PNNL-20919-1, Rev. 1

EMP, Attachment 1

Sampling and Analysis Plan

November 2024

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SG Ramos
JM Barnett
SF Snyder

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99354

Summary

This Sampling and Analysis Plan (SAP) is written for the Environmental Radiation Task activities related to radioactive air emissions (stack) monitoring and environmental radiological ambient air surveillance of Pacific Northwest National Laboratory (PNNL) operations at the PNNL-Richland campus and PNNL-Sequim campus. PNNL is a U.S. Department of Energy Office of Science laboratory in Richland, Washington. This plan is an attachment to PNNL's Environmental Radiological Air Monitoring Plan (EMP) (PNNL-20919) and addresses a discrete, vital subject area that is subject to revision independent of the main text of the EMP document. This SAP provides the requirements for planning sampling events and the requirements imposed on the services provided by the analytical laboratory to the PNNL Environmental Radiation Task.

Revision Number	Effective Date	Description of Change
Rev 0	December 2011	Initial document.
Rev 1	November 2024	• Major re-write with the following highlights: – PNNL-Richland campus is the term used to indicate operations in Richland, Washington, superseding use of the term PNNL Site. – PNNL-Sequim campus added and discussed, including site ambient dosimetry program. – Sampling and analysis for PNNL-managed emission units on the Hanford Site discussed, as appropriate, for the determination of radioactive material emissions to ambient air. – Discussion of new Environmental Information Management (EIM) System for stack and ambient air sample results. – Discussed elimination of the PNNL internal document *PNNL-Richland Campus Radiological Air Environmental Surveillance Sampling Schedule*, using this SAP as the location where the sampling locations, frequencies, and analyses are documented. – PNL-3 sampling station relocation.

Note:

Acronyms and Abbreviations

325RPL	325 Building Radiochemical Processing Laboratory
A2LA	American Association for Laboratory Accreditation
ANSI/HPS	American National Standards Institute
BS	blank spike
CAM	continuous air monitor/monitoring
CFR	*Code of Federal Regulations*
COC	chain of custody
cps	counts per second
DAG	Dose Assessment Guidance (third of three EMP attachments)
DOE	U.S. Department of Energy
DOECAP-AP	DOE Consolidated Audit Program-Accreditation Program
DMP	Data Management Plan (second of three EMP attachments)
DQO	data quality objectives
EIM	Environmental Information Management System
EMP	Environmental Radiological Air Management Plan
EM-QAP	Effluent Management-Quality Assurance Plan
EPA	U.S. Environmental Protection Agency
ERT	Environmental Radiation Task
F&O	Facilities & Operations
HASQARD	Hanford Analytical Services Quality Assurance Requirements Documents
LCS	laboratory control sample
MAPEP	U.S. DOE Mixed Analyte Performance Evaluation Program
MDA	minimum detectable activity
MDC	minimum detectable concentration
MSL	Marine Sciences Laboratory
NESHAP	National Emissions Standard for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
NOC	notice of construction
OSL	optically stimulated luminescence
PIC	potential impact category
PNNL	Pacific Northwest National Laboratory
PSF	Physical Sciences Facility
RAEL	Radioactive Air Emissions License
RAES	Radioactive Air Emissions Sampling
RPT	Radiation Protection Technologist
RS&EG	Radiochemical Science & Engineering Group
QC	quality control
QSM	U.S. DoD/DOE Consolidated Quality Systems Manual
RDL	required detection limit

RPD	relative percent difference
SAP	Sampling and Analysis Plan (first of three EMP attachments)
SOP	Standard Operating Procedure
SOW	Statement of Work
WDOH	Washington State Department of Health

Definitions

Accuracy	The degree of agreement of a measurement (or an average of measurements of the same thing), X, with an accepted reference or true value, T, usually expressed as the difference between the two values, X – T, or the difference as a percentage of the reference or true value, 100 (X – T)/T, and sometimes expressed as a ratio, X/T. Accuracy is a measure of the bias in a system. Accuracy represents the degree to which a measurement agrees with an accepted reference or true value. Sample accuracy is expressed as the percent recovery of a spiked sample. Acceptance criteria shall be established for each analyte and each analyte method and shall be agreed on by the laboratory and the client.
Batch	A group of samples that behave similarly with respect to the sampling or testing procedures being employed and that are processed as a unit. For quality control purposes, if the number of samples in a group is greater than 20, then each group of 20 samples or fewer will all be handled as a separate batch. [HASQARD definition]
Batch	Environmental samples prepared and/or analyzed together with the same process and personnel using the same lot(s) of reagents, A **preparation batch** is composed of 1 to 20 environmental samples of the same matrix, meeting the above-mentioned criteria and with a maximum time between the start of the processing of the first and last sample in the batch to be 24 hours. An **analytical batch** is composed of prepared environmental samples that are analyzed together as a group using the same calibration curve or factor. An analytical batch can include prepared samples originating from various environmental matrices and can exceed 20 samples (NELAC Quality Systems Committee). [Ambient Air standard operating procedure definition]
Chain of custody (COC)	An unbroken trail of accountability that ensures the physical security of samples, data, and records. The purpose of the chain-of-custody is to document sample possession and to demonstrate that the sample was maintained in a controlled and unaltered state. This demonstration supports the interpretation of the sample results and may be required in legal proceedings, and for a number of other purposes. Custody in the laboratory is defined as secured to prevent tampering and may be accomplished by having the sample in one of the following situations: 1) in actual physical possession, 2) in view of the sample custodian after being in physical possession, 3) in a locked area, or 4) in a designated secured area (e.g., accessible only to authorized personnel).
Composite	A single sample comprised of samples from two or more sampling periods selected to represent the material being analyzed. Composites combine samples from a single sampling location, unless otherwise indicated.

Laboratory control sample (LCS) A laboratory control sample (LCS) or blank spike (BS) is used to monitor the effectiveness of the sample preparation method. The LCS is a material similar in nature to the sample being processed containing the analyte(s) of interest (e.g., standard reference material). An LCS, if available, shall be prepared with each batch of samples processed at the same time. The BS is distilled or deionized water, or other suitable substrate spiked with the analyte(s) of interest. The blank, spiked with tracer would also meet the BS requirements. A BS is normally used when an appropriate LCS is unavailable.

Calculate as:

$$\%R = \frac{(SSR - SR)}{SA} * 100$$

where SSR = spiked sample result
SR = sample result
SA = spike added
R = recovery.

Laboratory duplicate An initial subsample of a sample that has been homogenized, further divided into two separate subsamples, and then subjected to the entire analytical procedure after being received by the laboratory. This is used to determine the precision of a method, expressed as relative percent difference between the two measurements.

Calculate as

$$RPD = \frac{|x_1 - x_2|}{\bar{x}} * 100 = \frac{2 * |x_1 - x_2|}{|x_1 + x_2|} * 100$$

where x_n = observed value of subsample *n*
RPD = relative percent difference.

Laboratory or preparation blank An analytical control prepared by the laboratory, containing distilled, deionized water and reagents, that is carried through the entire analytical procedure (digested and analyzed) concurrently with samples per each sample deliverable group. An aqueous method blank is treated with the same reagents as a sample with a water matrix. A solid method blank is treated with the same reagents as a soil sample. It is a test for contamination in sample preparation and analyses.

Matrix The component or substrate (e.g., surface water, drinking water) that contains the analyte of interest.

Matrix spike (MS) An aliquot of a sample spiked with known quantities of compounds and subjected to the entire analytical procedure after being received by the laboratory. The matrix spike duplicate provides the accuracy of a method and is expressed as relative percent difference of the two measurements.

Calculate as

$$\%R = \frac{(SSR - SR)}{SA} * 100$$

where SSR = spiked sample result
SR = sample result
SA = spike added
R = recovery.

Matrix spike duplicate A second aliquot of the same sample as the matrix spike, with the same known quantities of compounds added as the matrix spike and subjected to the entire analytical procedure with the matrix spike.

Calculate as

$$RPD = \frac{|x_1 - x_2|}{\bar{x}} * 100 = \frac{2 * |x_1 - x_2|}{|x_1 + x_2|} * 100$$

where x_n = observed value of the spiked sample *n*
RPD = relative percent difference.

Method detection limit The minimum concentration of a compound that can be measured and reported with 99% confidence that the value is above zero.

Minimum detectable activity (MDA) The smallest amount of activity that can be quantified by laboratory instruments for comparison with regulatory limits [radioactive emissions sample analysis SOW definition].

The MDA_i (pCi) for air emissions analysis is the *a priori* estimate of the minimum quantity of radionuclide “i” in a sample that can be detected by a particular type of analysis, considering counter background, detection efficiency, and count duration.

$$MDA_i = \{\left[\left(\frac{2.71}{TT}\right) + 2 \times L_c\right] \div A_i$$

where $A_i = 2.22 \times Y_i \times E_i$ and $L_c = 1.65 \times \sqrt{\frac{RB}{TB} \times (1 + \frac{TB}{TT})}$

and where
TT = sample counting time (minutes)
L_c = critical level (count rate)
Yi = fractional yield of countable emissions per disintegration of source atoms for radionuclide i
E_i = counting efficiency for radionuclide i
TB = background count time
RB = background count rate.

Minimum detectable concentration (MDC) – The minimum detectable activity (MDA) has been defined as a level of activity that is practically achievable by a measurement system. The sample MDA generally is applied as the mean (expected) activity of samples having a 5% probability of escaping detection and 5% probability of false detection. The MDA is calculated based on Currie's (1968) formula and is simplified to the following equation when the counting time in the sample is the same as in the background. The MDC is defined as the mean concentration of samples having a 5% probability of escaping detection and 5% probability of false detection.

The MDC is calculated as

$$MDC = \frac{MDA}{q * Y * decay}$$

where

q = sample quantity (e.g., g or ml)
Y = chemical yield
decay = decay factor (correction for radioactive decay to reference date).

Notification value The terminology used to trigger notification of Environmental Radiation Task staff for findings of ambient air concentrations of a specific radionuclide that, if sustained reporting of similar or greater values, alone or in combination with other specific nuclide analyses over the entire year, may result in an annual concentration that exceeds Table 2 of 40 CFR 61, Appendix E, levels. Ambient background is subtracted when Site emissions' impacts are determined. The Notification Value is established as 10% of the Table 2 value. A presumed 10 mrem/yr public receptor dose is incurred, based on older generic dose modeling, if the receptor has an average annual exposure to the Table 2 air concentration value. The sum of fractions is used to determine exceedance of combine analytical results from all radionuclides analyzed during the reporting period or average results for a year. If the following calculation is true, there was no exceedance:

$$1 \geq \sum_{i=1}^{n} (SR_i)/(T_i)$$

where

SR_i = sample result or average annual result for radionuclide *i*
T_i = Table 2 of 40 CFR 61, Appendix E, value for radionuclide *i*
i = radionuclide *i* is a nuclide emitted by site operations that is required to be measured during the monitoring period.

Precision A measure of the mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Various measures of precision exist depending on the "prescribed similar conditions." Precision represents a measure of the degree of reproducibility of measurements under prescribed similar conditions. Sample precision is calculated on the basis of duplicate analyses. Acceptance criteria shall be established for each analyte and each analyte method and shall be agreed on by the laboratory and the client.

