PNNL-20919 Rev. 2

# EMP - Environmental Radiological Air Monitoring Plan

## PNNL Operations in Washington

January 2025

SF Snyder
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LE Bisping
LN Dinh

U.S. DEPARTMENT OF ENERGY

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

PACIFIC NORTHWEST NATIONAL LABORATORY
*operated by*
BATTELLE
*for the*
UNITED STATES DEPARTMENT OF ENERGY
*under Contract DE-AC05-76RL01830*

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Pacific Northwest National Laboratory
Richland, Washington 99354

# Summary

The Environmental Radiological Air Monitoring Plan (EMP) for Pacific Northwest National Laboratory (PNNL) describes systems/processes/practices related to radiological operations in Richland and Sequim, Washington, that are associated with environmental radiological air monitoring and surveillance activities. The activities described support the lab's responsibility to maintain safe operations and minimize negative impacts to both onsite and offsite persons and environment. Dose assessments required by regulations and DOE Orders for the public and biota are described.

PNNL conducts environmental air surveillance monitoring as part of the PNNL Site Radioactive Air Emissions License (RAEL)-005 for Richland Campus, issued in 2010 with its most recent renewal effective in January 2021. The radioactive air emissions license for the PNNL-Sequim campus (RAEL-014) was issued to the U.S. Department of Energy in 2012 with its most recent renewal effective in January 2023.

The EMP is a compilation of the following four documents:

- Environmental Radiological Air Monitoring Plan (this main document) (PNNL-20919)
- Sampling and Analysis Plan (Attachment 1) (PNNL-20919-1)
- Data Management Plan (Attachment 2) (PNNL-20919-2)
- Dose Assessment Guidance (Attachment 3) (PNNL-20919-3).

Each of those documents covers topics that can be updated independently. The procedures, forms, and data management activities described herein may change in response to changes in facility operations of radiological research work or during routine reviews. As a result, each document may have different publication dates. The documents are available at https://www.pnnl.gov/publications/.

| PNNL-20919 Revision Number | Effective Date | Description of Change |
|---|---|---|
| 0 | December 2011 | Initial issuance. Plan was issued for the Richland site. |
| 1 | December 2019 | This revision incorporates the changes that were made in the *Data Quality Objectives Supporting Radiological Air Emissions Monitoring for the PNNL Richland Campus*, PNNL-19427, Rev. 2 (Snyder et al. 2017):<br>• Changes to the PNNL Richland Campus boundary; changes and addition in ambient air particulate monitoring station<br>• Addition of ambient air external dose monitoring.<br>This revision incorporates the changes that were made in the *Data Quality Objectives Supporting Radiological Air Emissions Monitoring for the Marine Sciences Laboratory*, Sequim Site, PNNL-22111, Rev. 1 (Snyder et al. 2019):<br>• Changes to the MSL/Sequim Site boundary and applicable air license<br>• Recommendation of ambient air particulate and external dose surveillance.<br>PNNL operations in Richland, Washington, (discussed in Snyder et al. 2017) and in Sequim, Washington, (discussed in Snyder et al. 2019) are combined in this EMP and jointly discussed. Radioactive emissions from PNNL-managed operations on the Hanford Site have been added.<br>• Title was changed to include “radiological air” for clarification and reference to governing agency was removed.<br>• All activities under PNNL’s Environmental Radiation Task are now discussed, including dose assessments.<br>• The following DOE orders and references were updated:<br>– DOE Order 231.1B Chg 1 supersedes and combines (DOE Order 231.1A chg1 and DOE M 231.1-1 Ch2)<br>– DOE guidance document DOE/EH-0173T updated as DOE-HDBK-1216-2015<br>– DOE Order 458.1 Chg 3 |
| 2 | January 2025 | This is a revision follows the 2024 updates to the three EMP attachments.<br>• Site names were updated to current terminology: PNNL-Richland campus and PNNL-Sequim campus.<br>• PNNL’s new database used for radiological air monitoring and surveillance samples<br>• Ambient external dose surveillance at PNNL-Sequim<br>• Actions resulting from the 2024 Richland campus Data Quality Objectives report |

# Acronyms and Abbreviations

| | |
|---|---|
| ALARA | as low as reasonably achievable |
| ANSI/HPS | American National Standards Institute/Health Physics Society |
| ASER | Annual Site Environmental Report |
| CAP88-PC | *Clean Air Act* Assessment Package 1988 – Personal Computer (software) |
| CFR | *Code of Federal Regulations* |
| COMPLY | COMPLY (software) |
| DAG | Dose Assessment Guidance (EMP Attachment 3) |
| DMP | Data Management Plan (EMP Attachment 2) |
| DOE | U.S. Department of Energy |
| DQO | Data Quality Objective |
| EDE | effective dose equivalent |
| EIM | Environmental Information Management |
| EMP | Environmental Radiological Air Monitoring Plan |
| EPA | U.S. Environmental Protection Agency |
| EPRP | Environmental Protection and Regulatory Programs |
| ERT | Environmental Radiation Task |
| HDI | How Do I...? (management system) |
| ISO | International Organization for Standardization |
| LLS | Low-level Sources |
| MCSP | Meteorological and Climatological Services Project |
| MEI | maximally exposed individual |
| mrem | millirem |
| MSL | Marine Science Laboratories |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| NDRM | Non-dispersible Radioactive Material |
| NOC | Notice of Construction |
| pdf | portable document format |
| PIC | Potential Impact Category |
| PNNL operations | activities conducted on the PNNL-Richland and Sequim campuses, and at PNNL-managed facilities on the Hanford Site |
| PNNL Operations | PNSO-managed operations at PNNL-Richland and Sequim campuses |
| PNNL | Pacific Northwest National Laboratory |
| PNSO | (U.S. Department of Energy) Pacific Northwest Site Office |
| PSF | Physical Sciences Facilities |
| PTE | Potential to Emit |
| QA | quality assurance |

| | |
|---|---|
| QAP | Effluent Management Quality Assurance Plan |
| QC | quality control |
| RAEL | Radioactive Air Emissions License |
| RAER | Radionuclide Air Emissions Report |
| RAGas | PNNL’s Radioactive Air Gas Emissions webtool |
| RMT | Radioactive Material Tracking |
| RPT | Radiation Protection Technologist |
| RTL | Research Technology Laboratory |
| SAP | Sampling and Analysis Plan (EMP Attachment 1) |
| SIOC | Sources for Instrument/Operational Checks |
| TED | Total Effective Dose |
| VRRM | Volumetrically Released Radioactive Material |
| WAC | Washington Administrative Code |
| WDOH | Washington State Department of Health |

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# 1.0 Introduction

The U.S. Department of Energy (DOE) Pacific Northwest National Laboratory (PNNL) Environmental Radiological Air Monitoring Plan (EMP) documents the surveillance activities used to assess the dose to those in the offsite environment from radionuclide emissions to air from PNNL operations[1]. This revision of the EMP combines the radiological air activities at the PNNL-Richland campus; Richland; PNNL-Sequim campus, Sequim; and at the PNNL-managed facilities on the Hanford Site, Richland, Washington (see Figure 1). The EMP describes the methods and actions necessary to assure that potential radiological impacts associated with PNNL Operations in Richland and Sequim are evaluated appropriately and consistently; and are not having an unacceptable impact on human or ecological health.

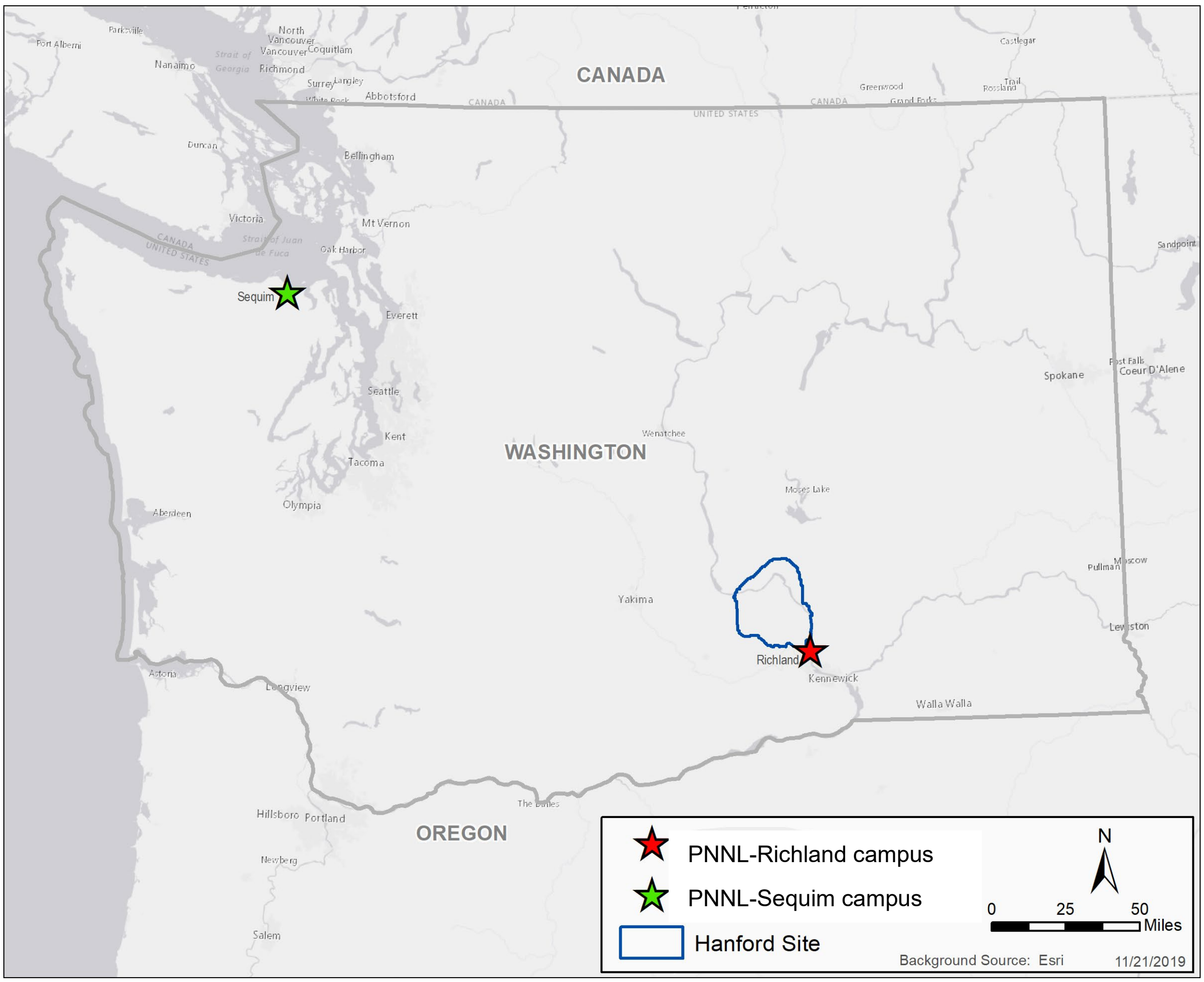


Figure 1. PNNL Operations in Washington State Occur at the Sequim Campus, Richland Campus, and Hanford Site

[1] Within this document:
PNNL Operations = PNNL-Richland campus and Sequim campus
PNNL operations = activities happening at PNNL Operations and at PNNL-managed Hanford Site facilities.

The 3.0-km$^2$ (740 acres) PNNL-Richland Campus is shown in Figure 2 along with the 1500-km$^2$ (370,000 acres) Hanford Site in the side graphic, and the PNNL environmental surveillance stations. The PNNL-Sequim campus, located on Washington State's Olympic Peninsula, encompasses 117 acres (0.728 km$^2$) of drylands (65 acres) and tidelands (52 ac), of which about 7.5 acres has been developed for research operations. Research operations occur at several laboratories and facilities, historically referred to as the Marine Sciences Laboratory (MSL) (see Figure 3). The PNNL Operations in Richland and Sequim (see Figure 1 for map of Washington State) are research facilities managed by the Pacific Northwest Site Office (PNSO) for the DOE Office of Science and is operated by Battelle.

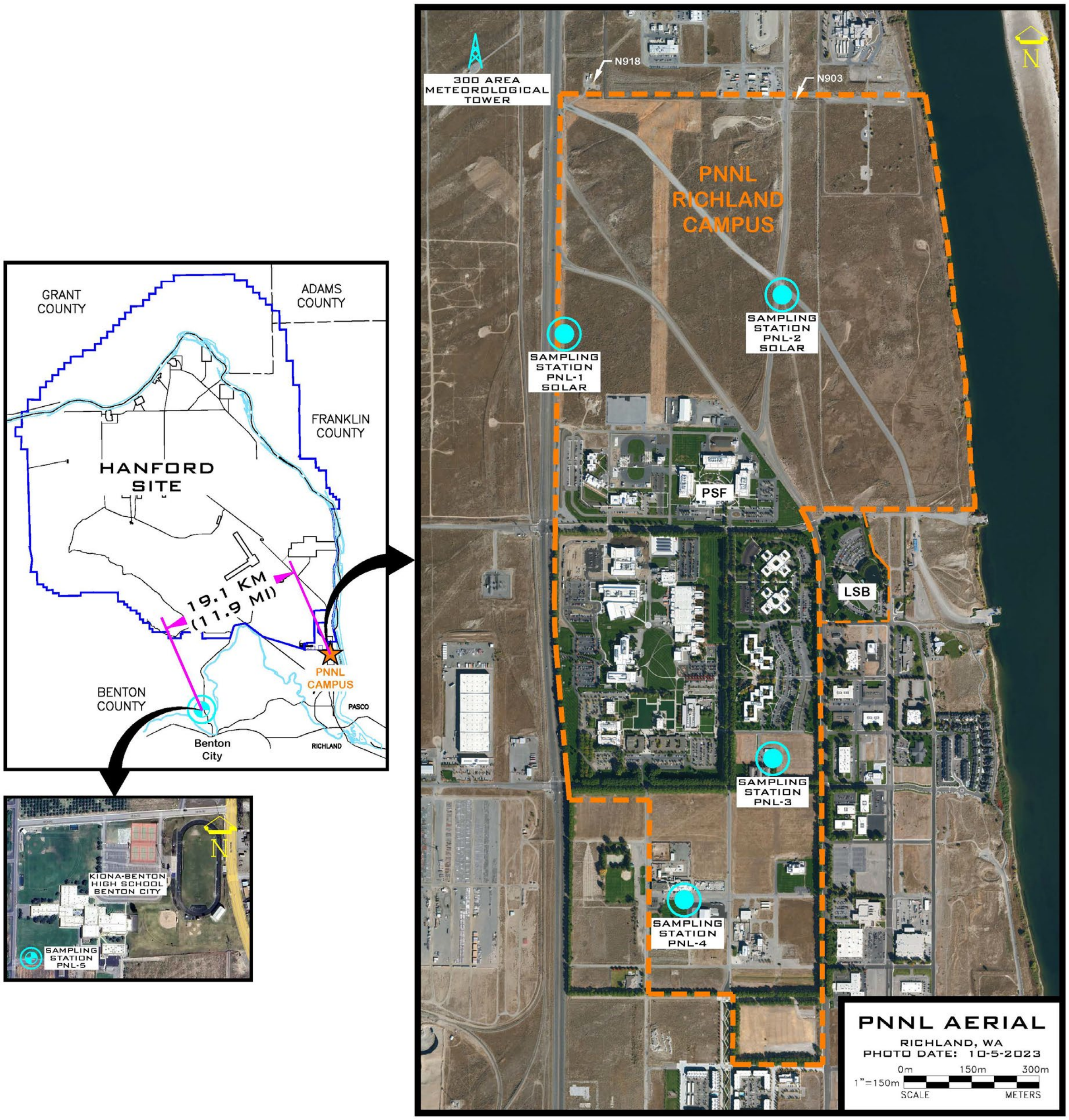


Figure 2. Location of PNNL-Richland Campus in Relation to the Hanford Site with PNNL Environmental Surveillance Stations Identified

