to be significantly influenced by a quality deficiency, and is qualified, accordingly, through analytical data validation.
Air and Emissions	Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbent tube, impinger solution, filter, or other device.
Analyst	The designated individual who performs the "hands-on" analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.
Analytical Action Levels (AALs)	The value of a quantity that will cause the decision maker to choose a course of action. The analytical action level may be a derived concentration level (such as the derived water concentration), background level, release criteria, regulatory decision limit, etc.
Analytical Batch	An analytical batch is a group of sample aliquots analyzed together on the same instrument detector system.
Analytical Data Validation	A technically based analyte and sample specific process that extends the qualification process beyond method or contractual compliance and provides a level of confidence in the data that an analyte is present or absent and if present, the associated variability. Data validation is a systematic process, performed external from the data generator, which applies a defined set of performance-based criteria to a body of data that may result in physical qualification of the data. Data validation occurs prior to drawing a conclusion from the body of data.
Analytical Data Verification	A process of evaluating the completeness, correctness, consistency, and compliance of a set of facts against a standard or contract. Data verification is defined as a systematic process, performed by either the data generator or by an entity external to the data generator.

Annual Limit on Intake (ALI)	The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective whole body dose equivalent of 5 rems (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. (10 CFR 20.1003)
Audit	A qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality (i.e., that they meet specified acceptance criteria).
Batch	Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A preparation batch is composed of one to 20 environmental samples of the same (2009 TNI standard)-defined matrix, meeting the above mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An analytical batch is composed of prepared environmental samples (extracts, digestives or concentrates) which are analyzed together as a group. An analytical batch can include prepared samples originating from various environmental matrices and cannot exceed 20 samples.
Biological Tissue	Any sample of a biological origin such as fish tissue, shellfish, or plant material. Such samples shall be grouped according to origin.
Blank	A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. See also: Equipment Blank, Field Blank, Instrument Blank, Method Blank, and Reagent Blank.
Blind Sample	A sub-sample for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process.
Calibration Verification	Calibration verification, as described in this procedure, is defined as a periodic evaluation of instrument standardization established during initial calibration. Using tolerance or statistical control charts, calibration verification can alert the instrument user of the occurrence of out-of-statistical-control instrumental conditions.

Carrier	A carrier is a stable element/compound, introduced into the sample preparation/analysis process that will behave chemically similar to the analyte isotope. It is by virtue of this chemical similarity that the carrier will "carry" the analyte isotope(s) through the sample preparation/analysis process. The amount of the carrier recovered at the end of the analysis compared to that added initially is often used in the calculation of the final result.
Chain of Custody Form	Record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; collector; time of collection; preservation; and requested analyses. See forms for an example.
Committed Dose Equivalent (CDE)	The dose equivalent to a specific organ for 50 years following intake (inhalation or Ingestion). It does not include contributions from external dose.
Committed Effective Dose Equivalent (CEDE)	The sum of the dose equivalent for 50 years following intake (inhalation or ingestion) of a radionuclide to each organ multiplied by a weighting factor. CEDE is used to estimate the risk from delayed health effects.
Conformance	An affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements.
Correctable Problem	Correctable problems are deficiencies within data packages which may be rectified through consultation with the laboratory. Correctable problems may be revealed during both data verification and data validation. Correctable problems revealed during verification are those deficiencies that can be addressed by obtaining additional information from the laboratory. Correctable problems revealed during validation are those deficiencies with analyses that can be solved by either a second preparation and/or analysis of a sample.
Corrective Action	The action taken to eliminate the causes of an existing nonconformity, defect or other undesirable situation in order to prevent recurrence.