Relative percent difference (RPD) The RPD applies only to laboratory quality control data and is used when two measurements exist. The RPD is generally used to express the precision of duplicate or spike duplicate samples. The RPD is computed using the following equation:

$$RPD = \frac{|x_1 - x_2|}{\bar{x}} * 100 = \frac{2 * |x_1 - x_2|}{|x_1 + x_2|} * 100$$

where x_n = observed value of sample *n*
RPD = relative percent difference.

Quality control (QC) The overall system of technical activities that measures the attributes and performance of a process, item, or service, against defined standards to verify that they meet the requirements established by the customer. Operational techniques and activities that are used to fulfill requirements for quality.

Required detection limit (RDL) Contractually required detection limit for the analyte of interest. The RDL can be at or above the Method Detection Limit.

Spike An aliquot of known concentration of the analyte of interest that is added to a replicate sample undergoing a chemical analysis process for purposes of providing a reference response. Spikes may have additional related terms such as blank spike, matrix spike, carrier, tracer, etc., depending on the intended use.

Uncertainty A measure of the total variability associated with sampling and measurement that includes the two major error components: systematic error (bias) and random error (imprecision). Uncertainty is expressed as the range of values in which the true value is estimated to lie. Each contributing source of uncertainty (i.e., systematic or random) is expected to be distributed over its range. Each systematic component can be estimated in terms of the measurement result for the contributing source of uncertainty. The analytical systematic component can be estimated using standard or spike recovery. The random analytical component can be estimated from replicate measurements of a sample. The total uncertainty is calculated as the square root of the sum of the squares of random and systematic variabilities. The component of uncertainty has to be expressed in the same unit designation (e.g., concentration percentage).

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1.0 Introduction

The objective of a Sampling and Analysis Plan (SAP) is to document the procedural and analytical requirements for performing sampling events to collect samples and measurements under the Environmental Radiation Task (ERT). Samples collect air effluent radiological data for the emission units and ambient air. Samples provide evidence that regulatory thresholds have not been exceeded and meet other applicable license requirements.

An SAP should provide information or references to information on:

- Methodology
- Equipment
- Various procedures (e.g., sampling, analytical etc.)
- Sampling and analysis schedules, locations, and sampling frequencies
- Disposal of residual materials
- Analytes of interest and required detection limits

This SAP covers the ERT's Radioactive Air Emissions and Environmental Surveillance (see Figure 4 of the Environmental Radiological Air Management Plan [EMP] Rev. 1) sampling and analysis activities for the Pacific Northwest National Laboratory (PNNL) Operations under the U.S. Department of Energy (DOE) at the PNNL-Richland campus and PNNL-Sequim campus (see Figure 1 of the EMP). Radioactive air emissions monitoring, sampling, and analysis activities of the Hanford Site emission units managed by PNNL are described as well, but Hanford Site environmental surveillance is managed by the DOE-Richland Operations Office integrating contractor.

Presently, the radiological activities on the PNNL-Richland campus are performed predominantly at the 3410, 3420, 3425, and 3430 Buildings, which are covered in Radioactive Air Emissions License (RAEL)-005. PNNL also manages radiological operations at several facilities in the Hanford Site 300 Area, which are covered in RAEL FF-01. Hanford Site facilities with PNNL-managed sampled emission units include the 325 Building Radiochemical Processing Laboratory (325RPL) and the 331 Building. Researchers on the PNNL-Sequim campus predominantly use very low levels of radiological materials with no requirements for emission unit sampling. PNNL radiological operations in Sequim are covered under the J-MSL fugitive emissions NOC of RAEL-014.

Current ERT routine radiological air sampling includes emission unit sampling, emission unit monitoring, ambient air sampling, and ambient air dosimetry, as appropriate and required. These activities are described in more detail in this SAP. Section 1.2 lists the procedures associated with sampling activities. The Data Management Plan (DMP; EMP Attachment 2; Bisping et al. 2024) describes data management of sampling data results and other data associated with the PNNL effluent and ambient air samples. Section 1.3 briefly summarizes PNNL sampling data management.

All PNNL emission unit configurations, including sampling system information, are summarized in PNNL-15992 (Klein et al. 2024). Emission unit sampling and monitoring is performed based on Washington State Department of Health (WDOH) permit requirements and assessment of current radiological research. Ambient air surveillance is performed based on WDOH permit requirements and PNNL data quality objectives (DQO) evaluations.

1.1 Ambient Air Sampling DQO Reports

In RAEL-005, the WDOH requires an Environmental Surveillance program for the PNNL-Richland campus. The rationale for analyte selection, media, and sampling site location has been vetted through the DQO process. The analytes of interest for stack sampling are based on the annual National Emissions Standard for Hazardous Air Pollutants (NESHAP) assessment. The analytes of interest for ambient air sampling are based on the radionuclides listed in the RAEL-005 with potential to emit doses specifically indicated. The most recent PNNL-Richland campus DQO revision was published in 2024 (Snyder et al. 2024). Snyder et al. (2024) again identified specific radionuclides for analysis along with the need for gross alpha and gross beta radiological analyses of air particulates only, collected on 2-inch glass-fiber filters. Ambient external dose surveillance has been conducted on the PNNL-Richland campus since 2016 with dosimeters placed at the same locations where ambient air particulate sampling is performed. The dosimeters measure the ambient external dose from beta, gamma, and X-ray sources.

The DQO process for the PNNL-Sequim campus indicated that radioactive air emissions from operations there do not require emission unit sampling or monitoring or ambient surveillance under the RAEL-014, Renewal 2. However, the most recent DQO (Snyder et al. 2019) recommended baseline radioactive air background surveillance be performed at the PNNL-Sequim campus for ambient external dose, which was implemented June 2024, and for particulate gross alpha and gross beta in air, which will be established at a later date.

1.2 Procedures and Desk Instructions

ERT staff are trained to conduct sampling, monitoring, and data evaluation activities to approved and controlled procedures, as listed below. The Effluent Management-Quality Assurance Plan (EM-QAP)[1] and applicable related documents (i.e., *Quality Requirements for Radioactive Air Emissions Sampling and Monitoring* and *Quality Requirements for Radioactive Air Environmental Surveillance Monitoring*) identify applicable work processes as well as associated procedures, desk instructions, and other documentation to support overall implementation of quality assurance requirements.

Once the PNNL-Sequim campus is actively sampling ambient air for particulates, a procedure that addresses the collection process will be created.

Radioactive Air Emissions Procedures:

- EPRP-AIR-004: *Chain of Custody Procedure*
- EPRP-AIR-005: *Troubleshooting and Repair of Stack Emission Sampling/Monitoring Systems*
- EPRP-AIR-010: *Hanford Stack Particulate Sampling Procedure*
- EPRP-AIR-011: *325 Building Stack Tritium Sampling Procedure*

[1] EM-QA-01, Current Revision. *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan*. Pacific Northwest National Laboratory, Richland, WA.

- EPRP-AIR-015**:** *Evaluating Rad Air Effluent Sampling Data*
- EPRP-AIR-023: *325 Building Stack Radionuclide Sampling and Monitoring Systems Daily Inspection*
- EPRP-AIR-025: *RPL Stack PNNL OS3300 Alpha/Beta CAM Filter Exchange*
- EPRP-AIR-028: *PSF Radioactive Air Emissions Sampling (RAES) Systems Filter Exchange and Inspection*

Environmental Surveillance Procedures (Ambient Air/Dosimetry):

- EPRP-AIR-029: *Air Particulate/Dosimeter Sampling and Routine Maintenance of Environmental Monitoring Stations for the PNNL Campus*
- EPRP-AIR-032: *Environmental Surveillance Radiological Air Monitoring Data Management and Evaluation*
- DI-AIR-004: *Ambient Air Dosimeters – Annual Dose Status*

1.3 Sample Data Management

Data management is a process by which data is acquired, validated, stored, protected, and processed to satisfy the needs of the data users. ERT data management activities are primarily achieved through the databases described in detail in the DMP and are summarized here.

The Locus Environmental Information Management System (EIM) is the primary ERT database used for radiological air sampling at PNNL. EIM is a comprehensive subscription-based cloud platform used for organizing, managing, and reporting environmental data. After ERT samples are collected and submitted for analyses, data deliverables are received, processed, and evaluated according to procedures, and uploaded to the database in preparation for compliance reporting.

A variety of records may be generated during the data management process, which may include chain of custody (COC) forms, daily inspection forms, discrepancy reports, suspect data reports, and data entry and validation checklists. Requirements for maintaining documents and records is described in the EM-QAP. Project records are maintained in accordance with the e-records file plan.

2.0 General Field Work

Sampling and analysis of a) radiological air emissions and b) in support of environmental surveillance of the PNNL Operations requires field work and subsequent sample handling activities. The field activities, directed by EPRP procedures, include those from sample scheduling through the collection process. Additional sampling details are described in later sections of this report.

In addition to the sample collection process, PNNL procedures identify equipment, supplies, and example sampling paperwork necessary for the Radiation Protection Technologist (RPTs) (or equivalent) to perform the sampling activities safely and correctly.

Field sampling is directed by the generation of a COC and conducted by a trained RPT (or equivalent). PNNL field sampling of radioactive material in air may be performed biweekly, monthly, quarterly, or semi-annually based on the type of air (stack, ambient), type of radioactive material and its emission levels (routine, special, or composited samples of particulates or tritium), and type of analysis (filter, desiccant, dosimeter).

2.1 Sampling/Monitoring Location

The stack air sample is drawn from an in-stack location downstream of the stack ventilation fans and pollution control equipment. Emission unit sampling locations are required to meet ANSI/HPS N13.1 conditions, with the overarching requirement being to draw a sample that accurately characterizes the air released to the ambient environment.

Ambient air sampling and monitoring location(s) are identified during the DQO process. Ambient air samples should characterize the air a person would breathe. PNNL management in cooperation with ERT staff make the final determinations of number of sampling points and specific locations (e.g., stack sampling, ambient air sampling, and ambient dosimetry).

2.2 Collection Process

The collection process begins with ERT staff initiating a request that regulatory sampling is required. The ERT staff prepares the necessary paperwork in EIM (see Section 1.3 of this report or DMP Rev. 1). Samples are collected by an RPT (or equivalent) and relinquished for processing using standard COC documentation. Any non-routine/special sampling that occurs will follow the same collection process.

2.2.1 COC and Exchange of Media

A COC is the chronological documentation that records the sequence of custody, control, transfer, analysis, and disposition of physical evidence, in this case, of environmental samples.

Regulatory compliance samples and environmental surveillance samples are documented and tracked on COC forms. EPRP-AIR-004 is the applicable COC procedure for stack emission samples and EPRP-AIR-029 for ambient air and dosimetry COCs. To show continuous control of the samples, the time of release must be the same as the time of acceptance. Often the receiving custodian needs to check samples and labels against paperwork. Therefore, samples should not be released until the next custodian is ready to accept. Both signatures MUST HAVE the same time stamp on the COC.