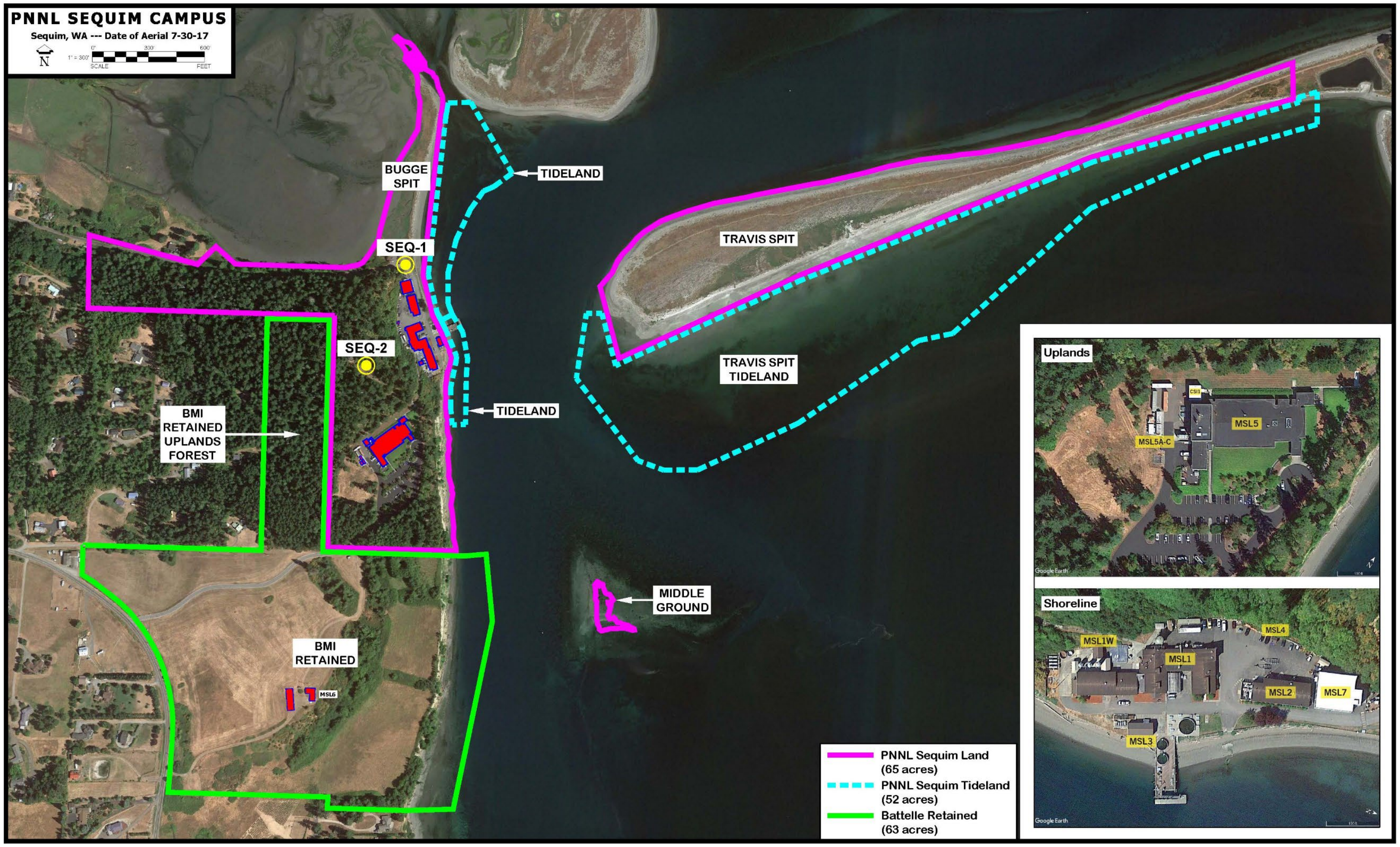


Figure 3. Map of PNNL-Sequim Campus (inclusive of the blue, magenta, and green boundaries) with Dosimeter Stations (SEQ-*n*) Identified.

Contractors are required to implement the environmental protection requirements of DOE Order 436.1A (2023), which includes the requirement for contractors to certify or conform their Environmental Management Systems with International Organization for Standardization (ISO) 14001:2015. PNNL has an ISO 14001 conforming program. The requirements of state and federal laws, regulations, and license/permits related to facilities are also addressed at this level. To assure the protection of PNNL workers, the public, and the environmental resources on and around PNNL operational sites, DOE and its contractors must implement the requirements of DOE Order 458.1 (2021). The current Battelle contract for PNNL Operations contains limited DOE Order 458.1 requirements.

This EMP documents the programmatic and operational aspects of environmental radiation surveillance at the PNNL fence line or beyond in Richland and Sequim, and includes processes needed to meet reporting requirements for public dose assessments and biota dose assessments related to radioactive air emissions.

The EMP development for the PNNL-Richland campus benefits from the institutional knowledge obtained through 50-plus years of monitoring and surveillance at the nearby Hanford Site. Quality assurance is an integral part of all environmental surveillance activities to assure that data quality is known and documented, and that the data meet DOE and contractor needs.

The EMP is a compilation of the following four documents:

- Environmental Radiological Air Monitoring Plan (EMP - this main document), (PNNL-20919)
- Sampling and Analysis Plan (SAP - Attachment 1), (PNNL-20919-1)
- Data Management Plan (DMP - Attachment 2), (PNNL-20919-2)
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Each of those documents covers topics that can be updated independently. The procedures, forms, and data management activities described herein may change in response to changes in facility operations of radiological research work or during routine reviews. As a result, each document may have different publication dates. These documents are available at https://www.pnnl.gov/publications/.

Historical context for this EMP and the PNNL radioactive air emissions activities includes the following information. Since the last revision of this EMP in January 2020, radiological operations at both Richland and Sequim have not significantly changed. In Richland, the north campus area is transforming from open field to improved infrastructure and initial development. This activity, along with two Physical Sciences Facilities (PSF) emission unit remodels, resulted in the relocation of two ambient air monitoring stations (Snyder et al. 2024a). In Sequim, it was determined that radioactive air emissions from operations at the campus do not require emission unit sampling or monitoring nor ambient air surveillance. However, it was recommended that a baseline of radioactive air background surveillance would be performed; installation of sampling station(s) for particulate gross alpha and gross beta in air as well as ambient external dosimetry were planned (Snyder et al. 2019b). While ambient external dosimetry began in June 2024 (see section 5.0 for details), installation of a particulate air sampler has been delayed until final land transfer decisions are made between Battelle and DOE. As requested by the Washington State Department of Health (WDOH), PNNL is continuing to conduct environmental air monitoring and surveillance as part of the PNNL Site

Radioactive Air Emissions Licenses (RAEL-005 for Richland Campus, most recent renewal effective in 2021; and RAEL-014 for PNNL-Sequim campus, most recent renewal effective in 2023). Licenses expire five years after their stated effective date.

This EMP also includes discussions of radionuclide emissions to air from PNNL-managed facilities on the Hanford Site. Hanford Site radionuclide emissions are under the RAEL-FF-01, managed by DOE-Richland Field Office. PNNL manages four facilities with radiological operations, in the Hanford Site 300 Area. PNNL also complies with the applicable site-wide NOC requirements of RAEL-FF-01 (e.g., 300 Area excavations and outdoor vented containers).

# 2.0 Environmental Radiation Task at PNNL

When radioactive emissions to the ambient air occur as part of routine operations, DOE facilities are required to demonstrate compliance with the Clean Air Act, National Emission Standards for Hazardous Air Pollutants (NESHAP) for radionuclides, as published in the 1989 amendments to 40 Code of Federal Regulations (CFR) Part 61, Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities”. The U.S. Environmental Protection Agency (EPA) is the federal agency tasked with oversight and implementation of the regulations. EPA has delegated regulatory authority to the Washington State Department of Health (WDOH) for facilities within Washington State.

The WDOH establishes regulations for radionuclide air emissions in WAC Chapter 246-247, “Radiation Protection – Air Emissions,” and adopts by reference the standards and approved methods specified in 40 CFR Part 61, Subpart H. Additional Washington State Department of Ecology regulations are found in WAC 173-480, “Ambient Air Quality Standards and Emission Limits for Radionuclides.”

Monitoring and surveillance of radionuclide emissions from PNNL operations is performed to confirm that operations are conducted in a manner that does not pose an undue risk to human and environmental health. Environmental radiation monitoring and surveillance for the PNNL Operations is the responsibility of the PNNL Environmental Protection and Regulatory Programs (EPRP) division and is conducted by the PNNL Effluent Monitoring group, and specifically by the Environmental Radiation Task (ERT) team, of the Effluent, Waste, and Transportation Programs under EPRP in accordance with reviewed and approved procedures. Documents relating to this EMP as well as Roles and Responsibilities of staff associated with actions under this EMP can be found at https://pnnl.sharepoint.com/sites/EPRP/SitePages/Effluent-Management-Documents.aspx. Section 8.0 discusses the applicable quality assurance program and procedures in detail.

Programmatic elements of the PNNL ERT can be seen in Figure 4. ERT includes both Radioactive Air Emissions and Environmental Surveillance activities, the results of which feed into the Dose Assessment (public and biota dose assessment) activity.

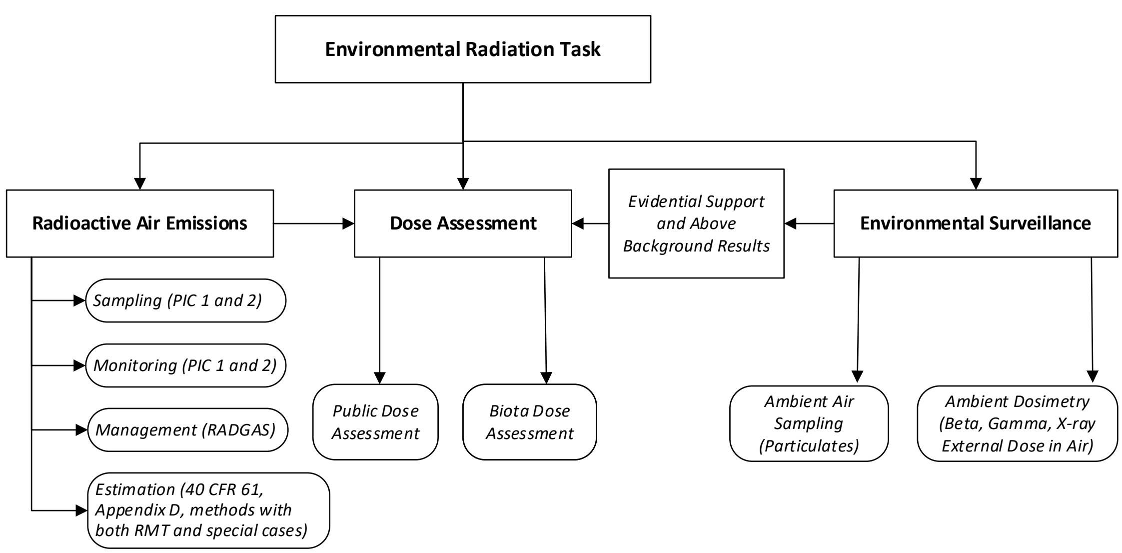


Figure 4. PNNL’s Environmental Radiation Task

Overviews of the individual components are provided in Sections 2.6, 2.8 and 2.9, with details in Section 3.0 (Radioactive Air Emissions), Section 4.0 (Ambient Air Sampling), Section 5.0 (Ambient Dosimetry), Section 6.0 (Public Dose Assessment) and Section 7.0 (Biota Dose Assessment).

As indicated in the Section 1.0, there are also three separately published attachments to this EMP which provide additional programmatic details: the SAP, the DMP, and the DAG.

## 2.1 Objectives and Requirements

The general requirements and objectives for sustainability and environmental surveillance for all DOE sites are contained in DOE Order 436.1A (2011), "*Departmental Sustainability*" and DOE Order 458.1 (2020), "*Radiation Protection of the Public and the Environment*." The broad surveillance objectives are to 1) demonstrate PNNL Operations compliance with legal and regulatory environmental requirements, 2) support adherence to DOE environmental protection policies and Orders, and 3) support environmental management decisions. These broad surveillance objectives are embodied in the primary surveillance objectives stated in Washington State Regulations (WAC 246-247), federal regulations (40 CFR Part 61, Subpart H), and DOE Orders and guidance documents (e.g., DOE Order 458.1 and DOE 2022b):

> "Support the determination of DOE's compliance status with applicable environmental quality standards, public exposure limits, and applicable laws and regulations."

Additional objectives that derive from this primary objective include:

- Assessing pre-operational environmental conditions.
- Assessing radiological doses to the public and to biota from site operations.
- Assessing radiological doses from other local sources, when appropriate.
- Reporting any non-routine releases.
- Maintaining an environmental monitoring plan (e.g., this plan) as part of an Environmental Management System.
- Determining the effectiveness of treatments and controls for site emissions.
- Determining the validity and effectiveness of computer models used to predict the concentrations of pollutants in the environment.
- Detecting and quantifying unplanned contaminant releases.
- Identifying and quantifying new or existing environmental quality problems.

Subsidiary objectives include:

- Providing public assurance that radiological operations are conducted in a manner protective of the public and environment.
- Providing environmental data to assist DOE or DOE contractors.

The DOE Orders, as noted above, require that the content of an environmental surveillance program be determined on a site-specific basis and must reflect specific facility or site characteristics; applicable regulations; hazards potentials; quantities and concentrations of materials released or potentially released to the environment; the extent and uses of affected air, land, and water; and specific local public, contractor, stakeholder, and regulatory agency interests and concerns.

The objectives of environmental radiation monitoring and surveillance include:

- Obtain ambient air concentration measurements at judicious locations to verify that possible exposures to the public from DOE operations remain low relative to standards.
- Use dosimeters to establish annual baseline radiation levels for external dose in air at PNNL Operations locations and if a future PNNL facility could emit short-lived radionuclides that are potentially a public dose limit concern, obtain measurements at critical locations.
- Provide early detection of potential increases in exposures to radioactive materials through gross alpha and gross beta measurements.
- Obtain ambient air samples or external dose measurements at the site perimeter or nearby to provide assurance to the public that the potential impacts from DOE operations are known or can be conservatively estimated.
- Obtain measurements and establish analytical laboratory service provider contracts to support regulatory reporting requirements.
- Sample offsite air per regulatory or license requirements.
- Provide data for computer models used to predict and assess public dose compliance and environmental contamination.
- Provide data used to support biota dose assessments.
- Obtain background measurements as part of program completeness and implementation.

## 2.2 Criteria

The ERT team reviews and evaluates the radioactive air emissions and environmental surveillance designs annually based on the above considerations, an awareness of planned PNNL operations activities, and consideration of the previous year’s environmental radiation surveillance activities. This review occurs within the Environmental Management System operations and in conjunction with information compiled and evaluated in the course of meeting reporting requirements. The evaluation also includes an effort to identify and review new radiological air surveillance compliance requirements (e.g., DOE Orders, directives, or other applicable federal or state requirements), DOE handbook (2022b) updates, and any Data Quality Objective (DQO) updates. Any actions taken in response to the evaluation are documented in the project files, in updates to the project documentation package, and in the sampling and analysis schedule. Plans for the upcoming calendar year are developed.

Periodic re-evaluations may be needed during the year to respond to changing operations or environmental conditions. Steps in the process may include:

- *Perform a pathway analysis* – The design process starts with a radiological pathway analysis performed for the calendar year just ended. This analysis is performed for radiological air emissions compliance and is based on facility emissions information. The pathway analysis serves as the basis for the design review. A comparison of the previous year’s results with pathway analysis conclusions helps to identify changes in environmental conditions that may lead to modifications to the sampling design and reporting requirements.