Counting uncertainty	Counting uncertainty, as described in this procedure, is defined as the statistical sample standard deviation, which is an approximation of the population standard deviation, and is numerically defined as the square root of the number of counts obtained from a detector. This relationship holds true, provided that the distribution that the counts follows the Poisson distribution. Units for counting uncertainty are the same as for the reported result, the minimum detectable activity (MDA), and the Critical Level, as provided.
Critical Level (L_c)	Used to determine the presence of absence of a radionuclide in a sample. If a result exceeds the L_c, one can state that the result is different from the background at the 95% confidence level (5% false negative rate). The L_c is set at a level where values below this level are of minimum concern. A default value of 10% of the analytical action level (AAL) is used for the requested analysis if no other value is provided.
Data Quality Objective (DQO)	Qualitative and quantitative statements that clarify the study objectives, and specify tolerable limits on decision error rates.
Derived Intervention Level (DIL)	The concentration of a radionuclide in food derived from the protective action guide and at which introduction of protective measures should be considered.
Derived Response Level (DRL)	A calculated value (*e.g.*, exposure rate or radionuclide concentration) that corresponds to a protective action guides (PAG), or a derived intervention level (DIL). The DRL is the level of activity in a sample that if in individual is exposed to for an extended period of time would lead to a dose equivalent to the PAG or DIL.
Derived Water Concentration (DWC)	The concentration of a radionuclide that would result in exposure to a specified dose level. Generally refers to a protective action guide or other specified dose- or risk-based factor.
Dose Conversion Factor (DCF)	The dose equivalent per unit intake of a radionuclide (mrem/ □Ci).
Drinking Water	Any aqueous sample that has been designated a potable or potential potable water source.
Equipment Blank	A sample of analyte-free media which has been used to rinse common sampling equipment to check effectiveness of decontamination procedures.
Field Blank	Blank prepared in the field by filling a clean container with sample matrix that is known to contain no contamination from the incident.

Hands-On Training Event	Training event which includes but is not limited to a capstone, web-based training, exercise, or drill
Holding Time	Holding time, as described in this procedure, is defined as the period of time between sample collection and sample activity detection.
Initial Calibration	Initial calibration, as described in this procedure, is defined as the standardization of an instrument used in radioactivity detection against a traceable radioactive source(s) of known identity and quantity. This standardization prevails until such time as analytical conditions are deemed out of acceptable tolerance or statistical control limits.
Inspection	An activity such as measuring, examining, testing, or gauging one or more characteristics of an entity and comparing the results with specified requirements in order to establish whether conformance is achieved for each characteristic.
Instrument Blank	A clean sample (e.g., distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination.
Laboratory Control Sample (however named, such as laboratory fortified blank, spiked blank, or QC check sample)	A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.
Laboratory Duplicate	Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.
Laboratory Information Management System	A computerized system for tracking workflows and sample custody through the analytical process.
Matrix	The substrate of a test sample. These matrix definitions shall be used to describe quality assurance/quality control (QA/QC) performance testing samples

Matrix Spike (spiked sample or fortified sample)	A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.
Matrix Spike Duplicate (spiked sample or fortified sample duplicate)	A second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.
Method Blank	A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.
Minimum Detectable Activity (MDA)	The activity at which the statistical uncertainty leads to a specific confidence level. A confidence level is a measure of how sure the analyst can be that the result is representative of the true value. In this procedure, the confidence level is taken to be 95% which corresponds to a 5% chance of false positive or false negative conclusions. The MDA is typically a function of background and count time but varies by detector type and analysis method.
Minimum Detectable Concentration (MDC)	The minimum detectable activity (MDA) expressed in concentration units relative to the sample weight or volume.
National Institute of Standards and Technology (NIST)	An agency of the US Department of Commerce's Technology Administration that is working with U.S. Environmental Protection Agency (EPA), states, 2009 TNI Standard, and other public and commercial entities to establish a system under which private sector companies and interested states can be accredited by NIST to provide NIST-traceable Proficiency Testing (PT) to those laboratories testing drinking water and wastewater.
Negative Control	Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results.

Non-correctable problem	Non-correctable problems are those deficiencies, within data packages that cannot be addressed through additional laboratory submittals, and sample results must stand as-is. Non-correctable problems are deficiencies within data packages which preclude the evaluation of data quality by predefined criteria. Non-correctable problems may be revealed during both data verification and data validation.
Non-Potable Water	Any aqueous sample excluded from the definition of Drinking Water matrix. Includes surface water, groundwater, effluents, water treatment chemicals, and TCLP or other extracts.
Performance Audit	The routine comparison of independently obtained qualitative and quantitative measurement system data with routinely obtained data in order to evaluate the proficiency of an analyst or laboratory.
Positive Control	Measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects.
Precision	The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.
Preparation Batch	A preparation batch is a group of sample aliquots prepared together at the same time using the same method and related to the same quality-indicator samples.
Preservation	Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical and/or biological integrity of the sample.
Proficiency Test Sample (PT)	A sample, the composition of which is unknown to the analyst and is provided to test whether the analyst/laboratory can produce analytical results within specified acceptance criteria.
Proficiency Testing	A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source.
Proficiency Testing Program	The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories.