2.2.2 Delivery to Lab

Field requirements end with the delivery of the samples to the designated analytical laboratory service provider. It is essential that COC be preserved during the transport. If a commercial carrier is involved, the tracking number is to be recorded on the COC.

3.0 Radioactive Air Emissions Sampling

All operational sources (“emission units”) of radioactive air emissions to the ambient environment are licensed with the WDOH (Table 1). PNNL-Richland campus emission units are registered in RAEL-005 and the PNNL-Sequim campus emission units in RAEL-014. PNNL-managed emission units on the Hanford Site are registered in RAEL-FF-01.

As required by 40 CFR 61, “National Emission Standards for Hazardous Air Pollutants, Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities” (*NESHAP;* 40 CFR 61, Subpart H), sampling and monitoring requirements for emission units are spelled out in PNNL-15992 (Klein et al. 2024). The regulation also requires compliance to ANSI/HPS N13.1-1999 which presents a graded approach for sampling and monitoring.

Stack sampling systems are used for the purpose of collecting samples and as required for monitoring emissions. Sample results are used as the basis for determining radioactive material emissions rates from emission units. Monitoring of emission units is done to capture near-real-time release rate information with stack monitoring-system-samples acquired but not analyzed under routine operations. Stack samples discussed in the remainder of Section 3.0 address those of the stack sampling system rather than the samples collected by the stack monitoring system, unless specifically indicated.

At PNNL, major (PIC-1[2] and PIC-2 [Barnett 2018]) emission units are continuously sampled, and PIC-1 emission units are also continuously monitored (Table 1). Periodic confirmatory sampling is conducted for PIC-3 emission units. No sampling is conducted for PIC-4 and PIC-5 classified emission units; such emissions are managed through administrative methods (e.g., RAGas) or emissions estimation methods of 40 CFR 61, Appendix D.

PNNL manages emission units on the PNNL-Richland campus and Hanford Site that are sampled. The single emission unit on the PNNL-Sequim campus is a PIC-4 fugitive source that does not require sampling.

The technical basis for radiological air emission sampling and monitoring includes a graded approach, the sampling objective, relevant building operating conditions and airborne contaminants, and action levels that signal changing conditions of significance.

This section discusses analytical laboratory services, sampling and monitoring, and data management details for sampling and monitoring of PNNL emission units. Surveillance of emissions in ambient air is discussed in Sections 4.0 and 5.0.

[2] See Table 3 and Table 4 of the EMP main text for PIC (potential impact category) definitions implemented by PNNL.

Table 1. Schedule for PNNL Major Emission Unit Routine Continuous Radionuclide Air Emission Sampling (Klein et al. 2024)

Emission Point	PNNL PIC	Sampling Frequency	Sample Type	Sample Period	Constituents Analyzed	Sample Media or Tracking Method	Comments
Hanford Site/300 Area Active Emission Units							
EP-325-01-S	1	Continuous	Particulate Water Vapor Gas Gas Composite Monitoring Monitoring	2 weeks 1 month 1 month Tracking 6 months 1 month 1 month	Alpha/Beta Tritium Tritium Radon Specific Nuclides CAM Alpha/Beta-gamma [(a)] CAM Tritium/ Kr-85	Filter Silica Gel Silica Gel RAGas Database Composite Filters Filter Gas Flow Proportional Counter	Major emission unit—ANSI/HPS N13.1-2011; isotopic analysis on composites; radon is tracked rather than sampled
EP-331-01-V	2	Continuous	Particulate Composite	2 weeks 6 months	Alpha/Beta Specific Nuclides	Filter Composited Filters	Major emission unit—ANSI N13.1-1969; isotopic analysis on composites
PNNL-Richland Campus Active Emission Units							
EP-3410-01-S	2	Continuous	Particulate Composite	2 weeks 6 months	Alpha/Beta Specific Nuclides	Filter Composited Filters	Major emission unit—ANSI/HPS N13.1–2011; isotopic analysis on composites
EP-3420-01-S	2	Continuous	Particulate Composite	2 weeks 6 months	Alpha/Beta Specific Nuclides	Filter Composited Filters	Major emission unit—ANSI/HPS N13.1–2011; isotopic analysis on composites
EP-3430-01-S	2	Continuous	Particulate Composite	2 weeks 6 months	Alpha/Beta Specific Nuclides	Filter Composited Filters	Major emission unit—ANSI/HPS N13.1–2011; isotopic analysis on composites

CAM = continuous air monitor; RAGas = Radioactive Gas database.
Alpha/Beta = gross alpha and gross beta
(a) The CAM measures gross alpha and gross beta/gamma activity as it is collected on the filter. Used CAM filters are stored by the analytical laboratory and may be analyzed if deemed necessary.

3.1 Sampled Effluent Air Analytical Laboratory Service Provider

Routine samples collected for radioactive stack air emissions are sent to the designated service provider[3] for analysis. Analyses covered by a Statement of Work (SOW) include routine and non-routine samples for gross alpha, gross beta, gamma spectrometry, and isotopic analyses. Non-routine samples may also be collected in conjunction with the stack monitoring systems. When necessary, PNNL will solicit offers for radiochemical air surveillance analytical services through the Request for Proposal process. Evaluation of proposals and award of contract will be conducted by a selection panel.

3.1.1 Technical Requirements

Sample collection (i.e., field work) ends when the RPT (or equivalent) completes the field paperwork and relinquishes stack air samples for analysis to the current service provider or locked storage. The analytical services SOW specifies the details for handling PNNL stack air samples. The following sections summarize the service provider's responsibilities in processing and reporting the stack samples.

3.1.2 Laboratory Qualification

For the stack air samples, the RS&EG has the capability to complete routine, non-routine, and special samples for particulate (gross alpha, gross beta, gamma spectrometry, and isotopic) and tritium analyses. Analyses are compliant with the NESHAP 40 CFR 61, Appendix B, Method 114 analytical techniques and are specified in the analytical services SOW.

The service provider must be independently qualified to perform sample analyses and participate in national comparison studies, also called performance evaluations (details provided in Section 4.1.2). The laboratory routinely analyzes stack samples for those radionuclides that are requested and their respective analytical method. The requirements for determining the critical level and the minimum detectable activity are specified, typically in a SOW.

3.1.3 Stack Sample Specification

Per procedures, all samples are tracked and managed by a COC. Various envelopes or columns are used to protect the integrity of the sample.

For routine stack particulate samples, the ERT supplies new 2-inch (47-mm) Versapor 3000[4] glass-fiber filters for particulate sampling (see Figure 1). The filters are transported in a coin envelope. Filters are changed out biweekly and sit on a honeycomb frit. Once installed in the holder, the filters are sealed along the edges by an O-ring to prevent leakage.

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[3] Presently, analyses of airborne radionuclide stack emission samples are conducted under an internal SOW established between the ERT and the PNNL Radiochemical Science and Engineering Group (RS&EG).

[4] Current vendor: Pall Corporation, Port Washington, NY.

Figure 1. Example of 2-inch Filter Head Assembly (Stacks)

Tritium sampling is conducted using silica gel columns (See Figure 2). The tritium sampling is split into vapor (HTO) and gas (HT) portions.

Figure 2. Tritium columns for sampling (3-columns for HTO and 2-columns for HT)

3.1.4 Stack Alpha/Beta CAM Specification

For the 325RPL Building Continuous Air Monitoring (CAM) system (see Figure 3) for alpha/beta particulates monitoring, the CAM filters[5] are 8 inches in diameter and are exchanged on a monthly basis. The relinquished CAM filters are held by the analytical laboratory. If follow-up analytical laboratory analysis was needed, a special request would be made. Near-real-time CAM radioactivity is monitored by an alpha-beta-pseudocoincident-difference method using a proportional counter. Flow rates for stack monitoring air samples and P10 counting gas (argon-methane mixture) are indicated on the baseline configuration sheets at the monitor location.

[5] Current vendor: GE Healthcare, Life Sciences, Whatman GF8 (10370111) Glass Fiber Filters, Pittsburgh, PA.

Local and remote annunciators alert staff when particulate levels are elevated and when components fail. These alarms require active resets of this particulate sampling system.

The particulate CAM may alarm due to either high count rates (set points: gross alpha 100 cps and gross beta 500 cps) or high concentrations (set points: gross alpha 1.77E-8 µCi/mL and gross beta 3.47E-8 µCi/mL) (see EPRP-AIR-026).

Figure 3. CAM Cabinet with Particulate CAM Filter Tray (central area of cabinet) and Tritium CAM Equipment (upper area of cabinet).

3.1.5 Stack Tritium CAM Specification

For the 325RPL Building LB110 CAM system (see Figure 3) for tritium, windowless counter tubes are used and air is measured with a proportional counter. P10 gas (argon-methane mixture) is used as a counting gas. A low sample flow or a detector failure (i.e., no power to LB110) alarm may sound and will be appropriately indicated on the alarm panel. These alarms are also transmitted to the 325RPL Power Operator. These alarms require active resets of the tritium sampling system.

The tritium CAM may also alarm due to either high integrated (24 hr) counts (set point 2.50E+07 µCi) or a high count-rate (set point 2.00E-05 µCi/mL). Either “high” alarm will be indicated as red on the alarm panel main screen. These alarms would also be transmitted to the 325RPL Power Operator. These alarms require active resets of the tritium sampling system.

3.1.6 Stack Sample Management

The PIC-1 and PIC-2 stack 2-week stack air samples collected by RPTs are delivered to the service provider using the standard COC documentation. Samples delivered to the service provider include the routinely analyzed record sample particulate filters and tritium silica gel samples. Particulate filter samples are managed such that future isotopic analyses can be conducted on composited samples (on a semi-annual basis). As indicated in Section 3.1.4, the monthly CAM particulate samples for the PIC-1 stack are not counted for activity but are held in case analysis is necessary.

The *Airborne Radionuclide Emissions Sample Analysis* SOW specifies the sample management activities. These include sample receipt and storage, holding time limits, quality control (QC), and sample disposition. Composite sample analysis results in the destruction of the sample media; however, the original COC forms are returned periodically, signed for sample completion, and maintained as regulatorily required.

3.1.7 Stack Sample Analytical Requirements

Each sample is analyzed by the analysis method identified in the SOW, which conforms to U.S. Environmental Protection Agency (EPA) 40 CFR 61, Appendix B, Method 114, “Test Methods for Measuring Radionuclide Emissions from Stationary Sources” (see Table 2). The specific radionuclide analyses for composite samples are determined by permit requirements and the annual NESHAPs Assessment. All holding times specified in the SOW must be met (ranging from prompt measurement to several days, as specified in the analytical service request).

Analytical standards are maintained. The minimum required analytical detectable activity levels are specified in the SOW. The measuring and test equipment used in the analysis will be calibrated and the calibration records maintained. Individuals responsible for the work are required to be trained.

