Pacific Northwest
NATIONAL LABORATORY

PNNL-29068

Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2018

Final

September 2019

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U.S. DEPARTMENT OF ENERGY

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Pacific Northwest National Laboratory
Richland, Washington 99354

Pacific Northwest National Laboratory
Annual Site Environmental Report for 2018
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EXECUTIVE SUMMARY

Pacific Northwest National Laboratory (PNNL), one of the U.S. Department of Energy (DOE) Office of Science's 10 national laboratories, provides innovative science and technology development in the areas of energy and the environment, fundamental and computational science, and national security. DOE's Pacific Northwest Site Office is responsible for oversight of PNNL.

This report provides a synopsis of ongoing environmental management performance and compliance activities conducted during 2018 to meet the requirements of DOE Order 231.1B, *Environmental, Safety and Health Reporting*, and DOE Order 458.1, *Radiation Protection of the Public and the Environment*, assuring that the public is informed of any event that could adversely affect the health and safety of the public, site staff, or the environment. The report addresses the operations that occur on the PNNL Richland Campus in Richland, Washington, and at the PNNL Marine Sciences Laboratory (MSL) near Sequim, Washington. It describes the location of and background for each facility; addresses compliance with all applicable DOE, federal, state, and local regulations and site-specific permits; documents environmental monitoring efforts and their status; presents potential radiation doses to staff and the public in the surrounding areas; and describes DOE-required data quality assurance methods used for data verification.

Compliance with Federal, State, and Local Laws and Regulations in 2018

PNNL is subject to many federal, state, and local environmental laws, regulations, guidance decrees, DOE requirements, and Executive Orders, as well as site-specific permits. Detailed requirements are integrated into all PNNL projects by means of environmental compliance representatives assigned to assess and assist with each project. PNNL continued to exhibit an excellent compliance record in 2018. Required reports were submitted, necessary reviews and permits for research and support activities were obtained, and all sitewide permits were current. Detailed information regarding 2018 compliance may be found in Section 2.0.

Environmental Sustainability Performance

PNNL's environmental management system (EMS) has been certified to meet the requirements of the International Standards Organization (ISO) 14001 standards since 2002, demonstrating commitment to safe and sustainable operations, and satisfying the requirements of DOE Order 436.1, *Departmental Sustainability*. The EMS is integrated into PNNL's Integrated Safety Management Program, which assures that staff are aware of project scope, risks/hazards, and controls available to address functions, processes, and procedures used to plan and perform work safely. PNNL is dedicated to responsible planning for and management of resources that could be affected by facility operations and exhibits excellent environmental sustainability performance in disciplines including energy and water conservation and sustainable building design, thereby assuming a leadership position in planning for a cleaner future. See Section 3.0 for further details concerning environmental and sustainability performance.

Environmental Monitoring and Dose Assessment

PNNL monitors air and water quality to assure compliance with all federal, state, and local regulatory requirements.

Air Emissions. Airborne emissions from PNNL facilities are monitored to assess the effectiveness of emission treatment and control systems as well as pollution management practices. The Benton Clean Air Agency implements and enforces most federal and state requirements on the PNNL Richland Campus, and the Olympic Region Clean Air Agency implements and enforces most federal and state requirements at MSL. There were no unplanned releases of regulated substances or substances of concern from PNNL facilities in 2018 (Sections 2.4, 4.2, and 5.2).

Liquid Effluent Monitoring. Liquid effluent discharges from PNNL Richland Campus operations are monitored under permits issued by the City of

Richland. Process wastewater from MSL is treated at an onsite wastewater treatment plant prior to being discharged to Sequim Bay under a permit issued by the Washington State Department of Ecology. In 2018, there were no unplanned releases of regulated pollutants or contaminated wastewater from PNNL facilities (Sections 2.5.1, 4.1, and 5.1).

Radiological Release of Property. PNNL uses the pre-approved guideline limits derived from guidance in DOE Order 458.1, Chg 3, *Radiation Protection of the Public and the Environment*, when releasing property potentially contaminated with residual radioactive material. No property with detectable residual radioactivity above authorized levels was released from PNNL in 2018 (Section 4.3).

Radiation Protection of Biota. Potential media exposure pathways (air, soil, water, and food) were considered in conjunction with particulate radioactive contamination of air pathways. Calculated dose rates for 2018 were well below dose rate limits for aquatic, terrestrial, and riparian animals and plants for both the PNNL Richland Campus and MSL (Section 4.4).

Environmental Radiological Monitoring. No radiological releases to the environment exceeded permitted limits in 2018.

Radioactive particulates in ambient air are monitored using a particulate air-sampling network located at the PNNL Richland Campus. In 2018, there was no indication that any PNNL activities increased the ambient air concentrations at the air-sampling locations. Maximum exposed individual (MEI) exposure to radionuclide air emissions resulted in a dose estimate of 1.8×10^{-5} mrem (1.8×10^{-7} mSv).

In 2018, within the 80 km (50 mi) radius of the PNNL Richland Campus, the collective dose from radionuclide air emissions that originated from the Campus was 7.6×10^{-5} person-rem (7.6×10^{-7} person-Sv). The PNNL Richland Campus MEI location was 0.64 km (0.40 mi) south-southeast of the Physical Sciences Facility 3410 Building (Section 4.2.1).

The MSL MEI location was 0.23 km (0.15 mi) west of the central emission location at MSL. The dose to the MEI from site emissions was 4.5×10^{-4} mrem (4.5×10^{-6} mSv) (Section 4.2.2). The 80 km (50 mi) collective dose for MSL emissions was 5.0×10^{-4} person-rem (5.0×10^{-6} person-Sv).

The total dose to either the PNNL Richland Campus or MSL MEI is well below the federal and state standard of 10 mrem/yr (0.1 mSv/yr).

Environmental Nonradiological Program Information. PNNL nonradiological air emissions are below levels that require stack monitoring; compliance is achieved by conforming to permit conditions (Section 5.0).

Natural and Cultural Resource Management

Protection and management of cultural and biological resources on PNNL lands is implemented through internal cultural and biological resource protection procedures, which are updated annually to reflect relevant changes in applicable laws and regulations and compliance methods. The *Pacific Northwest Site Office Cultural and Biological Resources Management Plan* provides guidance related to protecting and managing biological and cultural resources at PNNL.

Groundwater Protection

Groundwater under the PNNL Richland Campus is monitored routinely through seven groundwater monitoring wells and four heat pump production wells. Results are reported monthly to the Washington State Department of Ecology. PNNL is in compliance with all permit sampling requirements (Section 6.0).

Quality Assurance

Comprehensive quality assurance programs, which include various quality control practices and methods of verifying data, are maintained by monitoring and surveillance projects to assure data quality (Section 7.0).