- *Prepare a PNNL Operations environmental report* – The "PNNL Annual Site Environmental Report" summarizes the findings of environmental air surveillance, effluent monitoring, and cleanup activities conducted at a DOE site during the previous calendar year (e.g., Thompson et al. 2024).
- *Evaluate future/proposed site activities* – An activities projection from PNNL Operations identifies future activities to be considered in the ERT design. Resources useful in anticipating future environmental radiological air surveillance needs include various effluent and operational environmental monitoring plans, results from previous years' monitoring and surveillance results, and periodic technical exchanges between the ERT team, PNSO, and PNNL Operations facilities staff.
- *Assess the ERT* – An Annual Design Review meeting (DOE 2022b) is conducted early in each fiscal year to review past task activities and discuss future plans. Results of any programmatic reviews also are discussed.
- *Inspect sampling and measurement locations* – These inspections can indicate whether conditions at the sampling locations continue to meet site selection or sampling design criteria (see Snyder et al. 2024a and Snyder et al. 2019b).
- *Update the sampling and analysis schedule* – The schedule, as presented in the SAP, would be updated as necessary.

Changes in the ERT design also have an impact on the current scope and budget developed for the annual ERT and need to be considered for future planning efforts between DOE and PNNL.

The criteria for environmental surveillance consist of those identified in DOE handbook, *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (2022b), and the emission unit permit requirements in the PNNL RAELs (RAEL-005 and RAEL-014). The surveillance results can be used to corroborate the modeled radiological impact of the PNNL Richland and Sequim campuses. Estimated impacts typically overestimate any actual impact received by exposed individuals as a result of conservative assumptions used in computer modeling. Therefore, reported radiological dose assessment predictions are typically greater than actual environmental radiological air surveillance analytical results. As a secondary function, surveillance results for monitored nuclides also may indicate the adequacy of emission control equipment and the occurrence of unanticipated radiological releases.

## 2.3 Environmental ALARA

The as low as reasonably achievable (ALARA) process is used for PNNL Operations to manage and control releases of radioactive material. Activities that release radioactive material outside of facilities must meet regulatory standards. The driving requirements behind the environmental ALARA program are DOE Order 458.1 and WAC 246-247. DOE Order 458.1 requires the ALARA process for all activities that result in public dose. WAC 246-247 also mandates the ALARA process as a standard for controlling radioactive air emissions. DOE guidance is available in DOE 2022b.

The ALARA process does not define distinct limits, numerical values, or discrete thresholds for doses, but rather defines a philosophy, process, or goal of attaining doses as far below the applicable limit as is reasonably achievable. The environmental ALARA process is a logical procedure for managing projects, operations, and activities that result in radioactive releases to the environment; evaluating ways to reduce radiation exposures; and minimizing releases to the extent practical. The final product of an ALARA process is a preferred system (from among several candidate radiological protection alternatives) that provides maximum benefit at the lowest cost. The ALARA process is essentially one of optimization and cost-benefit analysis.

Nevertheless, the National Council on Radiation Protection and Measurements defined the negligible individual dose as having a value of 1 mrem/yr (NCRP 1993), and this dose value has been recommended as the stopping point for which additional ALARA considerations would not be required at lower doses (Abelquist 2019). While this value may be considered ALARA, WAC 246-247 and 40 CFR 61, Subpart H, limit a minor emission at an even more conservative level (below 0.1 mrem/yr potential to emit).

Implementation of the PNNL ALARA process occurs through the ALARA Program Description as part of the PNNL Radiological Control Management System Description. ALARA program evaluations for radiation protection purposes primarily consider occupational human health and the requirements of 10 CFR 835. The environmental ALARA process also considers societal, technological, economic, and public policy factors and the requirements of DOE Order 458.1. Some examples of environmental factors to consider are impacts to sensitive species and habitats, effects on cultural and historic resources, real or perceived restrictions to land use, sociopolitical aspects, and public perception. The ALARA committee consists of several representatives from PNNL directorates or organizations, and typically includes an EPRP representative.

## 2.4 Meteorological Characterization

Once radioactive material is emitted to the environment from the PNNL operations, the material is subject to dispersion. Atmospheric dispersion may be modeled using meteorological data. Site-specific meteorological data are available for both the PNNL-Richland and Sequim campuses.

The Meteorological and Climatological Services Project (MCSP) for the Hanford Site is described in DOE/RL-91-50 (DOE 2018), Section 6. The MCSP, through the operation of the Hanford Meteorology Station, provides operational meteorological support to DOE and Hanford Site contractors for site operations; sitewide emergency preparedness; and construction, remediation, environmental restoration, and safety-related activities. The MCSP provides information to organizations on the Hanford Site doing work that could be severely affected by adverse meteorological conditions (e.g., thunderstorms, strong winds, dense fog, snowstorms). The day-to-day meteorological data generated by the MCSP are essential for work activities to be conducted efficiently and under the safest conditions possible. The MCSP can provide real-time meteorological data in the event of a suspected or actual unplanned release of radioactive or hazardous material to the atmosphere, so personnel responding to the event can make appropriate and timely decisions and actions. The data are also integral to annual estimates of potential public radiation exposures the Hanford Site. Comprehensive climatological data records are maintained for use in a variety of other applications, such as post-accident analysis, dose reconstruction, building design, and environmental impact assessments. The MCSP maintains an electronic database with a large history of meteorological data. The last climatological summary with historical data was published in 2005 (Hoitink et al. 2005); meteorology also is summarized in the annual environmental reports from Hanford and PNNL (e.g., DOE 2024, Thompson et al. 2023). DOE/RL-91-50, Rev. 8 (DOE 2018), Section 6 describes the rationale and design of the MCSP, including the number and location of weather stations, the instruments used, forecasting capabilities, data management efforts, atmospheric dispersion modeling activities, and emergency response capabilities.

Data provided by the MCSP also are used by the PNNL ERT team to meet some of the program requirements for PNNL Richland operations. In particular, data from a monitoring tower in the Hanford Site 300 Area (station 11) are used for annual dose assessment modeling to meet EPA regulatory requirements. Data required for use in the CAP88-PC code (Rosnick 2017) dose assessment include the annual average joint frequency distribution of wind speed, wind direction, and atmospheric stability class. Data also has been used in the PNNL-Richland campus DQO development.

Meteorological and climatological data specific to PNNL-Sequim campus is limited. No formal onsite meteorological monitoring program exists. Snyder et al. (2024c) indicates the availability of meteorological data very representative of the Sequim campus upland areas (e.g., MSL-5), which is managed by Washington State University for agricultural meteorological monitoring. This station (Smith Station), located north of the mudflats at the site's northern boundary, while not under a PNNL maintenance contract has provided a sufficient quality of data for PNNL purposes starting in 2008.

## 2.5 Exposure Pathways

Dose assessments are conducted annually for relevant exposure pathways to assess site compliance with the dose criteria in DOE Order 458.1 and 40 CFR 61, Subpart H; WAC 246-247 for public dose assessments; and the DOE-HDBK-1153-2019 for biota dose assessments. Currently, only radiological emissions to ambient air routinely occur from PNNL operations. If other release pathways became relevant to site emissions (e.g., water or land disposal of wastes), additional design modifications, sampling, dose assessments, and methodologies would be identified and implemented for these exposure pathways but are limited to the PNNL Richland campus and the PNNL-Sequim campus operations (Hanford Site operations are covered separately under the Hanford Site contract).

An exposure pathway is identified based on 1) examination of the types, locations, and sources of contaminants (e.g., contaminated air, soil, liquid effluent); 2) principal contaminant release mechanisms; 3) the probable environmental fate and transport (including persistence, partitioning, and intermediate transfer) of contaminants of interest; and 4) the locations and activities of the potentially exposed individuals and populations. Environmental processes or mechanisms that could influence the fate and movement of chemical or physical agents through the environment, and the amount of exposure a person might receive at various receptor locations, are listed below.

Once a radionuclide is released into the environment, it may be:

- Transported (e.g., migrate downstream in solution or on suspended sediment, travel through the atmosphere as a gas or associated with airborne particles, or be carried offsite in contaminated wildlife).
- Physically or chemically transformed (e.g., volatilized, photolyzed, oxidized, reduced, hydrolyzed, or changed through radioactive decay).
- Biologically transformed (e.g., biodegraded, metabolized).
- Accumulated in the receiving media (e.g., sorbed in water, soil, or sediment or stored in organism [biota] tissues).

The environmental pathways by which contaminants are transported through environmental media to people are strongly influenced by environmental settings. The PNNL-Richland campus's environmental setting is equivalent to that summarized in the *Hanford Site National Environmental Policy Act (NEPA) Characterization* report (Duncan et al. 2007) and is not described here. The PNNL-Sequim campus pathways are discussed in detail in Snyder et al. (2019b).

Environmental pathways for biota dose assessments consider both internal doses and external dose exposures to sediments, water, and soil. Biota categories include aquatic animals, riparian animals, terrestrial animals, aquatic plants, and terrestrial plants (including riparian zone plants).

The results of the pathway analysis and exposure assessment serve as the bases for future years' environmental surveillance designs.

## 2.6 Radioactive Air Emissions Overview

Regulations of 40 CFR 61, Subpart H, require an assessment of all emission units that have the potential for radionuclide air emissions. Potential emissions are assessed annually by PNNL ERT staff members based on data obtained from sampling, monitoring, tracking, and estimation. Sampling, monitoring, and other regulatory compliance requirements are designated based on the potential to emit (PTE) dose criteria based on the identified emission unit Potential Impact Category (PIC). The *PNNL Facility Radionuclide Emission Units and Sampling Systems* document (Klein et al. 2024) describes each facility radionuclide air emission sampling program and provides current and historical facility emission unit system performance, operation, and design information. For sampled emission units, the building, exhaust unit, control technologies, and sample extraction details are provided. Additionally, applicable configuration drawings, figures, and photographs are included. For non-sampled emission units, details regarding the radionuclide source and emission estimation are provided. Sitewide permits for the lowest PNNL potential impact category, PIC-5, are described. Details about deregistered/transitioned emission units also are provided as necessary for at least 5 years post-closure/transition.

## 2.7 Annual Design Review

The Annual Design Review meeting is held in the fourth quarter of the calendar year, with an annual focus on radiological operations and a quinquennial focus that includes hazardous material operations. This Design Review considers whether the PNNL-Richland and Sequim campus' radiological and hazardous chemical emissions to the ambient environment are appropriately managed and maintained. Due to current PNNL hazardous (non-radioactive) inventories and activities, hazardous chemicals are reviewed during the Design Review every five years or more frequently if the potential for such emissions significantly increases. The Annual Design Review of the ERT is conducted to implement the guidance of Section 2 of DOE-HDBK-1216-2015. The Design Review includes ERT planning, procedures and documentation, emissions monitoring systems, and environmental surveillance systems.

The PNNL Annual Design Review provides confidence that sampling of effluents and ambient media align with current site operations and missions and are focused on contaminants with the greatest potential for contributing to offsite impacts. The review considers a graded approach to emissions monitoring and environmental surveillance, commensurate with the risk to the public and the environment from site operations. The review reflects on the previous year's performance as well as planning and goals for future years (1 to 5 years out). Based on Richland and Sequim campus current levels of hazardous material handling and potential offsite emissions of operational hazardous chemicals was last done in 2021).

This meeting considers whether PNNL Operations have current information for the following topics or if updates are required:

- *Perform a pathway analysis* – The design process starts with a radiological pathway analysis performed for the calendar year just ended. Currently, this analysis is performed for air emissions compliance and is based on facility emissions information. The pathway analysis serves as the basis for the design review with additional consideration for any new radionuclides planned for emissions in the next calendar year. The Annual NESHAP Assessment (DI-AIR-001) is reviewed for new radionuclide emissions for the coming year and then is considered in a pathway analysis for significantly impacted pathways and biota groups and changes to surveillance. A comparison of the previous year's results with pathway analysis conclusions helps identify changes in environmental conditions that may lead to modifications to the sampling design and reporting requirements.
- *Prepare a PNNL Site Environmental Report* – A site annual environmental report summarizes the findings of environmental surveillance, effluent monitoring, public dose assessments and biota dose assessments, and any cleanup activities conducted at a DOE site during the previous calendar year (e.g. CY2023 report was PNNL-36464).
- *Evaluate future/proposed site activities* – An activities' projection from PNNL identifies future activities to be considered in the surveillance design. Resources useful in anticipating future environmental surveillance needs include various effluent and operational environmental monitoring plans and sampling schedules, results from previous years' monitoring, and periodic technical exchanges between the Effluent Management, PNSO, and PNNL facilities staff. This evaluation should consider any potential new calendar year radionuclide emissions, for sampling and analysis design considerations.
- *Evaluate surveillance design* – Site selection and sampling system designs are assessed with field inspections of sampling and measurement locations. Atmospheric dispersion modeling can indicate whether conditions at the ambient sampling locations continue to meet sampling objectives based on such things as site boundary, potential receptors, and license conditions (see Snyder et al. 2024b; Snyder et al. 2024c). The evaluation also includes an effort to identify and review current DQOs for new surveillance compliance requirements. New or revised DOE Orders, directives, or other applicable federal or state requirements can necessitate updates.
- *Scope and budget* – Generally consider the scope (expansion or contraction) and budget for future ERT planning. To the extent possible through appropriate mechanisms, PNNL management will be made aware of significant required expense increases and notified of reasons for any budget contraction.

  If major ERT components are sub-contracted out, specific surveillance objectives, work scope, and budget could be provided in a project-specific documentation package written for the upcoming (next) fiscal year. The package would identify the plans and organization that would be used to conduct, control, and document project activities. It also represents an agreement between PNNL and the subcontractor on the objectives, scope, and work to be performed during that fiscal year.

As a result of the Annual Design Review, any actions taken are documented in the project files, in updates to the project documentation, and sampling and analysis schedule. Plans for the upcoming calendar year are developed.

## 2.8 Environmental Surveillance

WDOH indicated in the PNNL-Richland campus RAEL-005 license that an environmental monitoring program for the PNNL Site would be required; PNNL uses a DQO process to develop the program and determine environmental surveillance activities and the best locations to install sampling and monitoring equipment. It has been determined in the DQO and subsequent revisions (see Section 4.1) that routine emissions from facilities may be characterized as chronic emissions (or occurring at substantially the same rate over time). The DQO concluded that PNNL will establish an environmental surveillance program that samples particulate radionuclides in air at the Richland Campus.

A similar DQO process was applied for PNNL-Sequim campus (see Section 4.1); the decision was made that the emissions are so low that environmental surveillance currently is not required. The 2019 DQO revision maintained the decision that environmental surveillance is not required. However, establishing baseline background radiation levels at the PNNL-Sequim campus was recommended. Ambient dosimetry was installed at an upland and a lowland location in June 2024. Installation of an ambient particulate air sampling system(s) at the PNNL-Sequim Campus remains pending.

Activities inherent in the operation of the environmental surveillance for the Richland and Sequim campuses include surveillance design and implementation, procedure development, sample collection, sample analysis, database management, data review and evaluation, and reporting. The PNNL process of planning, collecting, and tracking air samples is handled via project database(s). In 2023, the Environmental Surveillance program transitioned to the Locus Environmental Information Management (EIM)[1] software system, which is a comprehensive subscription-based cloud platform for organizing, managing, and reporting environmental data. Other elements of the project include project management, quality assurance (QA) and quality control (QC), staff supervision, training, records management, and equipment maintenance (Barnett 2011).

### 2.8.1 Ambient Air Sampling Overview

The ambient radiological air surveillance of PNNL Operations is the responsibility of the PNNL ERT team. At the PNNL-Richland campus, 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. Samples are analyzed for gross alpha and gross beta and are composited semiannually (twice a year) for particulates based on license requirements. Ambient air sampling results provide an independent assessment of the effectiveness of effluent controls; monitors for fugitive contaminants; and establishes contaminant concentration norms.

No ambient air particulate sampling has been conducted at the PNNL-Sequim campus. The most recent PNNL-Sequim campus DQO revision (see Snyder et al. 2019b) recommended surveillance for baseline background levels of particulates (gross alpha and gross beta). Such sampling will be actively established once DOE land transfer decisions have been finalized. While the DQO recommended a particulate sampling location, this location may be changed pending final campus boundary determinations.