Sample results are reported according to the SOW data specification for stack sample analysis reports. Gross alpha and gross beta sample results are reported in units of pCi/sample. Particulate samples, analyzed as 6-month composites of the gross alpha/gross beta filters, have results reported in units of pCi. Tritium sample results from 325RPL are reported in units of pCi/sample for HT and HTO. QC for counting system performance validation, standards, and data review is incorporated into the SOW. The *Airborne Radionuclide Emissions Sample Analysis* SOW requires quarterly reports that identify sample analysis problems or deficiencies. A notification protocol and timeline are also specified.

As necessary, the ERT may ask for data rechecks, sample recounts, and sample reanalysis to confirm data results or to assess the validity of a sample result. ERT staff review all reported results using EPRP-AIR-015 prior to uploading to a records database.

Table 2. Analytical Methods for the Radionuclide Analyses of Stack Air Samples

Analyte of Interest	Sample period	Analytical Method	Contract-required MDA	40CFR61, Appendix B, Method 114 Analysis ID
Gross alpha, Gross beta[a]	2-week[b]	Gas-flow proportional counter	0.7 pCi/sample (alpha); 9 pCi/sample (beta);	Method 114, A-4 and B-4
Gross alpha, Gross beta	6-mo	Varies ("COMP1", as indicated in the SOW)	n/a n/a	Method 114, A-1 and B-5
Tritium (HT and HTO)	1-mo	Liquid Scintillation Spectrometry	27 pCi/mL of collected water	Method 114, B-5
Pu-241	6-mo	Liquid Scintillation Spectrometry	36 pCi/composite	Method 114, B-5
Am-241	6-mo	Radiochemistry- Alpha Spectrometry	0.8 pCi/composite	Method 114, A-1
Am-243	6-mo	Radiochemistry- Alpha Spectrometry	0.8 pCi/composite	Method 114, A-1
Cm-244[c]	6-mo	Radiochemistry- Alpha Spectrometry	1 pCi/composite	Method 114, A-1
Pu-238	6-mo	Radiochemistry- Alpha Spectrometry	0.7 pCi/composite	Method 114, A-1
Pu-239[c]	6-mo	Radiochemistry- Alpha Spectrometry	0.7 pCi/composite	Method 114, A-1
Pu-240[c]	6-mo	Radiochemistry- Alpha Spectrometry	0.7 pCi/composite	Method 114, A-1
U-233[c]	6-mo	Radiochemistry- Alpha Spectrometry	11 pCi/composite	Method 114, A-1
Co-60	6-mo	High Resolution Gamma Spectrometry	12 pCi/composite	Method 114, G-1
Cs-137	6-mo	High Resolution Gamma Spectrometry	14 pCi/composite	Method 114, G-1

(a) Gross alpha and gross beta counts performed on 2-week samples and composite samples. Stack air sample analyses use a Sr-90 standard for gross beta and Pu-239 standard for gross alpha.
(b) While gross alpha and gross beta analyses are also performed on 6-mo composites, emissions estimates are based on analyses of 2-week samples.
(c) Analytical results for Cm-244, Pu-239, and U-233 indicate combined results for Cm-243/244, Pu239/240, and U-233/234, respectively, because the isotopes cannot be distinguished between each other during analysis. The lower MDA of the two isotopes is used as the required analytical MDA.

3.1.8 Accuracy and Precision

The service provider has a quality assurance program in place to demonstrate overall capabilities and limitations for each analytical procedure, as required per the SOW. The precision and accuracy of the analytical methods will be determined and documented based on the QC sample results. Control charts will be maintained showing relative detector efficiency and background counts. The service provider shall also participate in a proficiency testing program insofar as analyses are applicable to that performed for PNNL and results are provided to ERT. QC sampling is also written into the analytical laboratory SOW. The QC samples demonstrate the vendor's overall capabilities and limitations for analytical procedures performed.

3.2 Stack Sampling and Monitoring

As the EPA authorized regulator in Washington State, the WDOH designates the criteria for the radionuclide and radiological criteria to be sampled. State regulations primarily reflect federal regulations but are also allowed to be more stringent than federal regulations. EPA granted partial approval to WDOH's request for program approval and delegation of authority to implement and enforce the Radionuclide NESHAP program in 71 FR 32276–32282. WDOH references the 40 CFR 61, Subpart H, for monitoring and test procedure requirements in RAELs.

PNNL documents the criteria and systems used to sample and monitor emission units. PNNL sampling system requirements for each PIC category are established in PNNL-19904, *Pacific Northwest National Laboratory Potential Impact Categories for Radiological Air Emission Monitoring* (Barnett 2018). PNNL sampling systems are documented in PNNL-15992, *Pacific Northwest National Laboratory Facility Radionuclide Emission Units and Sampling Systems*, (Klein et al. 2024).

Section 2 of Klein et al. (2024) indicate the PNNL procedures used in the Sampling System Design. To determine radionuclide emissions, emission unit radionuclide samples are analyzed (Ci/sample) and the total volumetric air flow rate for the sampling and reporting period (standard cubic feet per minute) is determined, in order to resolve the total activity emitted during the reporting period. Section 1.2 indicates the PNNL procedures and desk instructions for effluent management radiological air monitoring and sampling.

In summary, facility airborne radionuclide emission sampling requirements are derived from 40 CFR 61, Subpart H, WAC 246-247, and site-specific RAEL conditions.

Monitoring is required for PIC-1 stacks (Barnett 2018). Only one emission unit (EP-325-01-S) is monitored, currently. Particulates and gases are monitored. For particulates, a CAM measures gross alpha and gross beta/gamma activity as it is collected on the filter. Used CAM filters are stored by the analytical laboratory service provider and may be analyzed if deemed necessary. For gases, the CAM is used to measure gross alpha and gross beta/gamma activity.

3.2.1 Sampling and Analysis Schedule

The routine sampling and analysis schedule for PNNL-managed emission units on the PNNL-Richland campus and Hanford Site is indicated in Table 2. In addition, samples may be collected and analyzed from system cleaning or other activity, study, or survey; such samples have their own COC. The PIC-1 emission unit at 325RPL requires the widest variety of sampling. There are currently no systems that require routine periodic sampling.

Five emission units are sampled continuously for particulate radionuclides at PNNL-managed facilities on the PNNL-Richland campus (3 emission units) and on the Hanford Site (2 emission units). Four of these units have sampling systems that comply with the American National Standards Institute/Health Physics Society (ANSI/HPS) N13.1-1999 standard for sampling from stacks and ducts of nuclear facilities, and the fifth is grandfathered and compliant with the older ANSI N13.1-1969 standard.

The stack velocity and cyclonic flow conditions at the sample extraction point are measured according to 40 CFR 60, Appendix A-1, Method 2. PNNL Facilities & Operations (F&O) staff performs these measurements in support of the ERT.

3.2.2 Sampling Location

Stack effluent is sampled at a qualified location within the stack. Both federal and state regulations incorporate ANSI/HPS N13.1-2011 (ANSI/HPS 2011) for sampling system design requirements. The grandfathered emission unit is sampled to be compliant with the older ANSI N13.1-1969 standard. The N13.1-based determinations for sample locations of an emission unit's sampling system assure capture of a representative, well-mixed sample.

3.2.3 Equipment

The equipment used in sampling and monitoring are specific to the radioactive material being sampled or monitored (e.g., CAM of alpha/beta/gamma particulates and gases). Procedures for sampling and equipment maintenance/calibration are established to meet sampling system design requirements. A gas proportional counter is used for real-time monitoring. PNNL F&O staff maintain system equipment compliant with monitoring system design (also see Klein et al. 2024).

Stack sample flow rate systems follow guidance provided in Standard N13.1. Depending on the year the system was put into service or modified, ANSI N13.1-1969 (ANSI 1969) or ANSI/HPS N13.1-2011 (ANSI/HPS 2011) is utilized.

- For ANSI N13.1-1969 systems, PNNL measures the sample flow rate by a Brooks Instrument GT-1000 (0.586 to 5.86 standard cubic feet per minute [scfm]) rotameter and adjusted using a throttle valve (both located just downstream of the filter holder). A vacuum gauge (0 to 100 in. of water) is installed on the inlet side of the rotameter and used to correct the sample flow for vacuum conditions. Sampler flows are set at or near isokinetic based on stack flow measurements that are performed on an annual basis. The rotameter and vacuum gauge are calibrated and exchanged annually.
- For ANSI/HPS N13.1-2011 systems, PNNL measures the sample flow rate by using a Masstron (1.0 to 4.0 scfm) flow transmitter. The RAES system measures both the total stack exhaust mass flow rate and a representative variable sample mass flow rate with the sample flow being extracted from the building exhaust air stack. The sample flow rate is maintained proportionally to the stack air flow rate and operates over the calibrated range of air velocities and temperature with a minimum turndown ratio of 10:1. The RAES system interfaces with the vacuum air sampling system that draws the stack air samples through an extraction nozzle located on the sample probe.

3.2.4 Sample Collection and Delivery Process

Both particulate samples and tritium samples are collected at the 325RPL emission unit. Only particulate samples are collected at PNNL-Richland campus Physical Sciences Facility (PSF) major emission units. Sampling procedures, to assure quality-controlled samples are delivered to the analytical laboratory, can require daily, biweekly, or monthly actions by the RPTs (or equivalent).

3.2.4.1 Particulate Sample Collection and Delivery

Stack air record samples are collected by RPTs (or equivalent) guided by the EPRP-AIR-010 (Hanford Site emission units) and EPRP-AIR-028 (PNNL-Richland Campus emission units) procedures, with delivery to the analytical service provider using the standard COC procedure (EPRP-AIR-004) documentation. The 2-inch sample filter is collected to avoid cross contamination and maintain sample integrity. The RPT installs new filter media at the time of the exchange and updates the daily inspection report.

The RPT must maintain the security and integrity of all samples until they are relinquished to the analytical service provider. At the completion of the sampling exchange activities, the RPT returns the original field paperwork to EM ERT staff for proper sample tracking.

3.2.4.2 Tritium Sample Collection and Delivery

Tritium samples at 325RPL are collected by RPTs (or equivalent) monthly per procedure EPRP-AIR-010, with samples tracked and managed by COCs (EPR-AIR-004). At the same time, the 325RPL 8-inch CAM filter (see Section 3.1.4) is also exchanged. A ventilation outage is scheduled during the exchange process to ensure safety and no air flow during the sample exchange. The RPT (or equivalent) delivers the tritium samples to locked storage since the exchange is done after hours. The RPT must maintain the security and integrity of all samples until they are relinquished to the analytical service provider. At the completion of the sampling exchange activities, the RPT returns the original field paperwork to EM ERT staff for proper sample tracking.

3.2.5 Analysis and Reporting

Reports are delivered electronically and are such that data can be validated and uploaded to the appropriate sample database (see Section 1.3). Analytical Support Operations results indicate the analytical result at the date of measurement (i.e., no adjustments performed to consider radiological decay since the date of sample collection). Table 3 presents the time required for sample analysis.

The analytical lab analyses are electronically delivered. EM ERT staff will assess results to determine if they are elevated compared to historical norms or consistent with expectations based on research activities. Once reporting is determined to be acceptable, data is uploaded to EIM (see DMP). Any sample analysis issues are resolved with the analytical laboratory prior to being uploaded to EIM.