ACKNOWLEDGMENTS

Compilation of the Pacific Northwest National Laboratory Annual Site Environmental Report involved the collaboration and expertise of numerous PNNL staff. Principal contributors and their subject matter specialties include the following:

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
µg/L	microgram(s) per liter
µS/cm	microsiemen(s) per centimeter
µSv	microsievert(s)
ac	acre(s)
ALARA	as low as reasonably achievable
ASME	American Society of Mechanical Engineers
ASO	Analytical Support Operations (laboratory)
Battelle	Battelle Memorial Institute
BCAA	Benton Clean Air Agency
BP	Before Present
BPA	Bonneville Power Administration
Bq	bequerel(s)
BSF	Biological Sciences Facility
Btu	British thermal unit(s)
C&D	construction and demolition
CAA	*Clean Air Act*
CBRMP	Cultural and Biological Resources Management Plan
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	Code of Federal Regulations
Ci	curie(s)
cm	centimeter(s)
CSF	Computational Sciences Facility
CWA	*Clean Water Act*
CY	calendar year
CZMA	*Coastal Zone Management Act of 1972*
d	day(s)
DOE	U.S. Department of Energy
DOE-RL	DOE-Richland Operations Office
DOE-SC	DOE Office of Science
dpm	disintegrations per minute
DQO	data quality objective
ECM	energy and water conservation measure
ED	effective dose
EDE	effective dose equivalent
EDL	Engineering Development Laboratory
EISA	*Energy Independence and Security Act of 2007*

EM QAP	effluent management quality assurance plan
EMP	Environmental Management Plan
EMS	environmental management system
EMSL	William R. Wiley Environmental Molecular Sciences Laboratory
EO	Executive Order
EPEAT	Electronic Product Environmental Assessment Tool
EPA	U.S. Environmental Protection Agency
EPCRA	*Emergency Planning and Community Right-to-Know Act of 1986*
ERP	Environmental Research Permitting
ESA	*Endangered Species Act of 1973*
FEMA	Federal Emergency Management Agency
FR	*Federal Register*
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
FY	fiscal year
g	gram(s)
gal	gallon(s)
GBq	gigabecquerel(s)
GEL	General Engineering Laboratories
GHG	greenhouse gas
gpd	gallon(s) per day
gpm	gallon(s) per minute
GRI	Global Reporting Initiative
GSA	General Services Administration
Gy	gray(s)
ha	hectare(s)
HDI	How Do I….?
HPSB	high-performance sustainable building
in.	inch(es)
ISO	International Organization for Standardization
ISO/IEC	International Organization for Standardization/ International Electrotechnical Commission
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kW	kilowatt(s)
L	liter(s)
L/min	liter(s) per minute
lb	pound(s)
LNM	Local Notice to Mariners
LSL2	Life Sciences Laboratory 2
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
m/s	meter(s) per second
MAPEP	Mixed-Analyte Performance Evaluation Program
MDL	method detection limit
MEI	maximum exposed individual
mg	milligram(s)
mg/L	milligram(s) per liter
mGy/d	milligray(s) per day
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
MMPA	*Marine Mammal Protection Act of 1972*
MoU	Memorandum of Understanding
mph	mile(s) per hour
mrem	millirem
mrem/yr	millirem per year
MSFCMA	*Magnuson–Stevens Fishery Conservation and Management Act*
MSL	Marine Sciences Laboratory
mSv	millisievert(s)
mSv/yr	millisievert(s) per year

N/A	not applicable
ND	nondetectable
NEPA	*National Environmental Policy Act of 1969*
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NQA	nuclear quality assurance
NRHP	National Register of Historic Places
OAR	Oregon Administrative Rules
ORCAA	Olympic Region Clean Air Agency
PATON	permit and/or private aid to navigation
PCB	polychlorinated biphenyl
pCi/m^3	picocurie(s) per cubic meter
pCi/mL	picocurie(s) per milliliter
PIC-5	Potential Impact Category 5
PNL	Pacific Northwest Laboratory
PNNL	Pacific Northwest National Laboratory
PNSO	Pacific Northwest Site Office
PSF	Physical Sciences Facility
PSL	Physical Sciences Laboratory
QC	quality control
R&D	research and development
RAEL	radioactive air emission license
RCRA	*Resource Conservation and Recovery Act of 1976*
RESL	Radiological and Environmental Sciences Laboratory
RHA	*Rivers and Harbors Appropriations Act of 1899*
RTL	Research Technology Laboratory
RCW	Revised Code of Washington
s	second(s)
SEPA	*State Environmental Policy Act*
SHPO	State Historic Preservation Officer
SMA	*Shoreline Management Act of 1971*
Sv	sievert(s)
USACE	U.S. Army Corps of Engineers
U.S.C.	U.S. Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington State Department of Health
yr	year(s)

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) requires that all its site facilities develop an annual site environmental report to comply with DOE Order 231.1B, Chg 1, *Environment, Safety and Health Reporting*, and DOE Order 458.1, Admin Chg 3, *Radiation Protection of the Public and the Environment*. This report provides a synopsis of calendar year (CY) 2018 information related to environmental management performance and compliance efforts at Pacific Northwest National Laboratory (PNNL). It summarizes site compliance with federal, state, and local environmental laws, regulations, policies, directives, permits, and Orders, and provides environmental management performance benchmarks and their status to the public, regulatory agencies, community officials, Native American tribes, and public interest groups.

PNNL—one of 10 DOE Office of Science (DOE-SC) national laboratories—provides innovative science and technology solutions in energy and the environment, fundamental and computational science, and national security disciplines. Operated by Battelle Memorial Institute (Battelle) under contract to DOE-SC's Pacific Northwest Site Office (PNSO), PNNL performs work for a diverse set of clients, including the National Nuclear Security Administration, U.S. Department of Homeland Security, U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency (EPA), DOE Office of Environmental Management, and other federal agencies, as well as private industry. PNSO is responsible for program implementation, acquisition management, and laboratory stewardship at PNNL. Through its oversight role, PNSO manages the safe and efficient operation of PNNL while enabling the pursuit of visionary research and development (R&D) in support of complex national energy and environmental missions.

As part of PNNL's commitment to environmental stewardship, staff members conduct surveillance and monitoring tasks to confirm compliance with established standards and specific permit limits, as well as to provide information regarding any impacts on the environment from operations.

1.1 Location

PNNL includes facilities at the PNNL Richland Campus in Richland, Washington, and at the Marine Sciences Laboratory (MSL) near Sequim, Washington (Figure 1.1). Environmental activities at other locations are also included if they are under PNNL's responsibility (e.g., a permitted waste storage and treatment unit on the Hanford Site). In addition, PNNL conducts research at satellite offices in various other locations, including Seattle, Washington, and Portland, Oregon, as well as in various offsite field locations.

Figure 1.1. Locations of the PNNL Richland Campus and PNNL Marine Sciences Laboratory in Washington State

1.1.1 PNNL Richland Campus

The PNNL Richland Campus covers approximately 269 ha (664 ac) and is located in Benton County in southeastern Washington State, 275 km (171 mi) east-northeast of Portland, Oregon, 270 km (168 mi) southeast of Seattle, Washington, and 200 km (124 mi) southwest of Spokane, Washington. It is located at the northern boundary of the City of Richland, south of the DOE-Richland Operations Office's (DOE-RL's) Hanford Site 300 Area, and east of approximately 664 ha (1,641 ac) of Hanford Site land that was transferred to the City of Richland, Port of Benton, and Energy Northwest for economic development. PNNL also leases facilities located on private land and on the campus of Washington State University–Tri-Cities (Figure 1.2).

1.1.2 PNNL Marine Sciences Laboratory

MSL is located at the mouth of Sequim Bay, near the town of Sequim on the northern portion of the Olympic Peninsula in Clallam County, Washington. The Battelle Land–Sequim area encompasses 60.7 ha (149 ac) of uplands and tidelands, about 3 ha (7.4 ac) of which have been developed for research operations (Figure 1.3). The developed areas include MSL facilities, an innovative seawater treatment system, research docks, and outdoor experimental tanks and ponds. Research scientists and engineers at

MSL perform R&D in marine sciences, sustainable energy including algal biofuels, climate change and ocean acidification, biofouling/ biocorrosion, ultratrace detection for high fidelity sensing and forensics, coastal risk/hazard prediction and analysis, and quantifying transport, fate, and effects of chemicals in marine environments. DOE has exclusive use of about 36 ha (89 ac) of Battelle Land–Sequim, including the MSL facilities (Figure 1.3). All MSL operations are consolidated under PNSO oversight.