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

Annual design reviews are performed to assure that environmental surveillance activities are aligned with current site operations and missions in Richland and Sequim and are focused on radiological air contaminants with the greatest potential for contributing to offsite doses.

Ambient Air Sampling is described in detail in Section 4.0.

### 2.8.2 Ambient Dosimetry Overview

Ambient external dose surveillance was started on the PNNL-Richland campus in 2016, with 2017 being the first full operational year. Dosimeters measure ambient external dose of any airborne beta, gamma, and X-ray source. Richland dosimeters are currently placed at the same locations where ambient air particulate sampling is performed. Dose from soil deposition and any nearby radioactive sources could also be detected. Currently, there are no onsite external above-background-dose sources with sizeable dose rates at offsite public locations for which there is a public exposure risk concern (e.g., sources with short half-life air emissions such as Ce-144 or bulk material sources such as a gamma cell). External dose monitoring of ambient air acquires baseline information specific to the PNNL-Richland campus and its background station and establishes an ambient dosimetry program and processes if future operations include external dose sources. The proximity of the Hanford Site and nearby private radiological facilities may have an impact on the PNNL external dose surveillance; therefore, collecting this information now will help establish current regional variability and aid in future determinations of ambient external dose sources, whether from the PNNL-Richland campus or others.

Ambient external dose surveillance was started on the PNNL-Sequim campus in 2024, with 2025 being its first full operational year. The PNNL-Sequim campus DQO was revised (see Snyder et al. 2019b) with the 2018 license renewal and revision of the site's RAEL-014, and the recommendation to perform surveillance for baseline background levels of ambient external dose was proposed.

Separate from this public ambient external dose surveillance, PNNL monitors and controls onsite external dose for workers as part of PNNL Integrated Safety Management. No additional worker or PNNL building external dose monitoring activities are discussed herein.

The PNNL Dosimetry for environmental surveillance is described in detail in Section 5.0.

## 2.9 Dose Assessment Overview

Exposure to radioactive materials at high enough levels may result in health impacts to humans and biota (animal and plant life). Radioactive material emissions from PNNL Operations are managed so that offsite exposures to routine emissions are both well below levels determined to have long-term (e.g., cancer) impacts to members of the public and well below levels determined to have impacts to biota populations. When ambient concentrations of radioactive materials are well below such levels, no acute impacts (e.g., erythema, sudden biota death) would occur.

Ambient radioactive material exposures are primarily regulated by dose rather than air, water, or soil concentrations. Public dose assessments must meet annual dose criteria. Biota dose assessments must meet daily dose criteria, calculated as average daily dose in a calendar year. PNNL publishes public dose assessment and biota dose assessment results in annual site environmental reports (e.g., Thompson et al. 2024). PNNL also provides public dose assessment results in 40 CFR 61, Subpart H, compliance reporting (e.g., Snyder et al. 2024c, Snyder et al. 2024b).

The process from emissions to dose is shown in Figure 5. The dispersion, environmental media incorporation, human exposure, and dose estimate steps are accomplished with software due to the computational complexity, which considers site meteorology, uptake factors, intake rates, and nuclide chemical and radiological characteristics. Dispersion and dosimetry software is discussed in 6.0.

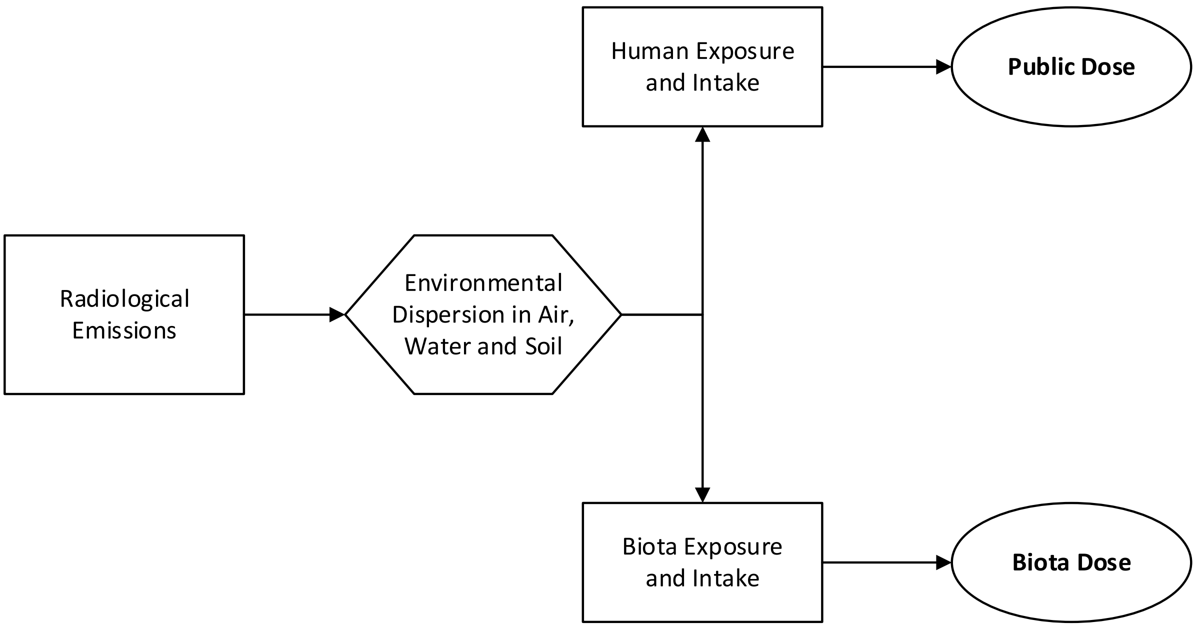


Figure 5. Process from Emission to Dose

Public dose assessment is discussed in Section 6.0; biota dose assessment is discussed in Section 7.0.

# 3.0 Radioactive Air Emissions

Radioactive air emissions are authorized under permit(s) with the WDOH. These emissions may be sampled, monitored, tracked, and/or estimated. Emissions results are reported annually and used for other compliance activities. Table 1 lists all registered radionuclide air emission units and permits with WDOH under RAEL-005 for the PNNL-Richland campus, and RAEL-014 for the PNNL-Sequim campus, and RAEL-FF-01 for the PNNL-managed facilities on the Hanford Site. The more traditional emission unit categories of major, minor, and fugitive are provided in Table 1. Section 3.1 provides emission unit classifications under the PIC classification system (also see Table 1 of the SAP, rev.1). Figure 6 (Richland facilities) indicates the licensed emission units at PNNL-managed facilities under PNNL purview for radioactive air emissions management in Richland. Figure 3 (PNNL-Sequim campus) indicates the boundaries encompassed by the RAEL-014 permit. Of all the PNNL-managed emission units, EP-325-01-S on the Hanford Site has historically emitted the most activity and had the greatest dose impact to a member of the public.

Emission units categorized as major emission units require continuous air effluent sampling for compliance purposes (and in some cases continuous monitoring), while those categorized as minor emission units require periodic sampling or calculated emissions for compliance purposes. Fugitive emissions are not reasonably monitored and use inventory management controls. The terms of “major” and “minor” emission units was introduced in *Recommendations for a Uniform Protocol for Periodic Confirmatory Measurements of ‘Minor’ Air Emissions Sources Subject to 40 CFR Part 61, Subpart H* (EPA 2007). A major emission unit has the potential to contribute greater than or equal to 1% of the 10 mrem/yr dose (i.e., 0.1 mrem/yr dose) to the offsite maximally exposed individual (MEI), while a minor emission unit has the potential to contribute less than 0.1 mrem/yr dose to the MEI offsite.

Each WDOH permit also indicates additional criteria for determining release rates of radioactive materials under the definition of PTE. In addition to information listed below, the criteria address control equipment, availability of measurements, and an alternate method approved for use.

PNNL-Richland campus buildings with emission units are 3410, 3420, 3425, 3430; (see Figure 6).

At the PNNL-Sequim campus, two buildings, MSL-1 and MSL-5 (see Figure 3), currently are administratively managed to contain radioactive material inventories that potentially result in fugitive radionuclide emissions. The current RAEL-014, however, is structured such that fugitive radionuclide emissions can take place at any PNNL-Sequim campus location.

PNNL manages operations at some facilities on the Hanford Site. Hanford Site ambient sampling and public dose assessments and biota dose assessments are managed by the DOE-Richland Operations Office and are not part of PNNL-managed operations. However, radioactive air emissions from the PNNL-managed facilities are overseen by PNNL staff. As a result, this section includes the discussion of radioactive air emissions for emission units on the Hanford Site for which PNNL staff have direct management authority. These are licensed under RAEL-FF-01 and include 300 Area emission units in the 325 Building (EP-325-01-S), 331 Building (EP-331-01-V and EP-331-09-S), 318 Building (fugitive emissions), and the 361 Building (fugitive emissions) (Figure 6).

Table 1. PNNL-managed Facilities with Radiological Air Emission Units

| Associated Air License | Build. ID | Building Name or Location | PNNL ID | License Emission Unit ID | Emission Unit Category[(a)] | CY Operational[(b)] |
|---|---|---|---|---|---|---|
| RAEL-005 | 3410 | Materials Sciences and Technology Laboratory | EP-3410-01-S | 1203 | Major | 2010 |
| RAEL-005 | 3420 | Radiation Detection Laboratory | EP-3420-01-S<br>EP-3420-02-S | 1204<br>1273 | Major<br>Minor | 2010<br>2010 |
| RAEL-005 | 3425 | Underground Lab | J-3425 | 1272 | Fugitive | 2010 |
| RAEL-005 | 3430 | Ultra-Trace Laboratory | EP-3430-01-S<br>EP-3430-02-S | 1205<br>1274 | Major<br>Minor | 2010<br>2010 |
| RAEL-005 | N/A | VRRM[(c)], Campus-wide | J-VRRM | 1369 | Fugitive | 2013 |
| RAEL-005 | N/A | NDRM[(d)], Campus-wide | J-NDRM | 1392 | Fugitive | 2013 |
| RAEL-005 | N/A | Facilities Restoration, Campus-wide | J-FR | 1409 | Fugitive | 2014 |
| RAEL-005 | N/A | SIOC[(e)], Campus-wide | J-LLS | 1416 | Fugitive | 2015 |
| RAEL-014 | MSL | Sequim Site, Sitewide | J-MSL | 1485 | Fugitive | 2018 |
| RAEL-FF-01[(f)] | 318 | Radiological Calibration Laboratory | J-318 | 1333 | Fugitive | (1966) |
| RAEL-FF-01[(f)] | 325 | Radiochemical Processing Laboratory | EP-325-01-S | 361 | Major | (1953) |
| RAEL-FF-01[(f)] | 331 | Life Sciences Laboratory I | EP-331-01-V<br>EP-331-09-S | 412<br>1370 | Major<br>Minor | (1970) |
| RAEL-FF-01[(f)] | 361 | Modular Equipment Shelter | J-361 | 1185 | Fugitive | 2007 |

(a) Major emission units include those with potential emissions that could result in an offsite dose greater than 0.1 mrem/yr to a maximally exposed member of the public. Minor emission units include those with potential emissions that would not result in an offsite dose that exceeds 0.1 mrem/yr. PTE dose establishing emission unit category are from RAEL-005, December 2020; RAEL-014, September 2022; and RAEL FF-01, September 2022.
(b) Year in parentheses is the year the building was constructed.
(c) Volumetrically Released Radioactive Material
(d) Non-Dispersible Radioactive Material
(e) Sources for Instrument/Operational Checks
(f) Only PNNL managed emission units are listed; Hanford Site site-wide emission units are not included.


Figure 6. PNNL-Managed Facilities' Emission Units on the Richland Campus and Hanford Site

## 3.1 Potential Impact Categories

The following is an excerpt from Barnett (2018); table numbers have been modified to align with this EMP. Refer to Barnett (2018) for additional details and latest information.

PNNL has adopted the suggested PIC definitions provided in ANSI/HPS N13.1-2011, as applied to the federal and state standards of 10 mrem/year.[2,3]

Following the graded approach advocated in ANSI/HPS N13.1-2011, PNNL has defined an additional PIC category (PIC-5), as applied to a group of materials used sitewide, with PTE criteria orders of magnitude below that of PIC-4 to allow for appropriate and efficient permitting and management of radioactive materials with inconsequential contributions to potential offsite dose (Table 2). The PIC-5 category is employed to classify a sitewide use of materials that have either been released from radiological control according to the PNNL How Do I? (HDI) Work Control “Radiological – General” or have been determined to be Administratively Controlled Radioactive Materials or Non-dispersible Radioactive Materials according to RCP-3.1.01, Radiological Work Planning.[4] When applicable, PNNL will permit PIC-5 items as a group for air emission purposes to allow for flexibility in the research and development environment by allowing sitewide use of these low-risk items.[5] Sitewide PIC-5 utilization does not preclude the use of the materials in PIC-4 or higher permitted locations. Similarly, an emission unit associated with a building or other well-defined location (e.g., land area, or pond) with a PTE of less than the PIC-5 threshold of 1E-6 mrem/yr is still assigned as a PIC-4.

Although PTEs for each emission unit are calculated annually using actual inventory, the PTE used for assigning PICs is the permitted PTE, which is based on maximum estimated inventory and throughput for permitted activities. For example, the 331 Building EP-331-01-V emission unit is permitted for a PTE >0.1 mrem/year and is considered a major emission unit. Therefore, this emission unit is considered PIC-2 instead of PIC-3 until it is downgraded to minor status. The PNNL-defined PIC categories are identified in Table 2.

PNNL has adopted the graded approach outlined in the standard and applied it to the PNNL PICs because the rigor of some of the requirements in the standard depend on the PIC category. Table 3 identifies the differences in sampling system requirements for the different PIC categories, as described in ANSI/HPS N13.1-2011.

New emission units and permitting actions will follow the guidance in Table 2. For existing emission units, a change to the PIC monitoring and sampling analysis requirements requires a permit modification and regulatory approval. For example, an emission unit going from a PIC-3 to a PIC-4 category will be considered for an “annual administrative review” in lieu of sampling during future permitting actions after regulatory approval (ANSI/HPS N13.1-2011).

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[2] Emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr. (40 CFR 61 Subpart H, 61.92)

[3] Emissions of radionuclides in the air shall not cause a maximum effective dose equivalent of more than 10 mrem/yr to the whole body to any member of the public. (WAC 173-480-040)

[4] Note that PIC-5 only applies to materials that were brought under radiological control and subsequently released; materials where radiological control was never required are not included in PTE calculations.

[5] The PNNL Start Clean Stay Clean Program may be considered in determining use locations for PIC-5 materials.

Table 2. PNNL Potential Impact Categories (Barnett 2018, Table 1.2)

| PIC | Operating Range – PTE (mrem/yr) | Monitoring and Sample Analysis |
|---|---|---|
| 1 | >5 | Continuous sampling for a record of emissions and in-line, real-time monitoring with alarm capability; consideration of separate accident monitoring system. |
| 2 | >0.1 and ≤5 | Continuous sampling for record of emissions, with retrospective, offline. periodic analysis. |
| 3 | >0.001 and ≤0.1 | Periodic confirmatory sampling and offline analysis. |
| 4 | ≤0.001 and non-PIC-5 | Annual administrative review of emission unit uses to confirm absence of radioactive materials in forms and quantities not conforming to prescribed specifications and limits. |
| 5 | ≤1E-6 | Applied to a group of materials used sitewide. As defined, this category is a subgroup under PIC-4 allowing for a graded approach for managing radioactive materials with little to no emission potential. Administrative control through the following steps:<br>1) The item is classified by Radiation Protection to be released from radiological control (e.g., volumetrically released liquids[(a)]) or is determined by Radiation Protection to be Administratively Controlled Material or Non-dispersible Radioactive Material.<br>2) Radiation Protection administers the classification programs with input from the Effluent Management and Waste Operations Groups<br>3) Radiation Protection maintains a record of these items and a periodic evaluation is performed on the processes. |

(a) The PTE calculated for 1 L of solution using volumetric release limits and worst-case isotopes from each radionuclide group was less than 5E-9 mrem/yr. Therefore, hundreds of these items would not exceed a PTE of 1E-6 mrem/yr.