Table 3. Typical Reporting Times for Analytical Support Operations Processing of Samples

	Business Days to Process Sample[(a)]	
Type of Analysis	Routine Processing	Priority Processing
Gross Alpha, Gross Beta	2	Possibly <2
Tritium	4	3
Gamma Spectroscopy	2	1
Isotopics[(b)]	7	Possibly <7

(a) The indicated processing time starts when sample is ready for analysis (e.g., radon progeny decay period already passed; all filters collected for composited sample). Typically, sample analysis occurs 5-7 d after sample system retrieval.)

(b) e.g., Isotopic uranium, curium, plutonium, americium.

3.2.6 Alarming and Notification

Tritium and particulate CAMs have alarm functions (see Sections 3.1.4 and 3.1.5). Alarm response and troubleshooting activities can be found in EPRP-AIR-005. In general, alarms will be acknowledged by the power operator or RPT. Unplanned alarms are called into 375-2400, so that technical staff can review the alarm information and take appropriate actions. Notifications from 375-2400 are communicated to management by technical staff responding to the alarm.

4.0 Ambient Air Sampling

The primary objective of ambient air surveillance is to collect quality samples to provide assurance to the public that the potential radiological impacts from DOE operations are known or can be conservatively estimated from sampling results. Results also would provide information in the event of significant radiological facility operational failures. Estimated impacts are compared to 40 CFR 61, Subpart H, and DOE Order 458.1 standards, as appropriate.

A particulate air sampling network continuously samples ambient levels of radioactive particulates at locations likely to be maximally impacted by PNNL-Richland campus particulate emissions. Radiological background samples are collected west of the PNNL-Richland campus in Benton City. The DQO for the PNNL-Richland campus (Snyder et al. 2024) identified specific radionuclides for analysis along with the need for gross alpha and gross beta radiological analyses of air particulates only. Samples are collected on a 2-inch glass fiber filter analyzed for gross alpha, gross beta, and composited periodically for particulates based on program requirements.

Ambient air particulate sampling has not been conducted at the PNNL-Sequim campus; however, the Sequim DQO (Snyder et al. 2019) recommended baseline radioactive air background surveillance be performed for particulate gross alpha and gross beta in air. These particulate sampling activities will occur at a later date. However, ambient external dose surveillance began in mid-2024 (see Section 5.0).

The ambient air database provides a repository for environmental surveillance data gathered during PNNL operations on and off site. In 2023, the Environmental Surveillance program, started to use the Locus EIM[6] cloud-based software system as the primary data management database for ambient air sampling and monitoring activities. The DMP provides additional details.

4.1 Ambient Air Analytical Laboratory Service Provider

Routine samples collected for environmental surveillance are sent to the designated service provider for analysis. When necessary, PNNL will solicit offers for radiochemical air surveillance analytical services[7] through the Request for Proposal process. Evaluation of proposals and award of contract will be conducted by a selection panel.

4.1.1 Technical Requirements

The analytical laboratory results must meet regulatory requirements. PNNL established a sampling system supported by field work to provide an adequate sample. The field work ends when the RPT (or equivalent) completes the field paperwork and relinquishes ambient air samples to locked storage or for analysis. A detailed SOW is prepared and provided to the service provider. The analytical services SOW specifies the details for handling PNNL ambient air samples. The following sections summarize the analytical laboratory's responsibilities in preparing, processing, and reporting the environmental surveillance samples.

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[6] Locus EIM, provided by Locus Technologies, Mountain View, California. https://locustec.com/.

[7] Since 2010, the analytical laboratory service provider performing radiological analyses on the PNNL-Richland campus ambient radiological air surveillance samples is GEL Laboratories, LLC, Charleston, SC.

4.1.2 Laboratory Qualification

PNNL will contract with an analytical laboratory service provider that is accredited through one of the bodies approved by the DOE Consolidated Audit Program-Accreditation Program (DOECAP-AP), such as the American Association for Laboratory Accreditation (A2LA) and uses the quality standards specified in the current version of the DoD/DOE Consolidated Quality Systems Manual (QSM) for Environmental Laboratories. An analytical laboratory that performs work to the *Hanford Analytical Services Quality Assurance Requirements Documents (HASQARD)*, Rev. 5 (DOE 2022), and has been evaluated as listed above, would be acceptable too. The SOW with the analytical laboratory is kept current to any relevant revisions of the EMP and SAP requirements.

4.1.3 Sampling Device Prepared at the Service Provider

The service provider supplies new 2-inch LB.5211[8] glass-fiber filters and prepare the PNNL provided filter head assemblies used to collect samples of airborne particulate matter. These assemblies prepared by the service provider are made available for re-use by PNNL within five (5) business days after receipt by the service provider.

4.1.3.1 Air Particulate Collection Assembly

The air particulate collection assemblies provided by PNNL consist of a combination cartridge and paper filter holder[9] (see Figure 4). The paper filter holder is machined from aluminum and anodized black (2-inch) or gold (47-mm) consisting of pieces that are threaded, twisted, or snapped together. The unit consists of a larger filter holder body and a retention ring to hold the filter in place.

Figure 4. Example of 2-inch Filter Head Assembly (Ambient Air)

4.1.3.2 Glass Fiber Filter Assembly Preparation Process

The service provider removes the exposed filter from the filter holder and replaces it with the appropriate 2-inch LB.5211 new glass fiber filter. Prior to installing the new filter, the service provider inspects the assembly and notify PNNL of any damaged or worn seals, damaged, plugged, or flattened filter support screens, or otherwise damaged assemblages. Care must be taken to place the new filter with the inlet side of the paper facing the inlet side of the filter assembly. After installation of the new filter, the service provider ensures that the filter retaining ring appears sufficiently tightened to prevent leakage during sampling. The service provider

[8] Current vendor: RADeCo, Inc., Plainfield, CT 06374.
[9] Current vendor: Hi-Q, Environmental Products Company, Inc, San Diego, CA 92121.

places each filter head assembly in a clear plastic storage jar with cover to prevent ambient dust exposure until the assembly is deployed.

4.1.4 Sample Receipt, Compositing, Preparation and Storage/Disposal

Ambient air samples will be collected by PNNL and hand delivered to the service provider receiving facility using the standard COC (see EPRP-AIR-029, Exhibit A2) to document sample possession. The service provider designates a one-point contact that is available during normal business hours to receive additional information and direction about sample analysis, as deemed necessary by PNNL. The following subsections describe routine air sample receipt, compositing, preparation, and storage/disposal.

4.1.4.1 Gross Alpha/Gross Beta Analyses

The service provider is scheduled to receive filter samples for gross alpha/gross beta analyses every 2 weeks. The *Radiochemical Air Surveillance Analytical Services SOW* indicates the COC protocol for the service provider. Any COC discrepancies that cannot be resolved by the service provider are reported to PNNL within 24 hours of receipt (see Section 4.1.8.1 for other notification requirements). Additionally, as part of a special study related to filter mass loading where filter paper is being weighed before and after use, ERT has requested the service provider also report gross alpha and gross beta analyses on the semiannual (twice a year) composites.

4.1.4.2 Compositing of Samples

PNNL will provide to the service provider site-specific composite sheets with the requested analyses and individual sample number(s) that should be composited (combined) to form the designated quarterly or semiannual (twice a year) composite. Due to destructive analytical techniques, the sequential order for performing composite analyses may be necessary. The service provider supplies containers for appropriate compositing (i.e., combining) of the biweekly samples. PNNL has five (5) business days following the receipt of test results for gross alpha/gross beta samples to review the data before samples can be composited for subsequent analyses.

4.1.4.3 Sample Preparation

Air samples are prepared to meet the performance requirements in 40 CFR 61, Subpart H. Ambient air samples are analyzed according to the methods identified in 40 CFR 61, Appendix B, Method 114, “Test Methods for Measuring Radionuclide Emissions from Stationary Sources” (see Table 4) or an agreed upon equivalent alternative. Gross alpha and gross beta concentrations are measured by counting an exposed glass-fiber filter on a gas-flow proportional counter. Gamma emitters are measured by combining alpha-beta filters collected during multiple sampling periods and counting them using a hyperpure germanium detector and a multi-channel, pulse-height analyzer. After these measurements have been conducted, the glass-fiber filters are chemically leached with acid to extract the analytes of interest.

4.1.4.4 Sample Storage and Disposal

While in their custody, the service provider must assure the security and integrity of all samples (initial as well as residual portions); sample extracts and other preparations; and analytical data and results. Gross alpha and gross beta samples (planchets) are to be stored and preserved for at least 30 calendar days following reporting of all results. These samples are used for the composite samples, and therefore, must be stored and protected.

The service provider notifies PNNL in writing of intent to dispose of residual samples or final analytical preparations 30 business days following the final reporting of all related analytical results. PNNL will specify, within 30 calendar days following laboratory notification of intent to dispose of residual samples and final analytical preparations, any residual samples or final analytical preparations to be withheld from disposal. The laboratory makes such residual samples or final analytical preparations available for pickup by PNNL. The laboratory disposes of all residual samples or final analytical preparations not designated to be withheld from disposal or not picked up within 14 calendar days.

4.1.5 Analytical Requirements

Each sample is analyzed according to the test(s) ordered on the COC form and/or composite sheet, and as requested by contract between PNNL and the selected analytical service provider.

4.1.5.1 Analytical Methods

The analytical method used for analysis of air samples is performed according to Appendix B of 40 CFR 61, Method 114, “Test Methods for Measuring Radionuclide Emissions from Stationary Sources” (see Table 4).

Table 4. Analytical Methods for the Radionuclide Analyses of Ambient Air Samples

Analyte of Interest	Analytical Method	40 CFR 61, Appendix B, Method 114 Analysis ID
Gross alpha, gross beta	Gas flow proportional counter	Method 114, A-4 (gross alpha) and B-4 (gross beta)
Am-241	Radiochemistry - Alpha Spectrometry	Method 114, A-1
Am-243	Radiochemistry - Alpha Spectrometry	Method 114, A-1
Cm-244[a]	Radiochemistry - Alpha Spectrometry	Method 114, A-1
Co-60	High Resolution Gamma Spectrometry	Method 114, G-1
Pu-238	Radiochemistry - Alpha Spectrometry	Method 114, A-1
Pu-239/240[a]	Radiochemistry - Alpha Spectrometry	Method 114, A-1
U-233[a,b]	Radiochemistry - Alpha Spectrometry	Method 114, A-1

(a) Analytical results indicate combined results for Cm-243/244, Pu-239/240, or U-233/234 because these isotopes cannot be distinguished between each other with the indicated analysis.
(b) Currently reported as U-233/234, using only alpha spectrometry. Inductively coupled plasma mass spectrometry (ICP-MS) could potentially be used to separate U-233 and U-234, although ICP-MS detection levels may not be ideal. However, ICP-MS is currently not listed as a Method 114 analytical method.

4.1.5.2 Analysis Standards

Ambient air sample results indicate the calibration reference standard used in the analyses. Measurement system for gross alpha, gross beta, alpha spectrometry, and gamma spectrometry measurement systems are to be calibrated to an appropriate National Institute of Standards and Technology (NIST)-traceable standard.