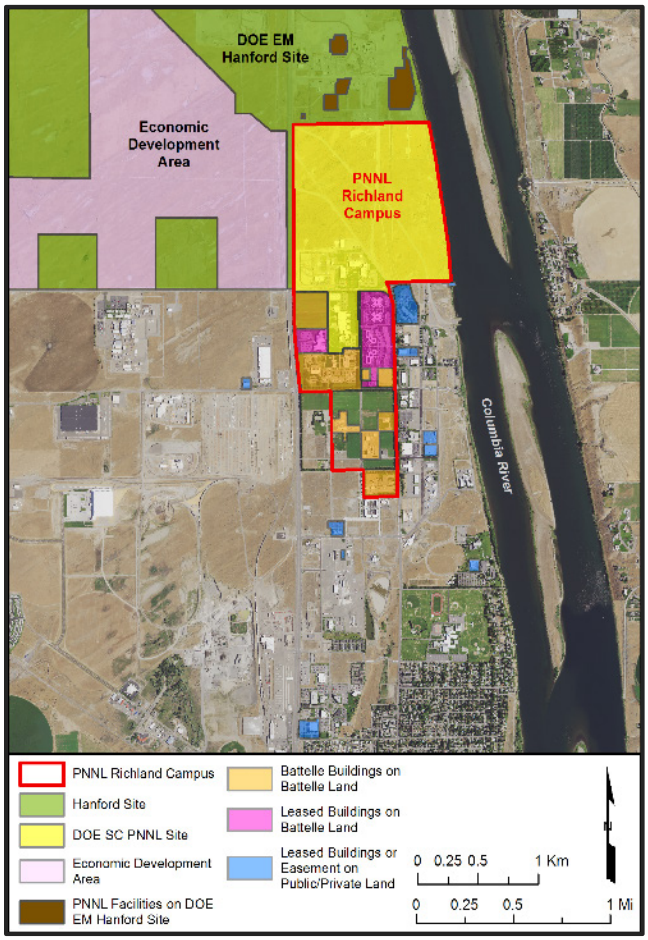


Figure 1.2. Pacific Northwest National Laboratory Richland Campus and Surrounding Area

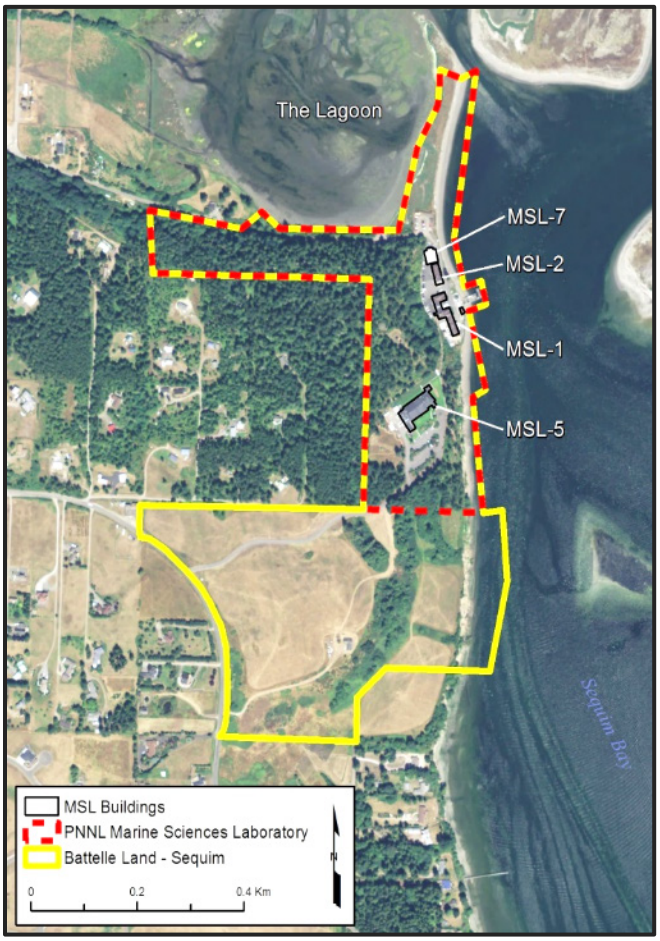


Figure 1.3. Battelle Land–Sequim Encompassing the PNNL Marine Sciences Laboratory Facilities and Surrounding Environment

1.2 Background and Mission

1.2.1 PNNL Richland Campus

In January 1965, Battelle was awarded the Pacific Northwest Laboratory (PNL) contract to operate the Hanford Site laboratories. In addition, Battelle invested its own funds to construct facilities to conduct non-Hanford Site research to promote R&D in the Pacific Northwest. In the late 1970s, research expanded to include energy, health, environment, and national security ventures. PNL contributed to areas including robotics, environmental monitoring, material coatings, veterinary medicine, and the formation of new plastics. In 1995, PNL was renamed Pacific Northwest National Laboratory. Over the years, PNNL researchers have developed versatile technologies, earning numerous R&D 100 awards, Federal Laboratory Consortium awards, Innovation awards, and patents for their R&D work and contributions.

PNNL is operated by Battelle for DOE-SC's PNSO, which was established in 2003. PNSO is responsible for overseeing all PNNL activities and for monitoring the Laboratory's compliance with applicable laws, policies, and DOE Orders. Research efforts on the PNNL Richland Campus include the development and analysis of high-performance materials for energy, construction, and transportation technologies and systems; national security-related radiation detection methodologies, including electromagnetics/

radiography, optics/infrared spectroscopy, and acoustics/ultrasonics; systems biology research, which develops comprehensive monitoring programs and performs environmental and biotechnology research; visual analytics technologies; cyber analytics; and critical infrastructure assessment and protection.

1.2.2 PNNL Marine Sciences Laboratory

In 1967, Battelle acquired acreage on Sequim Bay on the Strait of Juan de Fuca in Washington's Puget Sound near the City of Sequim. As part of Battelle's commitment to developing research facilities to benefit the region and serve the environment, the Marine Research Laboratory near Sequim was constructed to provide laboratories for marine-related work involving biology, physiology, histology, chemistry, physics, and engineering. In 1973, the Marine Research Laboratory opened; it was later renamed Marine Research Operations and is now referred to as MSL.

In October 2012, the PNNL operating contract was revised, giving DOE exclusive use of MSL and consolidating operations under PNSO oversight. Currently, researchers at MSL provide innovative science and technology solutions critical to the nation's energy, environmental, and security future. Capabilities are based on expertise in biotechnology, biogeochemistry, ecosystems science, toxicology, and earth systems modeling. In addition, a scientific dive team supports in-water research and analysis. The research laboratories encompass more than 15,000 ft^2 (1,400 m^2) of area, which includes an innovative seawater treatment system that treats up to 909 L (200 gal) per minute of sea water to remove chemical and biological impurities before returning the water to Sequim Bay. Research efforts include algal biofuels; biofouling/biocorrosion; climate change; environmental monitoring; quantifying transport, fate, and effects of chemicals in marine environments; coastal risk/hazard prediction and analysis; and detection and signature development against threats.

1.3 Demographics

The PNNL Richland Campus is located in Benton County, Washington, south of the Hanford Site, in an area that is primarily flat, semi-arid, and restricted from public access. Residents north and east of Hanford Site generally live on farms or in farming communities. Residents south, southwest, and west of the PNNL Richland Campus live in the urban communities of Richland, Kennewick, Pasco, and West Richland.