Table 3. Sampling System Requirements Based on Potential Impact Category (Barnett 2018, Table 1.4)

| PIC | Sampling Site | Sample Nozzle | Stack Flow | Sample Flow | CAMS |
|---|---|---|---|---|---|
| 1 | Must meet acceptance criteria for uniform velocity, tracer gas, and aerosol mixing and lack of cyclonic flow. | Aerosol transmission ratio within range of 0.8–1.3 for 10 µm (or greater) particles. This depends on stack and sample velocity, so this ratio required over a range of values if these vary. Aspiration ration of 0.8–1.5. Aspiration ratio is related to transmission ratio. | Must continuously measure. | Shall be varied in proportion to stack flow to permit an accurate assessment of the quantities of any releases. A controller (continuous control) shall be used to maintain the ratio of the sample flow rate and effluent flow rate within ± 20% of a predetermined value. | Required, but may be operated at a fixed flow rate. However, the ratio of sample flow to stack flow should not vary by more than ±25%. |
| 2 | Must meet acceptance criteria for uniform velocity, tracer gas, and aerosol mixing and lack of cyclonic flow. | For new or major modified emission units (after September 2002), aerosol transmission ratio within range of 0.8–1.3 for 10 µm (or greater) particles. This depends on stack and sample velocity, so this ratio is required over a range of values if these vary. Aspiration ratio of 0.8–5. Aspiration ratio is related to transmission ratio. | Must continuously measure if flow rate varies by >20% over a year. | May be varied or may be held constant. Continuous control if the sample flow rate can vary by more than ±20% over the sample period. | Not required. |
| 3 | Must meet acceptance criteria for uniform velocity, tracer gas, and aerosol mixing and lack of cyclonic flow. | | Only periodic measurements required. | May be varied or may be held constant. Continuous control if the flow rate can vary by more than ±20% over the sample period. | Not required. |
| 4 | No requirements to sample or monitor per ANSI/HPS N13.1-2011, Table 2: “Annual administrative review of facility uses to confirm absence of radioactive materials in forms and quantities not conforming to prescribed specifications and limits.” A registered emission unit associated with a building or other well-defined location (e.g., land area or pond) with a PTE of less than the PIC-5 threshold of 1E-6 mrem/yr is still assigned as a PIC-4. | | | | |
| 5 | Applied to a group of materials used sitewide. As defined by PNNL, this category is a subgroup under PIC-4 allowing for a graded approach for managing radioactive materials with little to no emission potential. Administrative control through the following steps:<br>1) The item is classified by Radiation Protection to be released from radiological control or is determined by Radiation Protection to be Administratively Controlled Material or Non-dispersible Radioactive Material.<br>2) Radiation Protection administers the classification programs with input from the Effluent Management and Waste Operations Groups<br>3) Radiation Protection maintains a record of these items and a periodic evaluation is performed on the processes. | | | | |

## 3.2 Sampling Air Emissions

The PNNL PIC-1 and PIC-2 emission units are continuously sampled using methods and equipment described in Klein et al. 2024 and are listed in the SAP.

Currently, five emission units are sampled continuously for particulate radionuclides at PNNL-managed facilities on the PNNL-Richland campus (3 of the 5, managed under the RAEL-005) and on the Hanford Site (2 of the 5, managed under the Hanford Site license RAEL-FF-01). Four of these units have sampling systems that comply with the American National Standards Institute/Health Physics Society (ANSI/HPS) N13.1-2011 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. In addition, one of the stacks under RAEL-FF-01 is sampled continuously for emissions of tritium gas.

## 3.3 Monitoring Air Emissions

Monitoring is required of a PIC-1 emission unit (Barnett 2018); that is, an emission unit where the PTE operating range is greater than 5 mrem/yr. In these instances, continuous sampling for a record of emissions and in-line, real-time monitoring (i.e., continuous air monitor) with alarm capability is required. The PNNL-managed emission unit EP-325-01-S on the Hanford Site, 300 Area, is categorized as PIC-1 and has continuous sampling and continuous monitoring both for particulates and tritium.

Currently, the PNNL-Richland campus has no emission unit categorized as PIC-1; there are no units that require continuous monitoring of emissions.

The PNNL-Sequim campus has a sitewide PIC-4, fugitive emission unit. There is no required emission unit monitoring there.

## 3.4 Management of Gas-state Emissions

To manage gas-state radioactive emissions, the Radioactive Air Gas Emissions webtool (RAGas) database is used. The RAGas webtool allows staff to enter proposed radioactive gas releases using the request form. At the completion of the work/release, the user is requested to indicate if the release did occur or was cancelled.

When the physical state of a radioactive material is a gas (e.g., noble gases, tritium gas), federal and state criteria indicate that a release fraction of 1.0 is used for emissions estimation when the gas containment is opened during use (Table 4). The RAGas database, maintained by ERT staff, tracks the radioactive gas releases in a calendar year at both the Richland (PNNL campus and Hanford Site) and Sequim locations. Gas-state radioactive materials are not sampled in the ambient environment.

## 3.5 Estimation of Emissions

Estimation of emissions is performed for routine operations using the Radioactive Material Tracking (RMT) database (see Appendix A of Barnett et al. 2018). The RMT system is a web-based, real-time tracking software system where radioactive material inventories are maintained. Both Richland and Sequim inventories are managed with RMT.

Occasionally, estimation of PNNL Operations emissions from non-routine radioactive material emissions is performed. The physical states of these sources are typically a liquid, particulate solid, or non-particulate solid. These emissions are released from a permitted emission unit, otherwise they would be reported as an unplanned release.

### 3.5.1 Estimations for Routine Operations

The RMT database manages emissions a priori based on radioactive source and its associated emission unit. The database is also used to generate an annual internal NESHAP report for all emission units for all buildings with radiological operations. For emissions not provided from methods described in Sections 3.2, 3.3, 3.4, and 3.5.2; the RMT NESHAP reports provide the basis for the *a posteriori* estimated emissions used in the annual 40 CFR Part 61, Subpart H, dose assessment (e.g., Snyder et.al 2024b). These emissions are calculated by multiplying the inventory by the assumed potential release fraction (Table 4). Potential release fractions, found in 40 CFR Part 61, Appendix D, and based on ANSI/HPS N13.1-2011 (ANSI/HPS 2011), are conservative estimates of potential release fractions based on the physical form of the radioactive material (Table 4). Sealed sources and other leak-proof containers are assigned a potential release fraction of 0 (zero).

Table 4. Physical Forms and Potential Annual Release Fractions for Radionuclides (Barnett et al. 2018, Table 2)

| Form | Description | Potential Release Fraction |
|---|---|---|
| Gas[a] | Radioactive material in a gaseous or vapor form. This includes solids or liquids heated to a high enough temperature to be in a volatized state or are intentionally dispersed into the environment. | 1 |
| Liquid[a] | Radioactive material is a liquid, solution, or slurry, and its primary container will be opened at some point during the calendar year. | $10^{-3}$ |
| Particulate solid[a] | Radioactive material will be present in powder form. | $10^{-3}$ |
| Non-particulate Solid[a] | Radioactive material is a monolithic solid or consists of relatively large chunks. | $10^{-6}$ |
| Non-dispersible Radioactive Material | Radioactive material in a leak-proof rigid container (including waste drums and boxes) that is not opened or is not planned to be opened through the calendar year. Also includes radioactive material determined to be non- dispersible in accordance with Radiation Control Program Procedure 3.1.01. | 0 |
| Sealed source: any type | Radioactive source manufactured, obtained, or retained for the purpose of using the emitted radiation. The sealed radioactive source consists of a known or estimated quantity of radioactive material contained within a sealed capsule, sealed between layer(s) of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. | 0 |

(a) The potential release fraction for this form is based on Table 1 of ANSI/HPS N13.1-2011 (ANSI/HPS 2011).

PIC-5 permits when utilized in a given calendar year, are included in NESHAP reporting. PIC-5 permitted emissions (other than the J-SIOC emissions) are estimated based on their permit authorization (i.e., J-VRRM, J-FR, and J-NDRM). Subpart H reporting for these PIC-5 permits covers the dose assignment with no specific emissions discussion. The sitewide Low-level Sources emission unit (J-SIOC PIC-5 permit) is currently the only PIC-5 emission unit that may assign dose based on either the permit limit or by calculation. To obtain dose by calculation, J-SIOC emissions are tracked in the RAGas database; then doses are estimated from the emissions using approved methods (e.g., CAP88-PC, COMPLY modeling).

### 3.5.2 Estimations for Special-Case Emissions

Every few years, a special-case estimate of an emission is performed to describe a radioactive material release from an emission unit covered by a RAEL but with a non-standard release scenario. Estimates are conservatively calculated and may represent an actual or, more likely, a potential emission. For example, under the former J-RTL emission unit of 2018, a contaminated pipe was unearthed, and emissions were estimated in a manner documented in project records and reported with all J-RTL emissions.

In the event of an unplanned release at any PNNL location, scenario-specific estimates of emissions would be performed with documentation maintained in project records.

## 3.6 Quality Control of Air Emissions Sampling and Monitoring

The goal of the QA program is to assure that accurate, reproducible, and defensible data are produced. In addition to the PNNL QA program described in Section 8.0, specific quality assurance and control processes are in place to assure the accuracy, precision, traceability, and limitations of data are known as identified in the Effluent Management Quality Assurance Plan, EM-QA-01, and applicable related EM-QA-01 documents (e.g., Quality Requirements for Radioactive Air Emissions Sampling and Monitoring). The generation of quality reports and documents requires controlled and verified data. The elements for emissions unit sampling and monitoring include sample scheduling, collection, and analysis; data management; reporting, and supporting calibration and air balance measurements. The Radioactive Air Emissions Sampling and Monitoring Related Document (see EM-QA-01) identifies key work processes and identifies associated procedures and documentation that go into the overall implementation of the QA requirements.

## 3.7 Data Management of Air Emissions Sampling and Monitoring

Data management is a process by which data is acquired, validated, stored, protected, and processed to satisfy the needs of the data users. For radioactive air emissions sampling and monitoring, data management of the various aspects of emissions sampling and monitoring are described in the EM-QA-01 under Section 5.5, Effluent, Waste, and Transportation Programs (current revision: 12.0, April 2024), and in the related document, *Quality Requirements for Radioactive Air Emissions Sampling and Monitoring* (current revision: 2.01, March 2024).

The objective of an annual summary of radioactive air emissions that are sampled and monitored for the purposes of the reporting described in Section 3.8 is to determine annual emission rates of radionuclides to ambient air. The data are accessible through the ERT Lead. Analytical results of samples are stored in the EIM database system that can be retrieved for review, further analysis, or for use in preparing reports. The DMP provides additional detail on managing analytical results.

## 3.8 Reporting of Air Emissions Sampling and Monitoring

Radioactive air emissions sampling and monitoring activities focus on materials that are released to the air from PNNL-managed PIC-1, -2, and -3 emission units. (PNNL-Sequim campus does not have emission units with these PIC categories.) Sampling and monitoring results are summarized for DOE and are provided annually to interested parties; federal, state, and local regulatory agencies; and other DOE contractors. Results are also made available to members of the public. In addition, unusual results or trends are reported to DOE and WDOH when they occur.

Annual reports that include radioactive air emission sampling and monitoring results are submitted to WDOH, EPA, and DOE. The sampled and monitored emissions report(s) are based on the process described in DI-AIR-002. The DI-AIR-002 report results are used to confirm required inputs to annual reports for PNNL operations.

# 4.0 Ambient Air Sampling

## 4.1 Design

Ambient air sampling is designed to meet the objectives listed in Section 2.0 while considering the environmental characteristics of the site, the potential for radiological release, potential receptor impacts, and the actual radiological releases from site operations. Reporting of ambient air sampling results focuses on the determination of environmental impacts and on compliance with public health and environmental standards or protection guides, rather than on providing detailed radiological characterization. Sample results are typically below the level of detection of most radionuclides. Experience gained from environmental surveillance activities and studies conducted at the adjacent Hanford Site for more than 50 years provided the foundation for the PNNL environmental surveillance design.

Ambient air sampling at the PNNL-Richland campus began in 2010 (Snyder et al. 2010). It is structured to be site specific and independent of Hanford Site operations and environmental radiological air surveillance. However, efficiencies can be gained from data collected under Hanford Site programs that apply to each site, specifically meteorological data (300 Area tower).

For the Richland and Sequim campuses sample locations are designated after a Data Quality Objectives (DQO) process is completed by appropriate subject matter experts and use of currently available data. Table 5 indicates the history of completed DQOs and drivers.

Table 5. Summary of Ambient Air DQOs, Associated Publications, and Drivers

| Campus | Reference | Driver |
|---|---|---|
| Richland | PNNL-19427, Rev. 0 (Barnett et al. 2010) | Initial assessment of particulate surveillance locations. |
| | PNNL-19427, Rev. 1 [a] (Barnett et al., 2012a) | Add a southern campus sampling station for southern campus facility surveillance and moving two northern sampling stations to be powered remotely by solar energy. |
| | Fritz et al. 2014 | Determine a campus-specific background station location rather than using Hanford Site background station data and accepting its sampling criteria. |
| | PNNL-19427, Rev 2 (Snyder et al. 2017) | Evaluating northern boundary change that expands campus footprint. |
| | PNNL-19427, Rev. 3 (Snyder et al. 2024) | North campus construction impacting existing station locations. |
| Sequim | PNNL-22111 (Barnett et al. 2012b) | Initial assessment for particulate and ambient external dose surveillance stations. |
| | PNNL-22111, Rev. 1 (Snyder et al. 2019b) | Evaluate impacts from change from a RAEL with two emission units to a Site-wide emission unit. |

(a) Later in 2016, dosimeters were added to all sampling stations to determine background ambient air dose rates using the adopted dosimetry system.

A PNNL-Richland campus background station (PNL-5) was established in Benton City, Washington, in 2016, with its first full calendar year of ambient radiological air sample acquisition in 2017 (Fritz et. al 2014, 2015). Prior to 2017, radiological background information for the PNNL-Richland campus was obtained from the Hanford background air concentration data (from the Yakima sampler station). The Yakima sampler station met the basic need for PNNL-Richland campus background information; however, it did not include the full suite of offsite surveillance radionuclides desired for the PNNL-Richland campus. The analytes of interest for ambient air sampling are based on the radionuclides listed in the RAEL-005. Particulate air samples from the PNNL-Richland campus background station (PNL-5) are analyzed for all required radionuclides (Table 3.6 of Snyder et al. 2024a).

Ambient air monitoring for radionuclides at the PNNL-Sequim campus is not required and was not conducted there until 2024 when ambient external dose surveillance began. As identified in Snyder et al. (2019b) ambient air sampling for particulates is recommended for capturing baseline background at the PNNL-Sequim campus. A particulate sampling station will be established when site property transfers between Battelle and DOE are completed.

### 4.1.1 PNNL-Richland Campus Exposure Pathways

The significance of a pathway is determined from measurements and calculations that estimate the amounts of radioactive materials transported along the pathway and by comparing contaminant concentrations, or potential doses, to environmental and public health protection standards or guides. A pathway also can be evaluated based on prior studies and observations of radionuclide movement through the environment and food chains. As a result of routine operations, the public may be impacted by the PNNL-Richland campus radiological releases via the air pathway from authorized airborne emissions to the ambient air. As of 2024, other pathways such as surface water and groundwater pathways were determined to be irrelevant (Snyder et al. 2024a). This reference also concludes that the ambient air should be sampled for particulates with dosimetry surveillance also conducted.

Calculations based on effluent data show the expected contaminant concentrations off the PNNL-Richland campus to be low for all potential radioactive air emissions and could frequently be below the levels detectable by current measurement technologies. For radionuclides that require continuous monitoring, the quantity of air sampled is set at detectable levels in order to meet the air concentration level of significance for dose impacts.