4.1.5.3 Sample Units

The laboratory performs the analyses according to the analytical test ordered and with the number of significant figures appropriate to the measurement process. Unless otherwise instructed, results are reported in pCi/m^3, per each sample (i.e., filter) for gross alpha/gross beta and per total composite sample (i.e., multiple filters from relevant the sampling period) for the analytes of interest. The individual sample numbers of the filters used in the composited samples are included with the data report [the air volume for an individual air filter, is recorded on the COC(s)]. If the laboratory determines that an aliquot is insufficient (e.g., is not representative and that the analysis could be biased), the laboratory contacts PNNL for instructions on how to proceed. Discrepancies can be discussed in the final report.

4.1.5.4 Holding Time

The service provider must meet all sample holding time requirements for the applicable method and/or protocol to which the sample(s) is being analyzed. If hold times are missed, as soon as the incident is realized, the service provider must contact ERT staff. Due to the presence of naturally occurring radon decay products, individual filter samples analyzed for gross alpha/beta are stored for a minimum of four days (96 hours) before analysis. Following the gross alpha and gross beta analyses, unless otherwise instructed, the samples are stored by the service provider for designated compositing.

4.1.6 Method Detection Limits and Required Reporting Limits

The service provider measures the activity on the air sample and combines the result with the volume of sampled air to report air concentrations of the analyte(s). By regulation, the ambient air sample result must be able to detect concentrations that would cause a public receptor dose that is 10% of the standard (40 CFR 61.93.b.5.iii) (i.e., indicative of a 1 mrem/yr dose). PNNL assigns 1% of the 40 CFR 61, Appendix E, Table 2 values to indicate this value for radionuclide-specific analyses (i.e., indicative of a 0.1 mrem dose). While the actual volume of air sampled may change due to equipment operations, achieving the contract required detection limit (RDL) is based on ideal sample volumes and the specific aliquot sizes required to perform various radionuclide analyses (Table 5). There is no Appendix E, Table 2, value for gross alpha and gross beta results.

Table 5. Contract Required Detection Limits for PNNL-Richland Campus Ambient Air Samples

Analyte	Contract Required Detection Limit (RDL) (pCi/m^3)	Notification Value[(a)] (pCi/m^3)
Gross Alpha	1.0E-03[(b)]	--
Gross Beta	1.0E-02[(b)]	--
Co-60	1.7E-04	1.7E-03
Cs-137	1.9E-04	1.9E-03
Am-241	1.9E-05	1.9E-04
Am-243	1.8E-05	1.8E-04
Cm-244[(c)]	2.6E-05	2.6E-04
Pu-238	2.1E-05	2.1E-04
Pu-239[(c)]	2.0E-05	2.0E-04
U-233[(c)]	7.1E-05	7.1E-04

(a) Notification value is 10% of concentration levels listed in Table 2 of 40 CFR 61, Appendix E.
(b) Based on review of historical results the PNL-5 (CY2017-23) annual average 95th percentile gross alpha air concentration is 9.9E-04 pCi/m3 and for gross beta is 1.6E-2 pCi/m3.
(c) Analytical results indicate combined results for Cm-243/244, Pu-239/240, and U-233/234 because these isotopes cannot be distinguished between each other during analysis. When applicable, the lower RDL of the two isotopes is used as the contract-required RDL.

As stated, the contract RDLs (Table 5) are 1% of the values in 40 CFR 61, Appendix E, Table 2 (with the exception of gross alpha and gross beta); achieving the limit is based on specific aliquot sizes for various radionuclide analyses. Detection limits for gross alpha and gross beta are based on a review of historical results at the background station (PNL-5) with a total air volume typical of a 2-week time period (approximately 910 m^3), with composite volume totals for designated quarterly or semiannual (twice a year) composite frequency.

If there is insufficient material to perform all tests ordered for a given sample, the service provider maintains the integrity of the sample and contacts PNNL for further instruction.

The RDL for the gamma scan analyses is for Co-60 and Cs-137. Other radionuclides detected in a gamma scan will have detection levels commensurate with counter background, photon yield, and energy as related to the Co-60 and Cs-137 analyses.

4.1.7 Performance Criteria

The following performance criteria are applied to the reporting of the sample results.

All analytical test results are reported as the measured positive or negative value with the associated uncertainties. Details of the reporting requirements are provided in Section 4.1.8. All measurement uncertainties are identified and carried through to the final analytical result. Each report of results includes estimates of the total propagated analytical uncertainty associated with the determination at the two-sigma level as well as the two-sigma counting uncertainty. The procedures for the determination of uncertainties are specified in the analytical lab's analytical test procedures.

The service provider provides documentation of limits for radioactive contamination allowable in reagents and sample collection media. Blank samples are analyzed for each batch of reagents and glass fiber air particulate filters. Such limits are to be consistent with the analytical specifications described in Section 4.1.6.

The reagent and blank sample collection media data are used to determine average batch blank values. The uncertainty of the reagent blank values is combined into the total propagated analytical uncertainty.

The service provider maintains records of instrument model number, detection system configuration (generic detector system electronic component schematic including the multi-channel analyzer as applicable), detector bias voltages, calibrated geometries, cross-talk values (if applicable), and detector identifications (if applicable).

The service provider documents in their records the vendor supplied analytical peak identification criteria for gamma scan analyses.

The service provider sets up instrumentation according to the manufacturer's instructions. Any changes or modifications to the manufacturer's instructions are documented for each instrument used. Such documentation is maintained by the service provider and available to PNNL upon request.

Counter efficiency, aliquot size, and count duration are optimized such that minimum detectable activities/concentrations (MDAs/MDCs) are at or below the RDLs given in Table 5. Equation 37 from Chapter 6 in EPA 520/1-80-012 (EPA 1980), using the average standard deviation of process blanks for individual methods of interest, is used to calculate MDAs/MDCs that demonstrate compliance with the RDLs required for the aliquot sizes shown in Table 5. The process blank computer files are to be updated semi-annually for analytical tests conducted frequently (i.e., gross alpha and gross beta) and at least annually for all other tests.

4.1.8 Reporting Requirements

Communication and reporting requirements for sample handling, processing, and analytical test results are discussed in the following section. Additional information on reporting of analytical results is in Section 4.1.7, Performance Criteria.

In addition, revisions to any analytical laboratory services Standard Operating Procedures (SOPs) shall be made available quarterly to ERT staff. The SOPs provided shall be those relevant to the analytical methods used for the analytical services SOW as well as general SOPs relevant to administration, QC, good practices, etc.

4.1.8.1 Notification Requirements by the Service Provider

Certain situations require prompt phone or e-mail communication by the analytical laboratory service provider to ERT staff. The analytical services SOW specifies the details for handling PNNL ambient air samples, notification, and document requirements. Below are several examples of when prompt notification is required by the service provider:

- Unusual or suspicious result for any analytical test ordered for any sample
- Any discrepancies between COC paperwork, sample labels, and sample receipt
- Failure to follow approved analytical procedures
- Lost or destroyed samples, missed hold-times, equipment failures
- Audit findings and/or failed performance evaluation studies (follow-up with corrective actions)

- Provider is placed under investigation or suspension by any regulatory agency
- Status Reports

If applicable, a Sample Receiving Log Summary Report is delivered electronically each week to PNNL. The Sample Receiving Log Summary Report specifies for each sample:

- PNNL sample number
- PNNL identification number
- Date of sample collection
- Date of sample receipt at the Lab's local receiving facility
- Analytical test result due date
- Each constituent group or individual constituent for which an analytical test was ordered.

A Monthly Not-Reported Results Summary Report of all PNNL samples delivered for analytical test results which are past due are to be delivered to PNNL within five (5) business days following the end of each calendar month. If there are no results to report, a summary report should be provided clarifying such. The Monthly Not-Reported Results Summary Report specifies for each relevant sample:

- PNNL sample number (e.g., Field Sample ID)
- PNNL identification number (e.g., analytical work package number)
- Date of sample collection
- Date of sample receipt
- Constituent for which an analytical test was ordered but not yet reported
- Analytical test results report due date
- Anticipated report date
- Explanation of overdue status.

4.1.8.2 Analysis and Reporting Times

Analytical test results for Routine and Priority processing of samples are typically delivered as specified in Table 6. Reporting times may be extended when necessary (e.g., sequential analyses are required to perform all tests ordered for a given sample). Before samples are composited for subsequent analyses, PNNL has five (5) business days following the receipt of air particulate sample analytical results to review the data. Thus, the reporting timeclock for composite samples begins five (5) business days after receipt of gross alpha/gross beta test results for the last sample of the composite.

Table 6. Typical Reporting Times for Routine and Priority Processing of Ambient Air Particulate Samples

Type of Ambient Air Analysis	Business Days Following Sample Receipt	
	Routine Processing	Priority Processing
Gross Alpha, Gross Beta	15	5
Gamma Spectroscopy	20	10
Alpha-emitting Isotopics[(a)]	25	15

(a) Includes uranium, curium, plutonium, and americium.

4.1.8.3 Analytical Data Report Deliverable

A report of analytical data shall consist of a hardcopy report (electronically scanned or generated documents compiled into a Portable Document Format [PDF]), and an electronic data deliverable (EDD) file compatible with the current EIM data loader format as covered in the analytical services SOW. The DMP provides additional details.

- Results are to be reported with nuclide-specific decay corrections applied, when necessary, to the date and time of sampling for discrete samples or to the date and time of the sampling mid-point for composited samples obtained over a time interval.
- No changes to the reporting medium or format are implemented without the prior written approval of PNNL. The service provider must notify PNNL in a timely manner when a change in its reporting software is made (including file naming and format).

4.1.9 Follow-up Analysis Request

The analytical laboratory service provider will perform a follow-up analysis in the form of a data recheck, sample recount, and/or sample reanalysis for routine and priority processing when requested. When suspect data is identified during the PNNL data review process, those data must be investigated to establish whether they reflect true conditions or an error. Managing suspect analytical data results are governed by the DMP and operating procedures. The service provider will report the results in writing in accordance with Section 4.1.8.

4.1.10 Accuracy and Precision

Accuracy or precision standards for PNNL Environmental Surveillance sampling include those for collection period coverage; radiochemical test results, QC sample results by the service provider, and use of certified standards.

The accuracy of an air sampling system is considered acceptable if the systems operational frequency collects a sample 85% or more of the time. The criteria to determine sufficient sample volume for a typical two-week air filter can be found in procedure EPRP-AIR-029.

Accuracy and precision are measured by the analytical laboratory service provider with the aid of blanks, duplicates, and spikes. An analytical batch of samples is defined as not more than 20 samples. When reporting composite results, there must be at a minimum one blank, one duplicate, and one spike analyzed per analytical batch of samples. When reporting individual air filter results, there must be one blank analyzed per analytical batch of samples.

Accuracy requirements for the QC samples as listed in Table 7 must be met by the laboratory control sample and any other spiked sample where the sample concentration is above the RDL and the spiked concentration ranges from five (5) times to no greater than ten (10) times the sample concentration and for duplicate sample results that are greater than the RDL.