In 2018, an estimated 201,900 people lived in Benton County and 94,300 people lived in adjacent Franklin County, increases of 15.2% and 20.7%, respectively, over 2010 figures (USCB 2019). During 2018, Benton and Franklin Counties accounted for 3.9% of Washington's population. Based on U.S. Census population data, the population within an 80 km (50 mi) radius of the PNNL Richland Campus is estimated to be about 432,000. This population estimate is used to calculate the radiation dose to the general public (Section 4.2).

MSL is located in Clallam County, Washington, an area of approximately 4,500 km^2 (1,740 mi^2) on the Olympic Peninsula in the northwestern corner of Washington State. An estimated 76,700 people lived in Clallam County in 2018, an increase of approximately 7.5% over 2010 figures and equivalent to approximately 1% of Washington's population (USCB 2019). Sequim, the nearest population center to MSL, had a population of 7,481 people in 2018 (USCB 2019).

1.4 Environmental Setting – PNNL Richland Campus

The PNNL Richland Campus has had varying degrees of previous disturbance. Upland areas with lower levels of prior disturbance largely support native shrub-steppe vegetation, while more heavily disturbed uplands support more invasive, non-native vegetation. Other areas have undergone complete habitat conversion and contain facilities that have landscaping and xeriscaping. The Columbia River riparian zone within the PNNL Richland Campus area is largely undisturbed and supports both native and non-native vegetation.

1.4.1 Geology and Soils

The PNNL Richland Campus lies above a gentle syncline formed by the intersection of the Yakima Fold Belt and the gently west-dipping Palouse Slope. The uppermost basalt flow belongs to the Ice Harbor Member of the Saddle Mountains Basalt. The overlying sediment layers are relatively thin, consisting of Ringold Formation and Hanford formation sediments. These sediment layers are predominantly coarse sandy alluvial deposits mantled by windblown sand. A generalized suprabasalt stratigraphic column showing what underlies the PNNL Richland Campus is shown in Figure 1.4. The stratigraphic column for the upper Ringold Formation and the Hanford formation is based on information obtained from the drilling of 11 boreholes within the footprint of the Biological Sciences Facility/Computational Sciences Facility (BSF/CSF) on the PNNL Richland Campus (Freedman et al. 2010).

The Hanford formation, a highly permeable mixture of sand and gravel that was deposited by Ice Age floods during the late Pleistocene period, comprises unconsolidated sediments that range in size from boulder-sized gravel to sand, silt, and clay. Late Miocene- to Pliocene-age sediments of the Ringold Formation underlie the Hanford formation. The Ringold Formation displays lower hydraulic conductivity and is texturally and structurally distinct from the overlying Hanford formation. Ringold Formation sediments contain sands, gravels, and muds that are typically more consolidated and less permeable than those in the Hanford formation. The basalt underlying the Ringold Formation has a very low vertical hydraulic conductivity, and forms an aquitard between the base of the unconfined aquifer and the confined aquifers within the basalt formations.

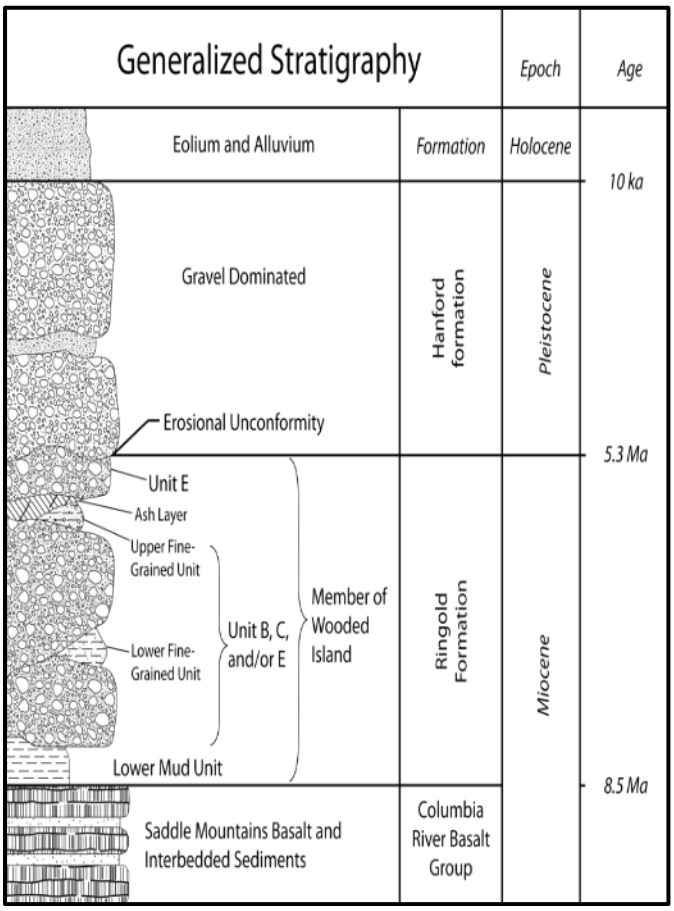


Figure 1.4. Generalized Stratigraphic Column Depicting the Stratigraphy Underlying the PNNL Richland Campus (modified from Reidel et al. 1992; Thorne et al. 1993; Lindsey 1995; Williams et al. 2000; DOE-RL 2002; and Williams et al. 2007)

1.4.2 Hydrology

The general direction of groundwater flow under the PNNL Richland Campus is toward the east-northeast from the Yakima River to the Columbia River (Figure 1.5). Field data collected on and around the PNNL Richland Campus indicate that the unconfined aquifer is predominantly in the Ringold Formation; however, depending on the water table elevation, the aquifer may inundate portions of the Hanford formation. The vadose zone below the PNNL Richland Campus, is about 15 m (49 ft) thick; its thickness generally decreases with proximity to the Columbia River, as the ground surface slopes toward the river. This zone consists of unsaturated sediments between the ground surface and the water table, predominantly within the Hanford formation (Newcomer 2007).

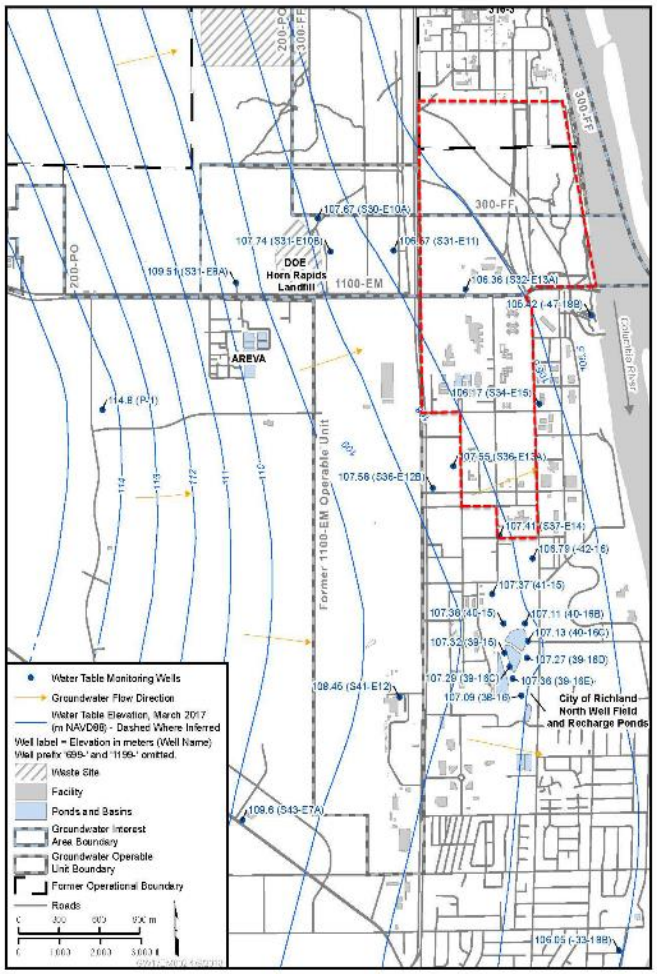


Figure 1.5. Water Table Elevations (m) in 2017 (modified from DOE-RL 2018a). Groundwater flow direction is normal to the water table contour lines. The approximate PNNL Richland Campus is outlined in red.