The ambient radiological air surveillance design uses a sampling approach to monitor the appropriate pathways. Samples are collected, and radionuclide concentrations are measured within and beyond the PNNL-Richland campus boundary. The environmental concentrations of airborne radionuclide releases from facilities generally would be the highest, and therefore most easily detected, nearer to the point of release. Exposures at locations just outside a facility boundary are typically the maximum that any member of the public (not routinely working on the PNNL-Richland campus) could receive. If emissions were significantly greater, an additional surveillance zone consisting of farther afield community locations within an 80-kilometer radius of the PNNL-Richland campus could be added.

As described in Section 4.1, background concentrations for the PNNL-Richland campus are measured at a location distant from the PNNL-Richland campus. These background concentrations can be compared to concentrations measured at the PNNL-Richland campus monitoring stations. A background location is essentially unaffected by site operations but may be affected by other man-made sources of contaminants such as fallout from nuclear weapons testing. A comparison of background concentrations to PNNL-Richland campus surveillance station concentrations may indicate the relative impact of DOE operations. However, nearby non-Campus emission sources may need to be considered (see Snyder et al. 2024b).

The amounts of most radioactive materials released from PNNL-Richland campus operations are typically very small. Often it is not possible to distinguish levels resulting from worldwide fallout and natural sources from those associated with PNNL-Richland campus releases. Therefore, offsite dose assessments performed for regulatory compliance may be estimated using the following methods:

- Doses are estimated from monitored air emissions with environmental transport and dose calculation computer models. These pathway modeling results reveal potential anomalies when comparison to actual, measured data (i.e., ambient surveillance results). Model performance is assessed in this process. When measured results exceed model results, the measured results may be used to evaluate the relative contribution from other sources, such as emissions from other offsite facilities or from fugitive sources.
- Doses from significant sources of fugitive air emissions (e.g., soil gases or re-suspended contaminated soils), where they exist, could be estimated from measured airborne concentrations at site perimeter locations.
- Biota (aquatic animals, terrestrial plants, and terrestrial animals) dose evaluations are discussed in Section 7.0.

### 4.1.2 PNNL-Sequim Campus Exposure Pathways

The significance of a pathway is determined from measurements and calculations that estimate the amounts of radioactive materials transported along the pathway and by comparing contaminant concentrations, or potential doses, to environmental and public health protection standards or guides. A pathway also can be evaluated based on prior studies and observations of radionuclide movement through the environment and food chains. The primary pathway for movement of radionuclides from the PNNL-Sequim campus to the public is atmospheric or waterborne.

Radionuclide emissions to air are minimal at the PNNL-Sequim campus, as demonstrated by its site-wide PIC-5 permitting in RAEL-014. Emissions there are less than those at the Richland Campus and are managed and estimated administratively. The air pathway is the predominant means of site radionuclide emissions. Air dispersion models consider surface soil deposition with a 100-year build-up time. Such models are anticipated to estimate a greater external dose from such surface soil exposure than from exposure to deposition into a tidal and fluid seawater environment.

Waterborne emissions are managed under site-specific wastewater permits and are beyond the scope of this document. In 2025, an effort is underway to connect the Sequim campus to the municipal water supply, so the water source and sanitary water sampling requirements are expected to change. Nevertheless, as stated in Snyder et al. (2024c), water pathways that are potentially important to the PNNL-Sequim campus only if emission rates increase substantially, as a result of plume deposition to the water. This could introduce radioactive materials to seawater with likely very low concentrations taken up by marine animals and later ingested by a member of the public, as well as external dose from recreational exposure (water submersion and boating activities). Ingestion of seawater is not considered a reasonable pathway of exposure. The abundance of freshwater sources eliminates the need for evaluation of desalinated sources of potable water.

Marine animals harvested at or near the PNNL-Sequim campus shoreline could potentially be ingested by a receptor. Free-swimming aquatic life (e.g., fish, crabs) would most likely be exposed infrequently to seawater or food with air-deposited material. Sessile animals (e.g., muscles, oysters, clams) and plants in the intertidal (littoral) zone are more likely to be routinely exposed to routine air deposition in the water. The intertidal life requires tidal, flowing currents to maintain a habitable environment, thereby constantly diluting any water with air-deposited material. The desirability of harvesting marine foods just off the PNNL-Sequim campus, which is an industrial facility, is far less than the nearby large areas of undeveloped shoreline.

Therefore, as indicated above, an evaluation of impacts to a member of the public from water pathways potentially important to the PNNL-Sequim campus is not recommended at this time. If emission levels were significantly increased (e.g., a major emission unit were located at the PNNL-Sequim campus), the water pathway should be re-visited. If needed, such impacts are typically addressed through water and biota sampling. It should be noted that impacts to the biota, as opposed to impacts to humans consuming the biota, are addressed in a conservative manner in the Annual Site Environmental Report (ASER) (e.g., Thompson et al. 2024).

Biota dose (aquatic animals, terrestrial plants, and terrestrial animals) evaluations are discussed in Section 7.0.

### 4.1.3 Media Selection

The highest sampling priority is given to media that could have a direct impact on members of the public. Currently, this is limited to particulate radionuclide sampling in offsite air, as concluded in Snyder et al. (2024a) for the PNNL-Richland campus; and for baseline information in Snyder et al. (2019b) for the PNNL-Sequim campus. Air is sampled because it is the primary media in which radionuclides could be transported from the PNNL Operations release locations to offsite areas where they could impact the public. All radionuclides of interest occur in particulate form at the PNNL-Richland campus. Other types of media may be selected for sampling in the future, as new programs evolve at the PNNL Operations. New media samples would be selected based on regulatory and directive requirements, as well as their sensitivity as indicators of loss of materials control, potential use for predicting contaminant accumulations and trends, potential to function as indicators of environmental quality, potential to serve as indicators of biotic impacts, and potential for bioaccumulation in food products (e.g., milk).

Ambient external dose surveillance was started on the PNNL-Richland campus in 2016, with 2017 being the first full operational year of onsite and offsite air sampling stations. Ambient external dose surveillance was started on the PNNL-Sequim campus in 2024, with 2025 being the first full year of onsite ambient air dosimetry to collect baseline background information. The information will provide representative samples for both locations at a time in PNNL operations when no sources of elevated external dose with potential for public exposures are used onsite; see further discussion in Section 6.0.

## 4.2 Sampling Protocol

The ERT team considers the following QA and QC criteria discussed in this section when selecting sampling locations, managing sampling and analysis schedules, determining analytical measurement criteria, validating analytical results, and performing data reporting and assessments.

The SAP provides details about the actual sampling process and the requirements imposed on the analytical laboratory for sample analysis. Sampling performed under the SAP provides assurance that the quality of the air sample and sample analysis data meets programmatic objectives. The ERT establishes which ambient air *particulate sample* radionuclide analyses are conducted based on the radionuclides listed in the RAEL-005. Gross alpha and gross beta/gamma are routinely analyzed in ambient air particulate samples.

### 4.2.1 Sampling Locations

Ambient radiological air samples are collected to determine background (un-impacted media) and radioactivity levels (impacted media). Background air sampling is conducted at a location that is reasonably expected to be unaffected by PNNL-Richland campus discharges (e.g., Fritz et al. 2014, 2015). The PNNL-Richland campus background air sampling station PNL-5 came online in September 2016 and is located approximately 12 miles from the PNNL-Richland campus in Benton City, Washington (see Figure 2). Sampling locations with the potential to represent the more greatly impacted offsite individual locations from PNNL-Richland campus radioactive air emissions; are selected to maximize the probability of detecting a loss of containment; and to help assess the magnitude of releases. This statement comes with the caveat that radioactive emissions from other nearby sources may be captured along with PNNL-Richland campus emissions. While the PNNL background station may detect Hanford Site emissions, no PNNL-Richland campus emissions are expected to be captured. Finally, Hanford Site air sampling is conducted in nearby communities to obtain data where potential exposures may occur from Hanford Site sources and to provide assurance to the communities that contaminant levels are well below standards established to protect public health and the environment. Hanford Site air sampling may be used as supplemental information to PNNL environmental radiological air monitoring and surveillance.

Ambient air sampling at PNNL-Sequim campus is planned. A single location for particulate air background sampling has been decided but may be revisited once land transfers between Battelle and DOE are finalized. In the meantime, ambient air external dose is being measured at a lowland and a central upland location. Scheduling, design review, and sampling approach concerning PNNL-Sequim campus environmental sampling will mirror the activities described for the PNNL-Richland campus.

The current PNNL-Richland campus sampling locations (see Figure 2) were determined based on several factors, including access and power availability, but principally driven from atmospheric dispersion modeling results. Sampling stations are installed in proximate offsite areas to measure the concentrations of radionuclides from routine operations at locations accessible by members of the public (Snyder et al. 2024a).

Air particulate samples are collected by continuously drawing air through particulate filters (see Figure 7). RPTs utilize approved procedures to consistently collect samples to avoid loss of sample mass, cross contamination, or misidentification. Measures such as exchanging whole sample collection media containers, rather than handling the collection media in the field accomplishes this, as does labeling and sealing or storing each sample so that sample integrity in the field is maintained. The sampler station design assures collection of a sample representative of an entire sampling interval (i.e., so results are not biased toward one portion of the interval). Sampling stations are placed outside of (building or structure) wake zones, away from vegetation, and in generally flat terrain. Sampling inlets are located 2 meters above the ground to provide measurements representative of radionuclide concentrations inhaled by humans.

Figure 7. Example of Two Exposed Air Particulate Filter-Head Assemblies Prior to Analyses

The WDOH requested and has been provided access to co-locate and collect particulate air samples at air monitoring stations PNL-3, PNL-4, and PNL-5 at the PNNL-Richland campus. Solar-powered monitoring stations PNL-1 and PNL-2 are not equipped for co-sampling; however, WDOH could co-locate their own solar-powered monitoring stations (panels and sampling equipment) at these PNNL locations. The WDOH samples would be managed by Washington State for independent sample analyses. Currently, both the WDOH and the Hanford Site co-locate air samplers at PNL-4 only. WDOH's environmental radiation oversight program data are published annually for the Hanford Site; data from other facilities are available upon request from the WDOH.

### 4.2.2 Sampling and Analysis Schedule

Sampling frequencies are based on the need to obtain time-representative samples, environmental factors that may impact collection efficiencies, and consideration of sampling equipment or sampling substrate limitations. Air filters are exchanged according to procedure. Samples are routinely collected, and multiple particulate samples may be composited, if necessary, to achieve lower detection levels or increase time representativeness. A sampling and analysis schedule for ambient radiological air is presented in the SAP detailing the sample locations, frequencies, and analyses.

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. To facilitate sample collections, an ERT staff member schedules and provides the initial sample collection documentation to a trained Radiation Protection Technologist (RPT or equivalent). The ERT staff also provides the analytical service provider with site-specific composite sheets with the requested analyses and the individual sample number(s) that should be composited (combined) to form the designated semiannual (twice a year) composite sample(s). Two consecutive 6-month composite samples represent calendar year results.

While sample results may provide an indication of an unplanned release, it is acknowledged that there will be a period of time between when samples are sent to the analytical laboratory and the analytical results are available. For the biweekly (every two weeks) gross alpha and gross beta samples, the current statement of work with the analytical laboratory (current version) provides the reporting times of test results for routine and priority processing of samples.

### 4.2.3 Analytical Detection

For particulate air samples, the general strategy for obtaining the lowest levels of detection practical is to use standard analytical procedures and to consider sampling strategy tradeoffs (e.g., time and location compositing versus discrete samples). Where technically feasible and practical, the minimum objective for a given medium and radiological contaminant combination is to detect a concentration that is equal to or below the concentration that would result in a dose to an adult of 1 mrem[1] total effective dose, if exposure to that concentration was sustained for 1 year. Dose is determined by prospective modeling for the Maximum Public Receptor, using approved models. This dose estimate follows the public dose estimation process, as briefly described in Figure 5. For example, the pathway for air assumes not only inhalation but also exposure to airborne materials deposited on the ground and to radionuclides taken up in locally grown foods via leaf deposition, root absorption, and in livestock consumption of locally grown feed.

Past sampling and modeling show that most radionuclide concentrations in environmental samples collected around the PNNL-Richland campus result in an annual dose to offsite receptors that is well below 1 mrem. In lieu of site-specific modeling, the minimum objective analytical detection limit for particulate air samples can be determined by using 10% of the air concentrations indicated in Table 2 of 40 CFR Part 61, Appendix E, or CAP88-PC-based methods. This minimum objective is designated in 40 CFR 61.93 (b.5) and site RAEL. The contract required detection limit for PNNL ambient air sampling allows for additional precision because it is based on 1% of the standard [using 1% of the air concentrations indicated in Table 2 of 40 CFR Part 61, Appendix E, or CAP88-PC-based methods]. Also see section 4.1.7 of the SAP, rev.1.

The radionuclides identified for ambient air sample composite nuclide-specific analyses are those listed in the site RAEL with a specific potential release rate. Evaluations have determined that due to the contract and analysis timing, the list of radionuclides routinely analyzed are in practicality limited by the RAEL. In contrast, stack sample analysis is more agile and can be more readily updated to reflect changing operational conditions. In addition, the current analytical laboratory routinely provides a suite of gamma-emitter results for composite samples. The current list of analytes to be monitored at the PNNL-Richland campus is indicated in the SAP or RAEL. The Sequim campus DQO (Snyder et al. 2019b) indicated that gross alpha and gross beta/gamma analyses would be appropriate for the baseline background sampling to be performed at that site.

PNNL specifies the target (a priori) minimum required detection limit for the various matrix/analysis combinations and other analytical information requirements to support regulatory reporting requirements. Aliquot size and count duration are optimized such that the minimum detectable activity (MDA) is at or below the required detection limit.

## 4.3 Quality Control of Ambient Air Sampling

The goal of the QA program is to assure that accurate, reproducible, and defensible data are produced. In addition to the PNNL QA program described in Section 8.0, specific analytical

[1] One mrem EDE is 10% of the member-of-the-public federal dose standard 40 CFR 61.93 (5.iii) for radionuclide emissions to air.

laboratory quality assurance and control processes are in place to assure the accuracy, precision, traceability, and limitations of data are known. The generation of quality reports and documents requires controlled and verified data. This section describes the QC elements for Environmental Surveillance and how they are implemented.

The operational techniques and activities used to fulfill quality control in ambient air surveillance is covered in PNNL controlled procedures as well as the *PNNL Effluent Management Quality Assurance Plan* (EM-QA-01).

Analytical laboratories contracted by PNNL are required to be 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) . The contracted services are performed according to their established internal quality control program and laboratory procedures and may be subject to additional special requirements identified in a statement of work. Laboratory QC samples are used to detect quality problems that occur during sampling and analysis. The ERT staff reviews the analytical laboratory’s QC performance, along with the applicable minimum detectable concentrations and method detection limit determinations. Deficiencies in data are identified and investigated. If corrective actions are necessary, they are documented, implemented, and then verified (e.g., by laboratory surveillance or audit).

In addition, the contracted laboratory must participate in national comparison studies, also called performance evaluations. For these studies, blind samples containing specific amounts of contaminants are distributed to the participating laboratories. The laboratories analyze the samples and submit their analytical results to the organizer for comparison and evaluation. The laboratory also submits the results of the comparisons and evaluations to ERT staff. Additional details regarding the analytical laboratory QA/QC requirements are provided in the SAP.

## 4.4 Data Management of Ambient Air Samples

Data management is a process by which data is acquired, validated, stored, protected, and processed to satisfy the needs of the data users. Data management objectives are primarily achieved through the project database(s). The Environmental Surveillance program transitioned data management activities to the Locus EIM software system in 2023. The former project database  referred to as PNNL SEM (Site Environmental Management) or PEIS (PNNL Environmental Information System), used the Hanford Environmental Information System (HEIS) (HEIS 1989) maintained by the Environmental Database Management organization of the Central Plateau Cleanup Company, is used as a repository for environmental surveillance data collected between 2010-2022. The ambient air database provides a repository for environmental surveillance data gathered during PNNL Operations onsite and offsite. It is intended to provide current and consistent data for all users. The system and its data are accessible through the ERT Lead.