Accuracy is based on the use of certified standards for each measurement process required to obtain results. The service provider documents these results. Analytical problems identified through analysis of QC samples must be promptly corrected.

4.1.11 QC Reporting

In addition to the analytical quality actions performed when PNNL samples are analyzed, the service provider assures the integrity and validity of analytical test results through implementation of an internal QC program. The service provider's QC Program must be described in a written procedure(s) and includes a corrective action system for discrepant results. An effective system for reviewing and analyzing such results must be maintained to detect problems due to contamination, or inadequate calibrations, calculations, procedures, or other causes. Standard methods are used whenever possible and methods that are developed or adapted must be tested and completely documented by the service provider.

The service provider prepares and analyzes spiked, blank, and replicate samples to verify the accuracy and precision of all analytical results (e.g., using DoD and DOE 2021). The total number of such samples is no less than 15% of all ordered tests. Spikes are included with each batch of samples processed and have, insofar as possible, a matrix, volume, and other relevant characteristics of the actual samples being analyzed. Spiked samples have a range of activity from five (5) times the sample result to no greater than ten (10) times the sample result. Reagent and sample matrix blanks are analyzed with each batch of samples processed except for gross alpha, gross beta, and gamma analyses where water is used as the blank and spike matrix only. Internal laboratory batch QC sample results will be reported in the data report along with sample results.

Table 7. Contract-Specific Accuracy and Precision Requirements for Radiochemical Analyses

Analytical Method	Blanks[(a)]	Accuracy for Spikes (LCS) [% Recovery]	Precision for Duplicates [STDEV][(b)]
Gamma Spectrometry	<5% Notification Level	80–120	RER <3 or RPD <25%
Alpha Spectrometry	<5% Notification Level	75–125	RER <3 or RPD < 25%
Gross Alpha/Beta Gas Flow Proportional Counter	< Contract Required Detection Limit	75-125[(c)]	Not Applicable

(a) Notification level is 10% of the concentration levels listed in Table 2, 40 CFR 61, Appendix E, converted to pCi/m^3.
(b) STDEV = standard deviation, RER = relative error ratio (sometimes called duplicate error ratio [DER]), RPD = relative percent difference.
(c) Only applicable for composites requesting gross alpha and gross beta analyses; not applicable for individual air particulate filters analyzed for gross alpha and gross beta.
LCS = laboratory control sample

4.1.12 Annual Analytical Laboratory Performance Evaluation Reporting

The analytical laboratory service provider participates in national comparison studies, also called performance evaluations, such as the DOE Mixed Analyte Performance Evaluation Program (MAPEP). For these studies, blind samples containing specific amounts of contaminants are distributed to participating laboratories. The laboratories analyze the samples and submit their analytical results to the study organizer for comparison and evaluation. The RDLs specified in Table 5 are applicable, and the procedures outlined in this SAP are used unless exceptions are granted in writing by PNNL.

The service provider supplies ERT staff with a copy of each report resulting from their participation in the comparison studies. The reports should be provided within 10 days of receipt and should include the resolution/proposed resolution for any identified problems. At a minimum, the report provides the sample identification number assigned to the performance samples, the analyzed concentrations, ratios, percent differences, as listed in the provider report. A summary of the performance evaluation studies is presented in the annual site environmental report.

4.2 Ambient Air Sample Collection

Ambient air samples are routinely collected per procedures. All samples are tracked and managed by a COC, and, if necessary, multiple particulate samples may be composited for radionuclide-specific analyses to achieve lower detection levels or achieve the design sampling frequency. Sampling frequencies are based on the need to obtain time-representative samples, though environmental factors may impact collection efficiencies, and sampling equipment or sampling substrate performance may impact actual sampling times.

As indicated previously, ambient air samples are currently collected at the PNNL-Richland campus. A DQO process was used to determine the need and potential location(s) for ambient air surveillance at the PNNL-Sequim campus in 2019 (Snyder et al. 2019). Sequim campus ambient air particulate sampling for background has not yet started. Sampling frequency and systems are expected to be similar to those of the PNNL-Richland campus. Detailed procedures for the PNNL-Richland campus area air sample collection process are documented in EPRP-AIR-029.

4.2.1 Sampling and Analysis Schedule

Ambient air particulate samples are collected as reported in Table 8. This schedule was formerly indicated in the PNNL internal document *PNNL-Richland Campus Radiological Air Environmental Surveillance Sampling Schedule*. Ambient air samples are collected on a biweekly (every 2 weeks) schedule and promptly sent to the service provider for analyses. After gross alpha/beta measurements, the samples are retained for compositing. Experience indicates that air-particulate glass-fiber filters must be collected at this frequency to avoid occasional excess particulate buildup on the filters. Following collection, each particulate sample is analyzed for gross alpha and for gross beta to provide an early indication of any unplanned contaminant release that may require expedited analysis of samples and/or additional or special sampling. Biweekly filter samples from a single location are composited by the service provider for semi-annual analysis (gamma emitters, uranium isotopes, plutonium isotopes, and americium isotopes) to track trends that are not likely to be detectable by the gross activity measurements. Radiochemical analyses of filters are performed semi-annually to provide data to confirm (low) emissions.

Table 8. Ambient Air Sample Locations, Frequencies, and Analyses

	Individual Samples	Composited Samples	
Location	Biweekly (Analyses)	Composite Group	Semi-Annual (Analyses)
PNNL-Richland Campus			
PNL-1 (solar)	α, β	PNL-1	Pu, U, γ, ^{241}Am, ^{243}Am, $^{243/244}$Cm
PNL-2 (solar)	α, β	PNL-2	Pu, U, γ, ^{241}Am, ^{243}Am, $^{243/244}$Cm
PNL-3	α, β	PNL-3	Pu, U, γ, ^{241}Am, ^{243}Am, $^{243/244}$Cm
PNL-4	α, β	PNL-4	Pu, U, γ, ^{241}Am, ^{243}Am, $^{243/244}$Cm
PNL-5[(a)]	α, β	PNL-5	Pu, U, γ, ^{241}Am, ^{243}Am, $^{243/244}$Cm
PNNL-Sequim Campus[(b)]			
TBD	TBD	TBD	TBD

(a) Background location established at Benton City, Washington.
(b) Locations and analyses to be determined (TBD).

Environmental surveillance activities are reviewed during the PNNL Site annual design review. Periodic re-evaluations may be needed during the year to respond to changing operations or environmental conditions. The environmental surveillance sampling plan will remain unchanged unless significant revisions are noted during the design review period.

4.2.2 Sampling Location

As noted in Table 8, there are presently five environmental surveillance sampling stations located on and adjacent to the PNNL-Richland campus (see Environmental Monitoring Plan [EMP], Figure 2). The two northern monitoring stations, PNL-1 and PNL-2 are N and NNW of the PSF; PNL-3 is located SE of PSF; PNL-4 is located south of PNL-3; and PNL-5, the background monitoring station, was established approximately 12 miles SW of the PNNL-Richland campus, using the criteria described in Fritz et al. (2015). Geo coordinates of stations are provided in Table 9. PNL-4 used to surveille a facility that no longer exists. The station is retained because of its value as a collocated station with both the WDOH and the Hanford Site (Snyder et al. 2024).

A recent DQO assessment (Snyder et al. 2024) was initiated due to planned Richland campus development. It concluded that PNL-2 should be relocated to accommodate pending north campus construction and PNL-3 should be relocated to better address PSF emissions and current stack configurations. PNL-3 was relocated in August 2024; PNL-2 relocation is anticipated in fiscal year 2025. To maintain integrity of monitoring locations, ambient monitoring locations are photographed annually to document any changes that could impact data quality.

4.2.3 Equipment

Procedures for sampling and equipment maintenance/calibration are established to meet sampling system design requirements. The following equipment and supplies may be needed when collecting air-particulate samples:

- Clean filter-head assemblies (in plastic jars with lids) with filters already installed.
- A calibrated air flow meter.
- Rain guards (hoods) for filter holders.

- Plastic tubing (3/8 and ½-inch inner diameter) for tubing repairs.
- Hose clamps (large and small, plastic and metal).
- Spare vacuum pump, air flow controller, calibrated air volume totalizer.
- Assorted tools for minor repairs.

Figure 5 provides a schematic of an air sampling system. Sampling inlets are located two meters above the ground to provide measurements representative of radionuclide concentrations inhaled by humans. The data-affecting flow-controller is verified against a NIST-traceable calibrated flow meter when the RPT (or equivalent) exchanges filter assemblies.

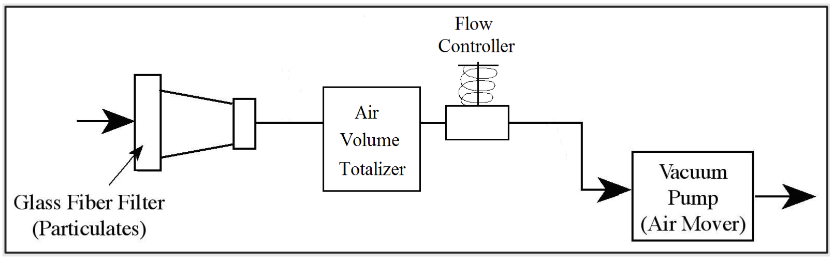

Figure 5. Air Sampling Systems for Radioactive Paritculates

4.2.4 Sample Collection and Delivery Process

Air is pulled through a filter head assembly containing a 2-inch glass-fiber filter at a desired rate of 1.6 cfm (~2.77m^3/hr) at the sampling station with a total air volume of approximately 910 m^3 for a 2-week time period. At the flow rate used, the filters have a sampling efficiency of at least 99% for 0.3-micrometer-diameter particles. Flow rates for particle filters are checked and readjusted (if needed) at the end of the sampling period and sample volumes are measured with a calibrated in-line dry-gas meter.

During sample collection, the RPT (or equivalent) removes the exposed particulate filter-head assembly and replaces with a new filter-head assembly. The exposed filter-head assembly is carefully placed in a storage jar, filter paper facing up. The RPT (or equivalent) enters all pertinent sampling information on the COC forms and on the sample label, then places the appropriate sample label inside the storage jar with the sample.

The RPT (or equivalent) must assure the security and integrity of all samples up until the time they are relinquished to the service provider. At the completion of the sampling activities, the RPT (or equivalent) returns the original field paperwork to ERT staff to assure proper sample tracking.

5.0 Ambient Dosimetry

Ambient dosimetry measures external dose rates of beta/gamma emitters, representative of an adult 24/7 exposure, with solid state dosimeters. The PNNL-Richland campus incorporated environmental dosimeters into their program late 2016, with 2017 being the first full year of operation. The PNNL-Sequim campus incorporated environmental dosimeters into their program in mid-2024. Ambient dosimeters began operating at the PNNL-Sequim campus following a DQO process that recommended baseline radioactive air background surveillance be performed for ambient external dose at the PNNL-Sequim campus (Snyder et al. 2019).