1.4.3 Flooding

While large Columbia River floods have occurred in the past, the likelihood of recurrence of large-scale flooding has been reduced by the construction of dams on the Columbia River. The largest flood on record for the Columbia River occurred in 1894 and had an estimated peak discharge of 21,000 m^3/s (742,000 ft^3/s) at the Hanford Site; the largest recent flood took place in 1948 and had an estimated peak discharge of 20,000 m^3/s (700,000 ft^3/s) (Duncan 2007). Exceptionally high runoff during the spring of 1996 resulted in a maximum discharge of nearly 11,750 m^3/s (415,000 ft^3/s) (Duncan 2007). The flood plain associated with the 1894 flood has been modeled based on topographic cross sections of the river; no portion of the PNNL Richland Campus was within this area.

The probable maximum flood has an unspecified, but very large return period (generally much greater than 500 years). Based on modeling conducted in 1976, the Hanford Site would be unaffected by the probable maximum flood on the Columbia River, a discharge of about 39,600 m^3/s (1.4 million ft^3/s) (Duncan 2007). A flood of this magnitude would result in a water-surface elevation of 119 m (390 ft) at the Columbia Generating Station, located about 12 km (7.5 mi) north of the PNNL Richland Campus (Energy Northwest 2011). The standard project flood, a flood that would occur during the combination of the harshest meteorological and hydrological conditions, has an unspecified return period, usually greater than several hundred years (Linsley et al. 1992). The regulated standard project flood used by the U.S. Army Corps of Engineers for the Columbia Generating Station is 16,100 m^3/s (570,000 ft^3/s) (Energy Northwest 2011). The 100-year regulated flood discharge for the Columbia River along the northern boundary of the Hanford Site is estimated to be 12,500 m^3/s (440,000 ft^3/s) (Duncan 2007); corresponding discharge at the PNNL Richland Campus would be somewhat larger. The Federal Emergency Management Agency (FEMA) floodplain maps extend only to the southern boundary of the PNNL Richland Campus (FEMA 1984). However, FEMA maps suggest that the PNNL Richland Campus, with a ground-surface elevation of about 122 m (400 ft), would be unaffected by a 100-year flood.

1.4.4 Climate and Meteorology

The rain-shadow effect of the Cascade Range, west of Yakima, influences the climate at the PNNL Richland Campus. North of the PNNL Richland Campus, the Rocky Mountains and ranges in southern British Columbia protect the region from severe, cold polar air masses moving southward across Canada and the winter storms associated with them. The Hanford Meteorological Station operates an array of remote meteorological towers across the Hanford Site. Staff at the Hanford Meteorological Station conduct meteorological monitoring to support Hanford Site operations, emergency preparedness and response, and atmospheric dispersion calculations for dose assessments. Normal monthly average temperatures on the Hanford Site range from a low of –0.5°C (31.1°F) in December to a high of 25.1°C (77.2°F) in July (DOE 2019). The maximum high temperature in 2018 was 42.8°C (109°F); the minimum was -11.7°C (11°F). The average annual temperature at the Hanford Site in 2018 was 13.0°C (55.4°F), 0.8°C above the 30-year average (1981–2010) of 12.2°C (53.9°F) (DOE 2019). The normal annual relative humidity at

the Hanford Meteorology Station is 55.3%; humidity is highest during winter, when it averages approximately 77%, and lowest during summer, when it averages 36.5%. Precipitation for 2018 was 16.3 cm (6.43 in.), 5.7% below average (17.3 cm [6.81 in.]) (DOE 2019).

Monthly average wind speeds are lowest during winter months, averaging about 3 m/s (7 mph), and highest during summer, averaging about 4 m/s (9 mph), but frequently exceed 13 m/s (30 mph) (DOE 2019).

Atmospheric dispersion is a function of wind speed, wind duration and direction, atmospheric stability, and mixing depth. Dispersion conditions are generally good if winds are moderate to strong, the atmosphere is of neutral or unstable stratification, and there is a deep mixing layer. Good dispersion conditions associated with neutral and unstable stratification exist approximately 57% of the time at the Hanford Site during summer (Poston et al. 2011). During winter, moderate to extremely stable stratification exists (approximately 66% of the time).

Fog has been recorded during every month of the year at the Hanford Meteorology Station; however, fog occurs mostly from November through February. Additional visibility reductions can occur in the form of windblown dust; the region has averaged four dust storms per year for the entire period of record (1945–2018) (DOE 2019).

1.4.5 Ecology

The PNNL Richland Campus is located in the lowest and most arid portion of the Columbia Plateau Ecoregion (LandScope Washington 2019; EPA 2013). The portion of the PNNL Richland Campus north of Horn Rapids Road (Figure 1.6) was previously part of the Hanford Site, and had been protected from agricultural use and development since 1943. It is still mostly dominated by native shrub-steppe vegetation and thus retains much of its native biodiversity and community structure (Figure 1.6). These areas are dominated by climax shrubs such as big sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*), with a noticeable component of native perennial bunchgrasses within an introduced annual grass understory. The portion of the PNNL Richland Campus south of Horn Rapids Road has been developed to various extents and consists of a mosaic of maintained landscapes, fallow agricultural fields, and previously disturbed, early-successional habitats dominated by introduced annual grasses or subclimax shrubs, such as common rabbitbrush (*Ericameria nauseosa*) (Figure 1.6). The more mature and undisturbed shrub-steppe communities generally support greater plant species diversity. Approximately 154 plant species, 36 bird species, and 9 other wildlife species have been observed in upland portions of the PNNL Richland campus (Appendix A).

A relatively undisturbed riparian community exists along the Columbia River shoreline north of Horn Rapids Road (Figure 1.6). The riparian community is limited to a narrow band of multilayered trees including Siberian elm (*Ulmus pumila*), white mulberry (*Morus alba*), and poplars (*Populus* spp.); shrubs such as coyote willow (*Salix exigua*) and rose (*Rosa woodsia*); and herbaceous and grass species. Species diversity is high in the riparian zone given its relatively small area. Approximately 87 plant species, 29 bird species, and 5 other wildlife species have been observed in the riparian zone of the PNNL Richland campus (Appendix A).

Priority habitats are those habitat types or elements that have unique or significant value to a diverse assemblage of species. Both the shrub-steppe and riparian habitats are listed by the Washington Department of Fish and Wildlife (WDFW) as priority habitats for the state and are considered to be priorities for management and conservation (WDFW 2019a).

The Hanford Reach of the Columbia River is adjacent to the eastern edge of the PNNL Richland Campus. This river supports a diverse fish and invertebrate community including three species listed under the *Endangered Species Act* (ESA) (Table 1.1). The Columbia River is designated as critical habitat for these species under the ESA (70 FR 52630, 75 FR 63898).