Analytical results are provided by the analytical laboratories and reported to the ERT team in either a portable document format (pdf) data report and/or electronic data file that is fully compatible with the current designed data loader format. Once obtained, data are evaluated according to procedure and entered into the database. Records generated may include chain-of-custody forms and data entry and validation checklists. Analytical results stored in the database can be retrieved for review, further analysis, or for use in preparing reports.

Additional details of the data management processes are described in the DMP; data review, evaluation, and reporting are summarized in the following sections. Sampling and analysis scheduling are incorporated in the SAP.

### 4.4.1 Data Review

Good data management, data validation, and statistical treatment practices are essential for producing high-quality results. The objectives for data management of the environmental surveillance results include managing data in a manner that assures timely collection, validation, and reporting in accordance with the sampling and analysis schedule and traceability from scheduling samples to archiving results in the database.

Contaminant-of-concern concentrations at each sampling and/or measuring point are:

- Estimated for each sampling and/or measurement time to determine the necessary accuracy and precision.
- Compared to previous concentrations measured at the same point to recognize changes or inconsistencies in concentration levels.
- Compared to reporting (notification) limits.
- Compared to concentrations measured at background sampling stations or other points.

Criteria for the data accumulated in the project database are indicated in the SAP. Environmental surveillance samples are collected according to the SAP, as coordinated with the ERT Lead. Data management assures timely scheduling, sample tracking, analysis tracking, and validation of analytical results. Validated results indicate the radiological air concentrations at the sampling station locations. Maintaining a database of results allows for timely data access and report generation. The DMP provides details about database hardware and software requirements, analysis result tracking, validation and interpretation of the analytical results, and data reporting.

### 4.4.2 Evaluation and Regulatory Notification

When environmental surveillance air sample results are received, the data is evaluated in accordance with procedures, any specific requirements of the *PNNL Effluent Management Quality Assurance Plan* (QAP; Barnett 2024) and compared to the notification values of 40 CFR 61, Appendix E, Table 2 (see Table 5 of SAP, rev. 1). Each sample result that exceeds the notification level is considered anomalous and the appropriate investigations or reporting is initiated. Project personnel review the anomaly to determine the validity of the result and whether additional information is needed from the analytical laboratory. Anomaly evaluations are maintained as part of the project record.

Sample results are compared to DOE reporting levels, which provide early indications of conditions that might require specific reporting to DOE-Headquarters as indicated by DOE Order 458.1. These DOE reporting levels are consistent with or more conservative than the EPA 40 CFR 61, Subpart H, reporting levels.

## 4.5 Reporting of Ambient Air Sampling

Surveillance activities focus on materials that are, or potentially could be, released to the air from PNNL Operations. Surveillance results are collected for DOE and are provided annually to interested parties; federal, state, and local regulatory agencies; and other DOE contractors. Results are also available to members of the public. In addition, unusual results or trends are reported to DOE and WDOH when they occur.

The ambient air sampling design described in this EMP is based on radiological pathway analyses that use data obtained under the requirements of PNNL RAEL-005 and RAEL-014, as appropriate. The pathway analyses and radiological dose assessments conducted for this plan, and the radiological dose assessments reported in annual compliance reporting to the WDOH and EPA, use the data provided by the MCSP described in DOE/RL-91-50, Rev. 4 (DOE 2008a), Section III.B, to determine atmospheric dispersion.

The results of radioactive air sampling of emission units and ambient air are reported annually to the WDOH, EPA, and DOE as part of a Radionuclide Air Emissions Report (RAER) and ASER for PNNL Operations. The impacts of PNNL Operations radiological air emissions, whether these emissions were determined from air monitoring, air surveillance, or release estimation, are indicated by estimates of dose to a member of the public and dose to biota.

Environmental surveillance and environmental monitoring are performed, in part, to monitor potential offsite impacts. The impacts of radiological air emissions from PNNL Operations are typically evaluated using environmental models that estimate dose to a MEI member of the public. Radioactive air emissions from both PNNL campuses have been negligible, as demonstrated over previous years. Compliance with the dose standard for a member of the public must not exceed 10 mrem/yr (40 CFR 61.92). This member of the public, MEI, is assumed to be an adult. Impacts to the MEI are potentially greatest from emission points that require continuous stack monitoring and correspond to those areas identified for offsite environmental air surveillance. Dose assessment results are reported in an annual RAERs (e.g., Snyder et al. 2024b, Snyder and Barnett 2024c). The air pathway is the only current contributor to this dose from either the PNNL-Richland campus or the PNNL-Sequim campus; no direct exposure pathways or water pathways contribute to the offsite public dose.

The DAG presents MEI dose assessment methodology used for PNNL RAERs. For the purposes of regulatory compliance, dose assessments use source term information from in-stack particulate (and tritium for stack EP-325-01-S, only) sampling from major emission units and 40 CFR Part 61, Appendix D, methods for minor emission units, as well as gas emissions from RaGas, rather than the offsite environmental air surveillance results. Ambient radiological air surveillance results are used as additional confirmation that releases are at the anticipated low-to-undetectable levels.

Compliance determination with federal regulations is by MEI dose determination from modeling locations routinely occupied. State regulators also request a dose determination from modeling for the location of the maximum annual air concentration at an unrestricted area, regardless of occupancy at that location (WAC 173-480).

Regarding ambient radiological air surveillance, semi-annual and average annual sampling results are reported in comparison to 40 CFR Part 61, Appendix E, Table 2 values. Such reporting highlights when ambient air sampler results indicate concentrations that, if continued over the entire year, may lead to MEI dose estimates that approach or exceed the regulatory limit. Managing suspect analytical data results are governed by the DMP and operating procedures.

# 5.0 Ambient Dosimetry

Ambient external dose may result from such sources as background radiation, significant research and calibration materials (e.g., cesium-137 sealed sources), or large enough emissions of certain beta and gamma emitters. PNNL-Richland campus and PNNL-Sequim campus radioactive material emissions to ambient air occur routinely at levels which are not generally detectable in the environment. These contributions from the PNNL-Richland campus to the ambient external dose are presently monitored as part of a comprehensive program and for surveillance of potential public impacts. Surveillance can be done if the potential external dose may exceed public dose standards or as confirmatory measurements of low dose rates.

Current PNNL Operations do not indicate ambient external doses to members of the public would approach dose limits. Inventories and emissions are managed to eliminate this concern. The history of each PNNL locale resulted in no pre-operational external dose surveillance to be conducted, as recommended in DOE 2022b. The current low emissions at each operating site allows external dose surveillance to be representative of pre-operational levels. Ambient levels of external dose from beta, gamma, and x-ray sources are monitored quarterly at the five PNNL-Richland campus particulate air monitoring stations and at two PNNL-Sequim campus locations. Due to the recent implementation of ambient air dosimetry at the Sequim campus, ambient external dose rates are unknown. The currently available results indicate no elevated results.

## 5.1 Objectives, Requirements, Criteria

The objective of ambient external dose surveillance is to determine the operational impact to members of the public from external dose contributors, as a result of PNNL Operations. DOE (2022b) identifies procedures, methods, and practices to meet DOE Order 458.1 requirements. A stated objective for DOE site environmental surveillance programs in (Section 6.4.1 of DOE 2022b) is to determine background levels and site contributions of radioactive materials in the environment. The minimum objective for external dose from both radioactive material emissions and external sources of radiation is to adequately detect external doses below EPA and WDOH air effluent dose standards and DOE dose criteria.

Dose to members of the public is controlled by DOE Order 458.1 and the EPA NESHAP dose standard. DOE Order 458.1 (4.b) standard limits the dose to a member of the public to a 100 mrem/yr TED. External dose is just one part of all the potential dose pathways (i.e., inhalation, ingestion, and external exposure) considered for the 100 mrem/yr limit. In 40 CFR 61, Subpart H, (61.92), radioactive emissions to ambient air are not to result in a dose to a member of the public above 10 mrem/yr EDE. For example, this means that the dose from radioactive air emissions at a DOE site can be up to 10 mrem/yr, then water and ground radionuclide sources (e.g., radioactive waste disposal site) could contribute up to 90 mrem and that site would remain under the DOE all-sources dose limit.

Under Washington State regulations, the WDOH, in WAC 246-247-040, points to Washington Department of Ecology regulations in WAC 173-480-040 for setting the ambient dose standard. WAC 173-480-040 follows the 40 CRF Part 61, Subpart H, standard of 10 mrem/yr EDE to any member of the public from radionuclide emissions to the air.

As approved by WDOH, compliance with air emissions dose standards are met by modeling the dose from measured or estimated radionuclide emissions using CAP88-PC [Rosnick et al. 2017 (or any other version)] for the PNNL-Richland campus and COMPLY for the PNNL-

Sequim campus. These models provide estimated dose from all pathways (i.e., inhalation, ingestion, and external dose) from site air emissions.

Model results can be used, but when measurements can be performed in a cost-effective manner with reliable results, these measurements should be taken. External dose results from the gamma and strong beta emissions of radionuclides. The measurement of ambient external dose should use a service provider that delivers the appropriate dosimeter and quality-assured dosimeter analyses. The service provider should follow the external dose reporting information in the ANSI/HPS Standard N13.37-2019, *Environmental Dosimetry—Criteria for System Design and Implementation* (2019).[2]

External dose should be monitored at the location(s) where maximum exposure from site sources to a member of the public is expected. Background external dose should also be measured at any designated background surveillance station. Additional consideration should be given to any nearby sources of potential external dose that are independent of site operations. The lack of significant PNNL external dose sources allows the use of the current PNNL-Richland campus particulate monitoring stations as appropriate external dose surveillance locations. Any location on the PNNL-Sequim campus is appropriate to capture baseline background results.

## 5.2 Design

PNNL-Richland campus has no significant quantities of external dose contributors; however, external dose surveillance establishes the Landauer system ambient external dose levels at the ambient air sampling stations PNL-1, PNL-2, PNL-3, PNL-4; and background station, PNL-5. The Sequim campus has two dosimeter stations, a central upland (SEQ-2) and a shore area (SEQ-1) location (see Figure 3).

Surveillance at both campuses is done with aluminum oxide dosimeters read by optically stimulated luminescence (OSL), using the Landauer[3] InLight® System. The system has a 5-mrem minimum detection level for beta, gamma, and X-ray emissions of 5 keV to 20 MeV. Each measurement has a reported 12% uncertainty (2-sigma, 95% confidence interval).[4] No neutron detection is performed. In addition, two control dosimeters are used: one to measure exposure during field deployment and the second to measure exposure during shipment to and from the service provider. An additional dosimeter with a six-month exposure period has been added to determine vault dose at each campus location. New vaults were purchased for control dosimeter storage in 2024. Knowledge of vault dose will better align reported results with ANSI/HPS N13.37 requirements, which will allow a more precise quarterly (and subsequently, annual) external ambient dose reporting for each sample location.

[2] Other historical and current environmental dosimetry reference documents include the U.S. Nuclear Regulatory Commission Reg Guide 4.13 (NRC 2019), and the withdrawn ANSI N545-1975 (R1993).

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

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

## 5.3 Sampling

A sampling and analysis schedule for ambient dosimeters is presented in the SAP detailing the sample locations, frequencies, and analyses. Dosimeters are exchanged according to procedure. Dosimeters are placed as close to 1-m above the ground surface as possible and hang freely from plastic ties. Dosimeters are exchanged quarterly. Dosimeters located at particulate sampling locations are checked every 2 weeks, coinciding with the particulate sample collection. Any in-field dosimeter issues identified by an RPT (or equivalent) are reported to an ERT staff member who works to resolve it.

## 5.4 Quality Control of Ambient Dosimetry

A high-quality ambient dosimetry program requires implementation of procedures to ensure accurate environmental monitoring results. Quality control for external dose surveillance is covered by approved and controlled procedures. In addition, the service provider should design the environmental dosimeter to meet ANSI/HPS N13.37 specifications.

The current service provider is Landauer who provides dosimetry services for ambient air external dose monitoring. Landauer provides two control dosimeters per shipment—the first to measure exposure during field deployment/retrieval activities and the second to measure exposure during shipment to and from the vendor. No control or background values are subtracted from the data reported by the vendor.

If the transit and control dosimeter results are within 5 mrem of each other, the station results are considered acceptable. Such consistency between the transit and control indicates no additional significant external dose was received during transit (postal transit and deployment/collection transit).

## 5.5 Data Management of Ambient Dosimetry

Data management is a process by which data is acquired, validated, stored, protected, and processed to satisfy the needs of the data users. The data management processes are described in the DMP. The sampling and analysis schedule are incorporated in the SAP. Dosimetry reports are delivered electronically, via the service providers secure portal and are evaluated according to procedure Records generated may include chain-of-custody forms, dosimetry reports, and data entry and validation checklists.

## 5.6 Reporting of Ambient Dosimetry

Quarterly dosimeter values are provided by the service provider via a secure portal. Project records are maintained in accordance with the E-Records CASE1830:08-10.

Reporting of quarterly and annual dosimeter results use the quarterly results from EIM. Data is assessed as indicate in section 2.5.2 of the DAG, rev. 4. This method, first implemented for CY2024 results, evaluates whether the onsite dosimeter results are statistically different from the background result using DI-AIR-004 for PNNL-Richland campus results. While the actual external dose at the surveillance location cannot be determined until vault dose is known (see section 5.2), the difference from background with 95% confidence can be assessed. The method of evaluation for the Sequim campus will be established after a full calendar year of quarterly results are collected.

A summary of results of the ambient external dose surveillance are reported in annual radioactive air emissions reports (e.g., PNNL-201436-14) and more completely in the PNNL ASER (e.g., Thompson et al. 2024). Results are reported for each station. No background results are subtracted from the proximal station results.

Currently no compliance requirements for reporting of ambient external dose surveillance results exist unless site sources are significant relative to the federal and state public exposure limits are 100 mrem/yr (DOE Order 458.1, and WAC 246-221-060). As a result, the current purpose of the ambient external dose surveillance program is to capture baseline data rather than monitor for potential PNNL sources.

# 6.0 Public Dose Assessment

Dose from radioactive material exposures are estimated for the maximally exposed member-of-the-public receptor (i.e., the MEI) in the vicinity of PNNL sites. Radioactive material emissions from PNNL sites are managed so routine emissions result in dose estimates that are well below regulatory dose standards and criteria. This emissions management includes *a priori* controls of planned operational activities with reported dose assessment results occurring *a posteriori* based on measured or estimated emissions.

Federal and state standards for radioactive material emissions to the ambient environment are regulated based on dose to the maximally exposed member of the public (mrem/yr, adult, whole-body effective dose from external and internal exposures). The dose criteria are established from public health risks based on national and international epidemiology of exposed populations. The public health risk is based on national and international epidemiology of exposed populations (e.g., NRC 2006). For cancer risk, it considers both the morbidity and mortality of cancers in various organs.

The public dose standards applicable to PNNL Operations are summarized in Table 6. The table indicates the dose standard or limit that should not be exceeded. The Richland and Sequim campuses are not adjacent, so the dose limits are applied to each facility. Despite the fact that the Hanford Site and PNNL-Richland campus are adjacent, each site is operated and WDOH-permitted separately, so the dose limits are also applied separately to each facility. Regulatory limits are set at levels that assume there may be several facilities in a region that have this same limit and a public receptor may potentially receive a dose from more than one facility. As a result, the limit was set at a low level whereby health impacts would not be expected even if the dose-estimate results for a single facility meet or marginally exceed the standard.