While neither campus has operational source material nor radionuclide emissions to air that result in elevated beta/gamma exposure levels at station locations, radiological research changes on a constant basis. Measuring ambient external dose now provides knowledge of levels and variability for monitored locations and provides reference points for the adopted system. In addition, the procedures and processes to perform this surveillance activity are established. The PNNL-Richland campus dosimeters are co-located at the same locations where ambient air particulate sampling is performed whereas at the PNNL-Sequim campus, only dosimeters are placed at two onsite locations. A single service provider supplies the dosimeter and dosimeter processing. Monitoring uses aluminum oxide dosimeters. An RPT (or equivalent) deploys and retrieves dosimeters using a PNNL COC form per PNNL procedure EPRP-AIR-029.

In addition, a 2020 ERT staff internal environmental dosimetry assessment evaluated compliance with ANSI requirements including ANSI/HPS N13.37, *Environmental Dosimetry—Criteria for System Design and Implementation*. The assessment did not identify any findings with corrective actions; however, any recommended opportunities for improvement were individually evaluated, documented, and implemented, when appropriate.

In 2024, new shielding (i.e., two lead vaults) was purchased for ambient dosimetry badge storage at both the PNNL-Richland campus and PNNL-Sequim campus. The shielding will store the control and transit dosimeters and, while not deployed, the field dosimeters will also be stored in the vault. The dose rate in the new vaults will be determined by using reference dosimeters stored over an extended period.

5.1 Ambient Air Dosimetry Service Provider

Internal or commercial vendors are available to provide such a service at a reasonable cost. Generally, the service provider should provide an appropriately rugged dosimeter package; be able to provide quality processing of dosimeters; and provide analysis results in a useable form. The analysis results are received from the service provider and uploaded to the EIM database.

5.1.1 Technical Requirements

External dose surveillance is done with aluminum oxide dosimeters read by optically stimulated luminescence (OSL), using the Landauer[10] InLight System. This system has a 5-mrem minimum detection level for beta, gamma, and x-ray emissions of 5 keV to 20 MeV. Ambient dosimeters, procured from Landauer dosimetry services, should follow the external dose reporting

[10] Landauer, 2 Science Rd, Glenwood, IL 60425-1586. www.landauer.com.

information in the ANSI/HPS Standard N13.37-2019.[11] The environmental dosimeters are designed to withstand extremes of temperature, humidity, precipitation, and other environmental conditions.

Each InLight dosimeter is sealed within a heavy-duty vinyl tamper resistant pouch with slots that permit attachment for easy deployment; the dosimeters batch will be color coded. A minimum of two control dosimeters are provided per shipment. The first is for field deployment/retrieval and used to measure any exposure during shipment and placement/collection; this dosimeter result is compared to the second control dosimeter result. The second is yellow and for transit used to measure exposure during shipment only.

PNNL will provide the service provider with the following information to print on the front of each InLight dosimeter: sample collection date, Location name (e.g., PNL-3), and sample ID. Also printed on the front, lower left corner, is a unique 5-digit sample ID assigned by the service provider. On the backside of the dosimeter is a unique badge serial number assigned by the service provider (Figure 6).

On a quarterly basis, dosimeters are collected, deployed, and relinquished by PNNL according to EPRP-AIR-029. Control dosimeters are placed in a shielded container when not in use.

Figure 6. Environmental Dosimeter

5.1.2 Reporting Requirements

For data management, the service provider reports are provided electronically, via the service provider's secure portal, and must be fully compatible with the designated data loader format within PNNL's EIM. The DMP provides additional details. At minimum, the data report includes the 5-digit lab-assigned location number, 6-digit EIM/PNNL assigned identifier, location name, gross and net ambient dose exposure (mrem), quarter and year deployed (e.g., Q1, 2024), and badge serial number unique to the dosimeter. EIM retains the actual sample deploy (start) and retrieve (end) dates, as recorded on the COC. Reported dose readings indicate the measurement for the monitored period. PNNL has requested that the service provider DOES NOT subtract the control badge value from the non-control dosimeter results. The gross and net readings reported by the service provider should be identical since the control dosimeter result is not subtracted.

[11] The Landauer environmental dosimeters indicate compliance with NRC Reg Guide 4.13 (NRC 2019), and the 'withdrawn' ANSI N545-1975 (R1993), replaced by ANSI N13.37.

Once the full year of dosimeter results are available in EIM, ERT staff use DI-AIR-004[12] for reporting purposes. PNNL reports ambient dosimeter results using ANSI/HPS Standard N13.37 (2019) guidance to report dose rates normalized to a 91-day standard monitoring period. This method is a modified ANSI/HPS Standard N13.37 (2019) analysis, as described in the Dose Assessment Guidance (DAG, EMP Attachment 3; Snyder and Cooley 2024). A summary of results is reported in the air emissions report (e.g., Snyder et al. 2023) Reported results are included in the Annual Site Environmental Report (e.g., Thompson et al. 2023).

ANSI/HPS Standard N13.37 (2019) indicates that correction for control badge shielding dose be applied when ambient air external exposure is assessed. This has not been implemented due to unavailable data. The external dose assessed by DI-AIR-004 indicates relative magnitude of normalized quarterly doses and whether the critical doses are above or below the annual background station dose. DI-AIR-004 evaluates whether critical station results are statistically above the background station results for the calendar year. This evaluation includes the uncertainty associated with dosimeters used, estimated to be 12% (2-sigma, 95% confidence interval).[13] New lead shields were received for control and transit dosimeter storage prior to critical station dosimeter deployment in the third quarter of 2024. Shielding dose can be assigned as part of the N13.37 process once the vault dose is assessed for at least 6 months.

EIM contains raw dosimeter data. Normalized dose results are reported nominally in the annual air compliance reports and in more detail in the PNNL Annual Site Environmental Report. This disparate reporting will remain the practice as long as there are no significant air effluent sources of external dose at each campus.

5.1.3 Quality Control

QC for external dose surveillance is covered by PNNL procedures EPRP-AIR-029 and EPRP-AIR-032. Examples of processes implemented to maintain ambient dosimetry quality are as follows. Both control dosimeters assigned to a shipment will accompany that shipment both from and to Landauer. Dosimeters will be stored away from radiation when not in use. In between sampling events, the yellow control and PNL-T transit dosimeters will be secured in a lead pig. Quality checks on dosimeter results are also performed as part of the data evaluation for ambient air dosimetry reporting in DI-AIR-004, *Ambient Air Dosimeters – Annual Dose Status*.

5.2 Ambient Dosimetry Sample Collection

Ambient dosimeters are routinely deployed and collected at the PNNL-Richland campus and PNNL-Sequim campus. Quarterly sampling frequencies may vary by about 12 days in a single year, due deployments around holidays and weekends. ERT staff perform data evaluations of the quarterly results (DI-AIR-004) for the PNNL-Richland campus to resolve ambient dose variations for each quarter (see DAG). Results for the PNNL-Sequim campus will be evaluated for annual ambient dose after the first full calendar year of sampling.

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[12] A similar Desk Instruction has not yet been developed for the PNNL-Sequim campus ambient air dosimetry results due to the short period of implementation. When created, the Desk Instruction for Sequim will align with DI-AIR-004.

[13] E-mail correspondence between Landauer (Gabriele Walerow) and PNNL (Lynn Bisping), dated July 02, 2018, Subj RE: Account 715897.

5.2.1 Sampling and Analysis Schedule

PNNL-Richland campus ambient dosimeters are collected in accordance with Table 9. This schedule was formerly indicated in the PNNL internal document *PNNL-Richland Campus Radiological Air Environmental Surveillance Sampling Schedule*. Dosimeters are placed adjacent to the five ambient air sampling locations on the PNNL-Richland campus. External radiation dose level is monitored with aluminum oxide dosimeters with two control dosimeters, one control measures exposure during field deployment/retrieval activities and the second measures exposure during shipment to and from the service provider. Ambient dosimeter sample locations, frequencies, and measurement are indicated in Table 9.

Table 9. Ambient Dosimeter Sample Locations, Frequencies, and Measurement

Location	Geo Coordinates (degrees)	Frequency	Measurement
PNNL-Richland Campus			
PNL-1	46.3562, -1192832	Quarterly	Ambient Dose
PNL-2	46.3596, -119.2771[(a)]	Quarterly	Ambient Dose
PNL-3	46.3446, -119.2747[(b)]	Quarterly	Ambient Dose
PNL-4	46.3406, -119.2783	Quarterly	Ambient Dose
PNL-5[(c)]	46.2758, -119.4991	Quarterly	Ambient Dose
PNNL-Sequim Campus			
SEQ-1	Approx. 48.080, -123.046	Quarterly	Ambient Dose
SEQ-2	Approx. 46.078, -123.047	Quarterly	Ambient Dose

(a) Prior to relocation.
(b) After relocation, 2024.
(c) Background station located in Benton City, Washington.

5.2.2 Sampling Location

The PNNL-Richland campus Environmental Surveillance program consists of four stations located on and adjacent to the PNNL-Richland campus and one station for regional background (see Environmental Monitoring Plan [EMP], Figure 2). PNL-1, PNL-2, and PNL-3 were established to monitor emissions from the campus' largest potential source of radioactive air emissions, the PSF Buildings 3410, 3420, and 3430. Relative to PSF, PNL1 is NNW, PNL-2 is N, and PNL-3 is SSE. PNL-4 monitors the southern campus which is farther from current radiological operations and is co-located with Hanford Site and WDOH sampling stations. PNL-5, the background monitoring station, is approximately 12 miles SW of the PNNL-Richland campus, in Benton City, Washington.

A DQO process was used to determine potential locations for ambient air dosimetry for the PNNL-Sequim campus (Snyder et al. 2019). The DQO did not recommend sampling for the purposes of emissions monitoring at the PNNL-Sequim campus because past and current emissions and sources are minimal. However, background results could be collected on site to provide current baseline data. Ambient dosimeters began operating at Sequim in June 2024, one located at the lowland north beach parking lot (SEQ-1) and another located at the upland location near the water towers (SEQ-2).

5.2.3 Equipment

The following equipment and supplies may be needed when collecting ambient air dosimetry:

- New unexposed dosimeter(s). designed to withstand extremes of temperature, humidity, precipitation, and other environmental conditions.
- Cable ties or similar device for fastening dosimeter (fastened ~1 meter above the ground level).
- Lead pig.

5.2.4 Dosimeter Collection/Deployment and Delivery Process

Ambient levels of external dose from beta, gamma, and X-ray sources are monitored with a dosimeter that is exchanged quarterly, using procedure EPRP-AIR-029. The RPT (or equivalent) removes the exposed dosimeter and replaces it with a new unexposed dosimeter (the location name on the exposed (old) dosimeter should match the location name of the unexposed [new] dosimeter being deployed). The RPT (or equivalent) enters all pertinent sampling information on the COC form, places all exposed (old) dosimeters, as well as the two related control dosimeters, in an envelope to relinquish to the ERT staff. The ERT staff verifies receipt and ensures dosimeters are shipped to the service provider, who reads their exposure level.

Unlike particulate air sampling that may require disposing of residual materials, environmental dosimeters have no residual radioactive materials that require disposal or other management. Dosimeters are returned in their entirety to the service provider.

6.0 References

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