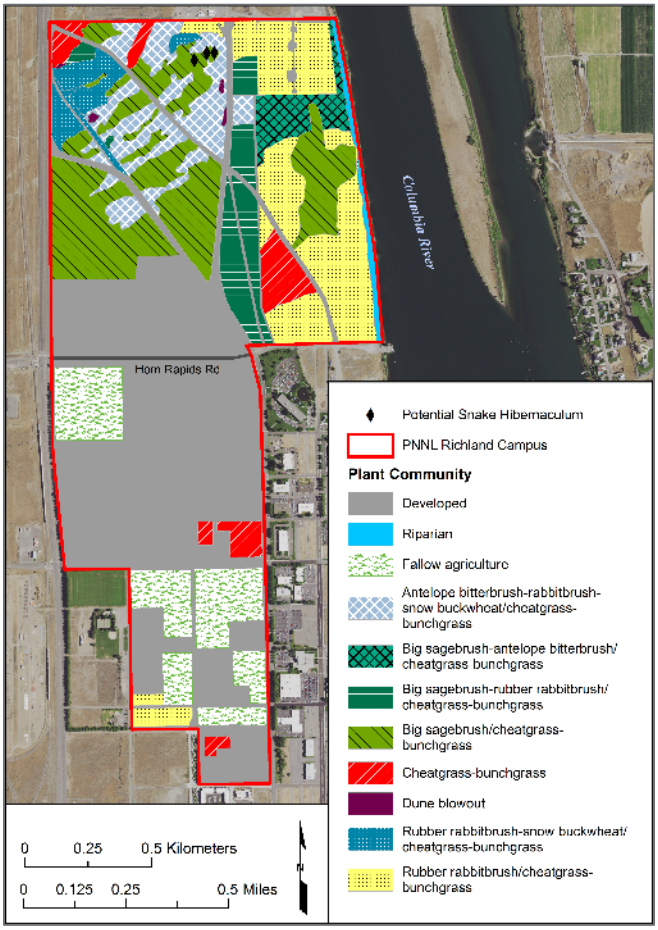


Figure 1.6. Habitat Polygons Located on the PNNL Richland Campus

Federal and state-listed wildlife and plant species known to occur or that potentially occur on or near the PNNL Richland Campus were identified using sources from the WDFW (2019b) and Washington Natural Heritage Program (WNHP 2018) and are listed in Table 1.1. The bald eagle (*Haliaeetus leucocephalus*), American white pelican (*Pelecanus erythrorhynchos*), sagebrush sparrow (*Artemisiospiza nevadensis*), and black-tailed jackrabbit (*Lepus californicus*) have been observed on the upland portions of the PNNL Richland Campus (see Appendix A).

1.5 Environmental Setting – PNNL Marine Sciences Laboratory Vicinity

Battelle Land–Sequim is located on Sequim Bay in Puget Sound and consists of forests, sandy beach shoreline, a bluff line, and developed areas with roads and structures (Figure 1.3). MSL facilities include buildings on the shoreline as well as structures approximately 27 m (89 ft) higher in elevation on a bluff overlooking the ocean.

The geology immediately underlying MSL is composed of glacial till from the Vashon glaciations that occurred 10,000 to 15,000 years ago. This glacial till sits atop several alternating layers of coarse- and fine-grained units, and ultimately bedrock around 305 m (1,000 ft) below ground surface. This layered stratigraphy results in several confined aquifers below the region as well as the uppermost unconfined aquifer. The aquifer units (both confined and unconfined) consist primarily of coarse-grained sand and gravel, while the confining units generally consist of fine-grained silt and clay deposits, but may contain discontinuous lenses of water-bearing sand and gravel (Thomas et al. 1999). The unconfined aquifer is nominally 9 m (30 ft) below ground surface under most of the MSL, and it moves in a northeasterly direction toward Sequim Bay.

Daily meteorological data are collected at the MSL weather station. The region is positioned in the rain shadow of the Olympic Mountains, so it receives less than 38 cm (15 in.) of rainfall annually despite its coastal location; average rainfall in 2018 was 31.5 cm (12.4 in.). The area experiences cool, wet winters and warm, dry summers; average monthly temperatures in 2018 ranged from 4.9°C to 15.8°C (40.8°F to 60.4°F). The annual average temperature in 2018 was 10.4°C (50.7°F); maximum temperature was 29.2°C (84.6°F) and minimum was -3.2°C (26.2°F). The annual relative humidity at MSL was 86.8% in 2018; humidity was highest during fall, when it averaged approximately 89.7%, and lowest during spring, when it averaged 84.2%. Regional winds are primarily from the west and northwest; however, the local topography of Battelle Land–Sequim also has localized wind patterns from the southeast and east. Wind speed averaged 1.1 m/s (2.4 mph) in 2018 at MSL; peak wind speed, 19.7 m/s (44.0 mph), occurred in the fall.

Table 1.1. Wildlife, Fish, and Plant Species of Conservation Concern Known to Occur or That Potentially Occur near the PNNL Richland Campus

Common Name	Genus and Species	Federal Status[a]	State Status[b]
Wildlife			
American white pelican	*Pelecanus erythrorhynchos*		Threatened
Bald eagle	*Haliaeetus leucocephalus*	Species of Concern	
Black-tailed jackrabbit	*Lepus californicus*		Candidate
Burrowing owl	*Athene cunicularia*		Candidate
Loggerhead shrike	*Lanius ludovicianus*		Candidate
Northern sagebrush lizard	*Sceloporus graciosus*		Candidate
Sagebrush sparrow	*Artemisiospiza nevadensis*		Candidate
Striped whipsnake	*Masticophis taeniatus*		Candidate
Townsend ground squirrel	*Urocitellus townsendii townsendii*		Candidate
Fish			
Upper Columbia River spring Chinook salmon	*Oncorhynchus tshawytscha*	Endangered	Candidate
Upper Columbia River steelhead	*Oncorhynchus mykiss*	Threatened	Candidate
Plants			
Awned halfchaff sedge	*Lipocarpha aristulata*		Threatened
Beaked spike-rush	*Eleocharis rostellata*		Sensitive
Canadian St. Johnswort	*Hypericum majus*		Sensitive
Columbian yellowcress	*Rorippa columbiae*		Threatened
Grand redstem	*Ammania robusta*		Threatened
Great Basin gilia	*Aliciella leptomeria*		Threatened
Loeflingia	*Loeflingia squarrosa*		Threatened
Lowland toothcup	*Rotala ramosior*		Sensitive
Rosy pussypaws	*Calyptridium roseum*		Threatened
Suksdorf monkeyflower	*Erythranthe suksdorfii*		Sensitive

Sources: WDFW (2019b) and WNHP (2018)

(a) Federal species of concern are those that may be in need of conservation actions, ranging from monitoring of populations and habitat to listing the species as federally threatened or endangered. Federal species of concern receive no legal protection and the classification does not imply that the species is being considered for listing as threatened or endangered (USFWS 2019).

(b) Candidate animal species are those fish and wildlife species that the Washington Department of Fish and Wildlife will review for possible listing as endangered, threatened, or sensitive (WDFW 2019b). Threatened plant species are those that are likely to become endangered within the near future in Washington if the factors contributing to their population decline or habitat loss continue. Endangered plant species are in danger of becoming extinct or extirpated from the state of Washington. Sensitive species are those that are vulnerable or declining and could become endangered or threatened in the state without active management or removal of threats (WNHP 2018).

1.5.1 Ecology

The MSL (Figure 1.3) lies in the Olympic Rain Shadow subdivision of the Puget Lowland Ecoregion, a north-south depression between the Olympic Peninsula and western slopes of the Cascade Mountains that flank the coastline of Puget Sound (LandScope Washington 2019; EPA 2013). Timber harvesting and cultivation have removed and fragmented the original coniferous forest and prairie-oak woodland (WWF 2019). Today, the region consists mostly of second-growth coniferous forest and agricultural fields; little of the original forest habitat remains (EPA 2013; LandScope Washington 2019).