Protective Action Guide (PAG)	The projected dose, from an accidental release of radioactive material, where specific actions to reduce or avoid dose are warranted.
Quality Assurance	An integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence.
Quality Control	The overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users.
Quality Control Chart	For purposes of this procedure, a quality control chart is used to determine if the response of the instrument has changed statistically. The quality control chart is used to determine if the statistical response change is significant when compared to precision and accuracy criteria..
Quality Control Sample	An uncontaminated sample matrix spiked with known amounts of analytes from a source independent from the calibration standards. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system. .
Quality-indicator Sample	Quality-indicator samples are those samples made ready in the laboratory which provide direct or indirect evaluation of the status of analytical system and resulting data quality. Collectively, quality indicator samples are the laboratory control sample, laboratory duplicate, matrix spike, and method blank.
Quantitation Limits	Levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported at a specified degree of confidence.
Reagent Blank.	(Method reagent blank): A sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.
Reference Standard	A standard, generally of the highest metrological quality available at a given location, from which measurements made at that location are derived.
Replicate Analyses	The measurements of the variable of interest performed identically on two or more sub-samples of the same sample within a short time interval.

Reporting Batch	A reporting batch is a group of sample results reported together in a single data package. The reporting batch may be comprised of samples prepared and analyzed together in the same preparation batch or samples prepared and analyzed in different preparation or analytical batches.
Required Detection Limit (RDL)	The RDL is a contractually-specified detection limit (LOQ or MDC) which, under typical analytical circumstances, should be achievable. The laboratory sample-specific minimum detectable activity (MDA) or Critical Level will be compared to the RDL to evaluate performance.
Sample Tracking	Procedures employed to record the possession of the samples from the time of sampling until analysis, reporting, and archiving. These procedures include use of a chain of custody (COC) Form documenting collection, transport, and receipt of compliance samples to the laboratory. Laboratory access is also limited and controlled to protect the integrity of the samples.
Solid and Chemical Materials	Includes soils, sediments, sludge, products and by-products of an industrial process that results in a matrix not previously defined.
Spike	A known mass of target analyte added to a blank sample or sub-sample; used to determine recovery efficiency or for other quality control purposes.
Standard Operating Procedures (SOPs)	A written document which details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and which is accepted as the method for performing certain routine or repetitive tasks.
Standard Reference Material (SRM)	A material or substance of one or more properties of which are sufficiently well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials. The SRM is characterized by the U.S. National Institute of Standards and Technology (NIST) or other certified testing authority, and issued with a certificate providing the results of the characterization.
Surrogate	A substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes.
Tolerance Chart	For purposes of this manual, a tolerance chart is based upon maintaining a change of instrument response to a tolerance level judged acceptable to meet overall quality requirements for the technique; a tolerance level should never be more restrictive than what is statistically possible.

Total Effective Dose Equivalent (TEDE)	The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).
Total Propagated Uncertainty (TPU)	The sum-in-quadrature of the random components of the individual uncertainties (the square root of the sum of the squares) plus the magnitude of the estimated individual systematic relative uncertainties. TPU may include uncertainties introduced through field sampling and analytical laboratory procedures. For the purposes of this manual, TPU includes only those random and systematic uncertainties associated only with laboratory preparation and analysis. This may also be referred to as the Combined Standard Uncertainty.
Traceability	The property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.
Traceable Reference Material (TRM)	A NIST prepared standard reference material or a sample of known activity or concentration prepared from a NIST standard reference material (derived standard material).
Tracer	A tracer is a radioactive isotope, introduced into the sample preparation/analysis process that will behave chemically similar to the analyte isotope. The tracer isotope is of the same element as the analyte isotope(s) except where the decay mode, half-life, or availability dictates the use of the isotope of a different element. The activity of tracer detected at the end of the analysis compared to that added initially is used in the calculation of the final result.
Turn-around Time	Turn-around-time is contractually-specified as the amount of time which elapses between laboratory receipt of the raw samples and subsequent data receipt by the client.
Validation	The process of substantiating specified performance criteria.

Verification	Confirmation by examination and provision of evidence that specified requirements have been met. NOTE: In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment. The result of verification leads to a decision either to restore in service, to perform adjustment, to repair, to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring instrument's individual record.
Well Characterized Reference Material (WCRM)	The WCRM may be derived from a field sample which has been well characterized through multiple analyses providing a high level of confidence of the activity level in the sample. The WCRM may be submitted to NIST for characterization and classification as a certified reference material.

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