Table 6. Dose Criteria for Public Dose Assessment

| Source | Criteria | Receptor | PNNL Location |
|---|---|---|---|
| 40 CFR 61, Subpart H | 10 mrem/yr | MEI | Richland campus, Sequim campus |
| DOE Order 458.1 | 100 mrem/yr | MEI or Representative Person | Richland campus, Sequim campus |
| WAC 246-247 | 10 mrem/yr | MEI | Richland campus, Sequim campus |
| WAC 173-480 | 10 mrem/yr | MA receptor | Richland campus, Sequim campus |
| RAEL-005 | Varies by emission unit | MEI | Richland campus |
| RAEL-014 | Varies by emission unit | MEI | Sequim campus |
| RAEL-FF-01, PNNL-managed emission unit | Varies by emission unit | MEI (fractional dose contribution from PNNL sources) | PNNL-managed emissions on the Hanford SIte |

For radiological emissions to ambient air, PNNL reports[5] annual MEI public dose assessment results under 40 CFR 61, Subpart H; and WAC 246-247 and reports the public dose

[5] PNNL operations on the Hanford Site result in ambient radiological emissions to air which are included in Hanford Site dose compliance reports (e.g. DOE 2018). Operations within the Hanford Site boundary operates under a different WDOH radioactive air emissions license, separate from the PNNL Richland Campus RAEL-005.

assessment at the maximum offsite air location under WAC 173-480-040 (Snyder et al. 2024b and Snyder et al. 2024c). PNNL reports the public dose assessment for radiological emissions to ambient air, water, and soil (i.e., “other”) under DOE Order 458.1 annually in the Site Environmental Report (e.g., Thompson et al. 2024). Dose assessments may also be done as necessary for non-routine operations. The DAG, Revision 4, contains details regarding dose calculations from radionuclide emissions to air at the PNNL-Richland and Sequim campuses.

Public receptor doses at the PNNL-Richland campus from air effluent are calculated with CAP88-PC v4.0 (Rosnick 2017 or other version) software. The MEI location is determined based on initial CAP88-PC case runs of the maximum-dose-contribution stack and the meteorology relevant to the time frame of interest.[6] This “signaling” stack and associated MEI location assumption is reconfirmed after CAP88-PC cases are run. If the initial determination was found to be faulty, all cases would be re-run with the updated MEI location determination. CAP88-PC inputs include:

- Emissions estimates (Ci/yr) – see Section 3.5.
- Emission unit height and diameter - see Klein et al. 2024, with current year flow data.
- Hanford Site Meteorological Station 11 (300 Area, 10 m) wind data.
- Hanford Site Meteorological Station 21 (HMS, 10 m) average precipitation and temperature; stability class data.
- Exposure parameters – see Snyder and Barnett (2016) or a published Subpart H report.
- For collective dose, 50-mi population data (Rose et al. 2023).

Public receptor doses at PNNL-Sequim campus are calculated with COMPLY v1.7.1 software at Level 4. A graded approach option is available, using summary meteorological information (average wind speed toward the receptor) or a wind rose (frequency and average wind speeds in all directions from the central emission location). The MEI location is based on initial case runs of the maximum-dose-contributing nuclide (or otherwise representative nuclide). A central emission location is assumed for PNNL-Sequim campus (see Snyder et al. 2024c). Other COMPLY inputs include:

- Emissions estimates (Ci/yr) – see Section 3.5.
- Central emission unit height and diameter – see Snyder et al. (2019b).
- Sequim Site meteorology - see Washington State University AgWeather net Sequim station data.
- Exposure parameters – see e.g., Snyder et al. (2024c).

Collective doses are estimated using a custom spreadsheet and 50-mi population data from Rose et al. 2023. Canada is within 50-miles of PNNL-Sequim campus, so U.S. and Canadian total collective doses are reported.

If meteorological data does not sufficiently represent the year of evaluation due to instrumentation or data collection issues, a long-term meteorological file (5-years or more for the same station) is substituted. The issue and substitution are clearly indicated in the regulatory report.

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[6] In rare cases, the most appropriate meteorological year’s data is unavailable or unacceptable. Recent five-year to ten-year average meteorology is an acceptable substitute.

Emission-unit-specific doses to the MEI are presented within the Subpart H compliance report (e.g., Snyder et al. 2024b, Snyder et al.2024c). These are then compared to the emission unit limits to determine compliance with permit conditions, formally in DI-AIR-002. Annual compliance reports must be submitted by June 30 every year.

Additional emission criteria are also considered based on 40 CFR 61, Subparts I, Q, and T. In addition to 40 CFR 61, Subpart H, requirements, WAC 246-247-035 adopts by reference, Subparts I and Q for federal facilities and 40 CFR 61, Subpart T for non-federal facilities. These criteria are discussed below for completeness and are shown in Table 7.

Table 7. Other Public Exposure Criteria

| Source | Criteria | Receptor |
|---|---|---|
| 40 CFR 61, Subpart I | 10 mrem/yr total | MEI |
| 40 CFR 61, Subpart I | 3 mrem/yr iodine | MEI |
| 40 CFR 61, Subpart Q | < 20 $pCi/m^2{\cdot}s$ Rn-222[(a)] | Air |
| 40 CFR 61, Subpart T | < 20 $pCi/m^2{\cdot}s$ Rn-222[(b)] | Air (ambient) |

(a) Limited to DOE owned storage and disposal facilities for radium-containing material that emit Rn-222, as an average for the entire source, into the air.
(b) Limited to Rn-222 emissions to the ambient air from uranium mill tailings pile that are no longer operational.

While not expected, there is a possibility that 40 CFR 61, Subpart I, *National Emission Standards for Radionuclide Emissions from Federal Facilities other than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H*, may be applicable to radiological emissions to ambient air associated with non-DOE federal operations (Battelle activities) outside of the bounds of the PNNL Richland or PNNL-Sequim campuses. Such a circumstance would occur if a non-DOE federal organization conducted a radiological activity with emissions to ambient air (non-DOE operations, but activities administratively approved by PNSO). The 10 mrem/yr dose criteria for a member of the public are the same as those in Subpart H, but there is also an annual radioiodine-specific criterion of 3 mrem/yr whole-body dose. Under this Subpart I requirement, annual reports must be submitted by March 31 every year.

The federal regulation 40 CFR 61, Subpart Q-*National Emission Standards for Radon Emissions from Department of Energy Facilities* applies to operations at storage and disposal facilities for radium-containing material. Compliance is required to be reported supplemental to the Subpart H compliance reporting. Facilities under this subpart emit Rn-222 into the air from the radiological decay of radium, and the standard is established on an emission rate rather than a dose. The 40 CFR 61, Subpart Q, (61.192) standard is that no DOE source shall emit more than 20 $pCi/m^2{\cdot}s$ of Rn-222, as an average for the entire source, into air. No reporting requirements are indicated in the regulation, but they are included in the Memorandum of Understanding between EPA and DOE concerning “The Clean Air Act Emissions Standards for Radionuclides,” 40 CFR Part 61, including Subparts H, I, Q, and T (1995). PNNL does not have or operate a storage and disposal facility for radium-containing material.

Under 40 CFR 61, Subpart T- *National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings*, compliance is required to be reported supplemental to the Subpart H compliance reporting, but this regulation does not apply to PNNL operations.

# 7.0 Biota Dose Assessment

Biota (aquatic animals, riparian animals, terrestrial plants, and terrestrial animals) require protection from adverse impacts of radiological emissions under DOE Order 458.1. PNNL site radiological emissions to the ambient environment are managed to limit public dose. Such emissions management successfully results in biota doses below dose standards using the current graded biota dose assessment approach. The biota dose standards and biota Dose Assessment Guidance (DAG) are in the DOE Technical Standard, DOE-1153-2019 (Re-affirmed 2022), *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2022a).

Biota dose standards are based on international recommendations (ICRP 2014) from research findings indicating the deleterious impacts determined for various representative organisms (Table 8). The biota dose criteria are prudently designated for biota population protection. Population protection is paramount for these criteria, rather than protection of the most sensitive individual in all members of the biota category. Protection of the most sensitive taxonomic group (e.g., population taxa) in a category is used as the criteria basis. DOE 2022a indicates:

> "The biota dose rate criteria specified in this technical standard are based on the current state of science and knowledge regarding effects of ionizing radiation on plants and animals. They should not be interpreted as a "bright line" that, if exceeded, would trigger a mandatory regulatory or remedial action. Rather, they should be interpreted and applied more as "Dose Rate Guidelines" that provide an indication that populations of plants and animals could be impacted from exposure to ionizing radiation and that further investigation and action is likely necessary."

The DOE 2022a biota dose criteria for the four biota categories are indicated in Table 8. Managing biota dose under the biota dose criteria would prevent exposures to lethal doses.[7]

Table 8. DOE Biota Dose Rate Criteria with Example Reference Organisms Used as the Basis for the Criteria

| Biota Category | DOE 2022a Dose Rate Criteria | Reference Organism and Identified Dose Range for Deleterious Effects[(a, b)] |
|---|---|---|
| Aquatic animal | 1 rad/d (10 mGy/d) | Crab (1 to 10 rad/d)<br>Trout (0.1 to 1 rad/d)<br>Flatfish (0.1 to 1 rad/d) |
| Riparian animal | 0.1 rad/d (1 mGy/d) | Frog (0.1 to 1 rad/d)<br>Duck (0.01 to 0.1 rad/d) |
| Terrestrial plant | 1 rad/d (10 mGy/d) | Pine tree (0.01 to 0.1 rad/d)<br>Wild grass (0.1 to 1 rad/d) |
| Terrestrial animal | 0.1 rad/d (1 mGy/d) | Deer (0.01 to 0.1 rad/d)<br>Bee (1 to 10 rad/d)<br>Earthworm (1 to 10 rad/d)<br>Rat (0.01 to 0.1 rad/d) |

(a) To convert rad/d to mGy/d, multiply rad/d by 10.
(b) From ICRP 2014.

[7] Figure 1-2 of DOE 2022a provides a graphic of lethal dose ranges for various taxonomic groups, ranging from 100 to 1 million rad, total dose delivered over a short time.

A DOE site may have a sampling program to determine radioactive material concentrations in environmental media or in a specific biota. It was determined through the DQO process and confirmed in the latest revisions (Snyder et al. 2024a, Snyder et al. 2019b) that ambient air sampling was relevant for the PNNL Operations and, even though not required, also recommended at PNNL-Sequim campus. No other environmental media, nor biota sampling, is conducted for the purposes of biota dose assessment.

PNNL reports[8] the biota dose assessment results in the ASER (e.g., Thompson et al.2024). The biota dose is based on site radiological emissions to the ambient air; there are presently no other sources of radiological emissions contributing to the biota dose.

As indicated above, the biota dose standards are based on the risk of deleterious effects to a reference animal or plant from ionizing radiation. Exposure to environmental media (water, soil, or sediment) containing radionuclides from site emissions to the ambient environment is assessed using a graded approach. PNNL's Richland and Sequim campus water, soil, and sediment concentrations are estimated from site air effluent emissions for site-specific biota dose assessments. Additional details regarding the biota dose assessment process for the PNNL-Richland campus and PNNL-Sequim campus are found in the DAG.

[8] PNNL operations on the Hanford Site result in radiological emissions to ambient air. Biota dose assessment results for operations on the Hanford Site are included in the Hanford Site ASER (e.g., DOE 2024).

# 8.0 Quality Assurance

## 8.1 PNNL QA Program

The PNNL Laboratory-level QA program is based upon the requirements as defined in DOE Order 414.1D, *Quality Assurance*, and 10 CFR 830, *Nuclear Safety Management*, Subpart A, "Quality Assurance Requirements." PNNL has chosen to implement the following consensus standards in a graded approach:

- ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications*, Part I, "Requirements for Quality Assurance Programs for Nuclear Facilities."
- ASME NQA-1-2000, Part II, Subpart 2.7, "Quality Assurance Requirements for Computer Software for Nuclear Facility Applications," including problem reporting and corrective action.
- ASME NQA-1-2000, Part IV, Subpart 4.2, "Guidance on Graded Application of Quality Assurance (QA) for Nuclear-Related Research and Development."

The PNNL Quality Assurance Program Description/Quality Management M&O Program Description describes the Laboratory-level QA program that applies to all work performed by PNNL. Laboratory-level procedures for implementing the QA requirements are deployed through PNNL's web-based "How Do I…?" (HDI) system, a standards-based system for managing and deploying requirements and procedures to PNNL staff.

## 8.2 Effluent Management QA Program

The Environmental Management M&O Program is implemented by the Effluent Management group under the PNNL Environmental Protection and Regulatory Programs Division (EPRP). The applicable QA requirements are described in the QAP (Barnett 2024) and the related radioactive air quality requirements documents that describe the specific QA elements applicable to each activity (see Table 9).

Table 9. Effluent Management Quality Assurance Requirements Documents for Environmental Radiological Air Monitoring

| |
|---|
| Effluent Management Quality Assurance Plan EM-QA-01 (Barnett 2024) |
| Quality Requirements for Radioactive Air Emissions Sampling and Monitoring |
| Quality Requirements for Radioactive Air Environmental Surveillance Monitoring |

The *PNNL Effluent Management Quality Assurance Plan* addresses the requirements of DOE Order 414.1D and the requirements of EPA QA/R-2 (EPA 2001a) and EPA QA/R-5 (EPA 2001b). The related quality requirements documents were approved by the PNNL QA organization that monitors compliance. Work performed through contracts or statements of work, including sample analyses, must meet the same QA requirements as specified in the QA documents. Potential suppliers of items and services that could have an impact on quality (e.g., analytical services, calibration services, providers of Reference Standard Material), are evaluated before contracts were awarded.

Environmental surveillance activities for radionuclides in ambient air for the PNNL Operations in Richland and Sequim were determined using the DQO process described in the EPA guidance on *Systematic Planning Using the Data Quality Objectives Process* (EPA 2006) (see Table 5).

The DQO process provides a standard working tool for project managers and planners to develop DQOs for determining the type, quantity, and quality of data needed to reach defensible decisions or make credible estimates.

The ERT performs activities to approved and controlled procedures. The QAP and applicable related documents (e.g., *Quality Requirements for Radioactive Air Emissions Sampling and Monitoring* and *Quality Requirements for Radioactive Air Environmental Surveillance Monitoring*) identify applicable work processes and they identify associated procedures and documentation to support overall QA requirements implementation.

Assessments are performed on environmental surveillance activities and procedures to confirm/evaluate compliance with project, PNNL, and DOE quality requirements. The PNSO Manager, PNNL Management, ERT Lead, or Quality Engineer also may initiate an assessment on a routine and/or random basis. Assessment results are documented and provided to the initiating parties. Corrective actions, if needed, are documented and verified (e.g., by a field performance review), as applicable.

# 9.0 Records Management

This section summarizes record keeping requirements for the variety of records generated during PNNL Operations environmental radiological air monitoring and surveillance activities. The SAP and DMP also indicate the specific records maintained by those program components. Records are those documents that furnish auditable evidence of a completed activity or operation or identify the quality of items and/or activities affecting quality. These records (e.g., reports, calculations, analytical data, or photographs) are retained for a specific period of time.

Requirements for maintaining documents and records is described in the QAP (Barnett 2024). Project records are controlled and filed in accordance with the E-Records CASE1830:08-10.

# 10.0 References

10 CFR 830. *Nuclear Safety Management, Subpart A, Quality Assurance Requirements*. Code of Federal Regulations, U.S. Department of Energy.

10 CFR 835. *Occupational Radiation Protection.* Code of Federal Regulations, U.S. Department of Energy.

40 CFR 61. *National Emission Standards for Hazardous Air Pollutants*. Code of Federal Regulations, U.S. Environmental Protection Agency.

40 CFR 61, Appendix D. *National Emission Standards for Hazardous Air Pollutants. Appendix D, Methods for Estimating Radionuclide Emissions.* Code of Federal Regulations, U.S. Environmental Protection Agency.

40 CFR 61, Appendix E. *National Emission Standards for Hazardous Air Pollutants. Appendix E, Compliance Procedures Methods for Determining Compliance with Subpart I.* Code of Federal Regulations, U.S. Environmental Protection Agency.

40 CFR 61, Subpart H. *National Emission Standards for Hazardous Air Pollutants. Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*. Code of Federal Regulations, U.S. Environmental Protection Agency.

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