The uplands at MSL consist of mixed conifer forest dominated by Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*), and field/meadow, bluff, sand spit, and developed areas (Figure 1.7). Areas below the bluff include a laboratory and support facilities, a tidal beach area, a sand spit, and approximately 2.6 ha (6.5 ac) of estuarine and marine wetlands. Approximately 107 plant species, 87 bird species, and 7 other wildlife species have been observed during several biological surveys of MSL (Appendix B).

The relatively undisturbed nearshore areas of Puget Sound and the open coast are listed by the WDFW as priority habitat for the state (WDFW 2019a), and are therefore considered to be a priority for management and conservation (Clallam County 2017). The feeder bluffs adjacent to MSL, which are an important source of sediments that form and sustain beaches, are also considered a priority for conservation (Clallam County 2017, WDFW 2019a). Nearly 90 avian species, representing all common avian groups, have been observed in the MSL vicinity as well as several mammals and amphibians (Appendix B).

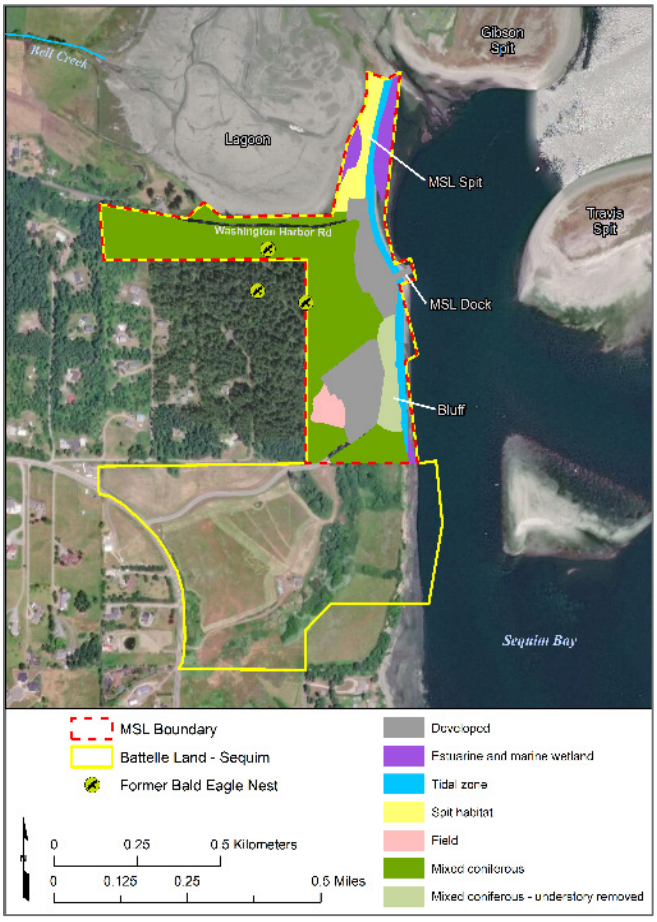


Figure 1.7. Plant Communities and Locations of Former Bald Eagle Nests at MSL

The nearshore and open-water environment of Sequim Bay provides potential habitat for various aquatic and terrestrial species, most notably several federally listed threatened species (Table 1.2). Several marine mammals, including harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), Dall's porpoise (*Phocoenoides dalli*), and harbor porpoise (*Phocoena phocoena*) inhabit Sequim Bay. Klapot Point on the southwest tip of Travis Spit, located across the mouth of Sequim Bay from MSL (Figure 1.7), provides a haulout area for harbor seals. Although rare, killer whales (*Orcinus orca*) have been observed in Sequim Bay.

Three terrestrial animal species of conservation concern are known to occur or potentially occur near MSL facilities, as well as eight aquatic and two invertebrate species of conservation concern (Table 1.2). Several, including the bald eagle and peregrine falcon (*Falco peregrinus*), have been observed on MSL property (Appendix B). No plant species of state or federal concern are currently known to occur near the MSL. Sequim Bay is designated critical habitat for some of the federally listed species in Table 1.2 (70 FR 52630, 75 FR 63898, 79 FR 68041).

Table 1.2. Animal Species of Conservation Concern Known to Occur or that Potentially Occur at and in the Vicinity of the PNNL Marine Sciences Laboratory

Common Name	Genus and Species	Federal Status[a]	State Status[b]
Wildlife			
Bald eagle	*Haliaeetus leucocephalus*	Species of Concern	
Brandt's cormorant	*Phalacrocorax penicillatus*		Candidate
Peregrine falcon	*Falco peregrinus*	Species of Concern	
Fish			
bull trout	*Salvelinus confluentus*	Threatened	Candidate
Hood Canal summer-run chum salmon	*Oncorhynchus keta*	Threatened	Candidate
North American green sturgeon	*Acipenser medirostris*	Threatened	
Pacific eulachon	*Thaleichthys pacificus*	Threatened	Candidate
Puget Sound bocaccio	*Sebastes paucispinis*	Endangered	Candidate
Puget Sound Chinook salmon	*Oncorhynchus tshawytscha*	Threatened	Candidate
Puget Sound steelhead	*Oncorhynchus mykiss*	Threatened	
yelloweye rockfish	*Sebastes ruberrimus*	Threatened	Candidate
Invertebrates			
Sand-verbena moth	*Copablepharon fuscum*		Candidate
Taylor's checkerspot butterfly	*Euphydryas editha taylori*	Endangered	Endangered

Source: WDFW (2019b)

(a) Endangered species are those in danger of extinction throughout all or a significant portion of their range. Species of concern are those that may be in need of conservation actions that could range from monitoring of populations and habitat to listing them as federally threatened or endangered. Federal species of concern receive no legal protection and the classification does not imply that the species is being considered for listing as threatened or endangered (USFWS 2019).

(b) Endangered species are those that are native to the state of Washington and are seriously threatened with extinction throughout all or a significant portion of their range within the state (WAC 232-12-297). Candidate species are those that WDFW will review for possible listing as endangered, threatened, or sensitive.

1.6 Cultural Setting – PNNL Richland Campus

The archaeological record of the Mid-Columbia Basin bears evidence of more than 10,000 years of human occupation. The history of the Mid-Columbia Basin includes four distinct periods of human occupation: the Precontact period, the Ethnographic period, the Euro-American period, and the Manhattan Project period.

1.6.1 Precontact Period

Archaeological investigations conducted throughout the Columbia Plateau provide a definitive cultural chronology dating back to the end of the Pleistocene (about 11,000 years before present [BP]). The protected area of the Hanford Site has contributed to the extensive archaeological deposits documenting thousands of years of Precontact human activity throughout the Columbia Plateau. The archaeological record shows a progression from the earliest inhabitants who were mobile, lived in caves or rock shelters, and subsisted primarily by hunting large mammals, to the development of dwellings approximately 4,500 years ago when the inhabitants subsisted on a more diverse diet, to the eventual creation of pit houses and long-house villages and a subsistence centered around riverine resources, especially salmon.

1.6.2 Ethnographic Period

The ethnohistoric/ethnographic period began in the late 1700s to the early 1800s at the time of initial American Indian contact with non-Native American settlers in the area and extends to the present day. Ethnohistorically, the Walla Walla, Palouse, Nez Perce, Umatilla, Wanapum, and Yakama used land now encompassed by the Hanford Site. The Wanapum band reportedly occupied village sites along the Columbia River from as far north as the Wenatchee River to its confluence with the Snake River. Fishing sites at Priest Rapids and in the vicinity were used by other surrounding groups, including the Yakama,

Wallula, Nez Perce, Palus, Columbia, and Spokane (Galm et al. 1981). Residents relied on a pattern of seasonal rounds that included semi-permanent residences in villages along major waterways during the winter months. Subsistence focused on seasonally available plant and animal resources. Documented archaeological sites in the vicinity of the PNNL Richland Campus include fishing and village sites along the shoreline, stone quarrying sites, temporary camps, and plant processing locations (Schroeder and Landreau 2012; Hodges et al. 2003; Smith 1910).

1.6.3 Euro-American Period

The Lewis and Clark expedition of 1805 began the Euro-American exploration and settlement of the region. Explorers sought trade items from Native Americans and trade routes were established. Gold miners, livestock producers, and homesteaders soon followed. By the 1860s, the discovery of gold north and east of the mid-Columbia region resulted in an influx of miners traveling through the area. Ringold, White Bluffs, and Wahluke were stops along the transportation routes used by miners and the supporting industry. The mining industry created a demand for beef, and the Mid-Columbia Basin was ideal for livestock production. An increase in Euro-American settlement began in eastern Washington in the late 1800s, first by livestock producers then by homesteaders who settled the area and plowed the rangeland to plant crops beginning in the 1880s.

As farming increased, water resources other than rainfall were needed to produce higher crop yields. Many irrigation projects began; most were privately and insufficiently funded. Land speculators began constructing large-scale irrigation canals to supply water to thousands of acres in the White Bluffs, Hanford, Fruitvale, Vernita, and Richland areas (Sharpe 1999). However, poor economic conditions associated with the Great Depression of the 1930s created economic hardship for local residents. The hardship continued until the government took over the area under the *First War Powers Act of 1941* (50 U.S.C. App. 601 *et seq.*) (Marceau et al. 2003).

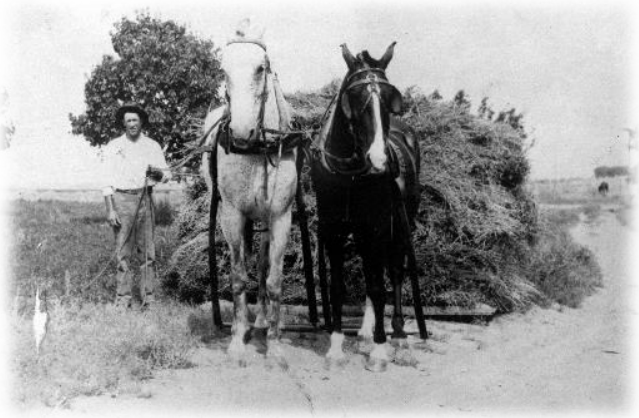
1.6.4 Manhattan Project and Cold War Era

In 1942, the area around Hanford, Washington, was selected by the federal government as one of the three principal Manhattan Project sites. Occupying portions of Grant, Franklin, and Benton Counties, the Hanford Site was created to support the United States' plutonium-production effort during World War II. Plutonium production, chemical separation, and R&D focused on process improvements and were the primary activities during the Manhattan Project, as well as the subsequent Cold War Era.

The Hanford Site underwent a major expansion at the beginning of the cold war in the late 1940s. The town of North Richland was developed as a construction camp that eventually housed more than 13,000 people in barracks and more than 2,000 trailers. The town had a school, hospital, police and fire service, and entertainment facilities such as a tavern, movie theater, and stores. The town waned in the early 1950s as Hanford construction slowed, but the area continued to be used as Camp Hanford, headquarters for an Army battalion that first operated anti-aircraft batteries and eventually Nike missile bases around the Hanford Site. Camp Hanford closed in 1961 after the Nike missiles were decommissioned. In 1965 the Atomic Energy Commission tried to help diversify the Tri-Cities economy by restructuring the Hanford contracts and requiring new contractors to invest in new private ventures and facilities. Battelle Memorial Institute was awarded the research contract to run the Pacific Northwest Laboratory (eventually PNNL) in 1966. Battelle purchased 93 ha (230 ac) of former North Richland/Camp Hanford land, and hired the firm of Naramore, Bain, Brady, and Johanson to design the first four buildings of the PNNL Richland Campus. These buildings along with others that were completed by the early 1970s, now are each individually eligible for listing on the National Register of Historic Places and constitute a recommended Historic District. PNNL was assigned to the DOE Office of Science in 2003, and approximately 176 ha (434 ac) of former Hanford land was reassigned from the DOE Office of Environmental Management to PNSO in several actions between 2003 and 2016; the remaining 93 ha (230 ac) of the PNNL Richland Campus are still owned by Battelle.

1.7 Cultural Setting – PNNL Marine Sciences Laboratory Vicinity

The archaeological record suggests the presence of northwest coastal populations as early as 10,000 BP (Ackerman et al. 1985). Sites dating to the earliest occupation of the region often contain assemblages of sea mammal bones as well as evidence of heavy reliance on salmon, herring, and shellfish. The richness of these resources may have supported semi-sedentary winter occupation of coastal sites as early as 7,000 BP (Cannon 1991).



As the Holocene era progressed and the climate of the region warmed, salmon and the human populations that subsisted on them could move into upland areas and places away from the coasts that were previously inaccessible. As the Canadian Cordilleran glacier retreated, Puget Sound was created and new interior coastal territories opened up (Schalk 1988). By about 5,000 BP consumption of shellfish began to play a dominant role in regional subsistence patterns. The abundance of shellfish, salmon, and other wild resources in the region formed the basis of an economic and subsistence pattern that was exceptionally stable. This stability allowed for the development of complex hunter/fisher/gatherer societies that persisted into the late 18th century (Fagan 2001), as well as a homogeneous regional social system facilitated by widespread regional trade networks (Croes 1989).

1.7.1 Ethnographic Period

MSL is located within the Central Coast Salish Culture Area, which includes the southern end of the Strait of Georgia, most of the Strait of Juan de Fuca, the lower Frasier Valley, and other nearby areas. Five traditional languages were spoken throughout the area: Squamish, Halkomelem, Nooksack, Northern Straits, and Klallam (Suttles and Lane 1990a). Klallam speakers lived in the vicinity of MSL. There were 13 Klallam winter villages in this region—all but one was located on saltwater shores (Schalk 1988).

Fishing for salmon and other anadromous fish was a major component of the subsistence pattern within the Central Coast Salish Culture Area. In addition to salmon, saltwater fish such as halibut, herring, lingcod, and flounder were caught. Invertebrates such clams, cockles, mussels, sea urchins, crabs, and barnacles were abundant (Schalk 1988, Suttles and Lane 1990a).

The Klallam-speaking people were one of the few groups in the region to practice whaling; whales were hunted opportunistically, when spotted from shore (Schalk 1988). Terrestrial game played a relatively small role in the overall subsistence pattern (Schalk 1988), but deer and other mammals were hunted by a small number of specialized hunters. Women gathered at least 40 different edible plants including sprouts, stems, bulbs, roots, berries, fruits, and nuts.

Most travel in the region was by canoe, and winter village sites were located where canoes could be beached. Villages often consisted of one or more rows of plank houses paralleling the shore. Houses were constructed on a post and beam framework, with plank walls and shed roofs (Suttles and Lane 1990a).

One important aspect of Salish society was the practice of ritual feasts and gift-giving events known as potlatches, which marked important events or a change in an individual's status (Suttles and Lane 1990a; Fagan 2001). A typical potlatch included members from several or all the houses of a village preparing a feast and giving large quantities of accumulated wealth and gifts to guests from neighboring villages. The redistribution of

accumulated goods was important for establishing and reinforcing status or fame and as an investment in securing relationships and support networks between villages and neighbors (Suttles and Lane 1990b).

1.7.2 Historic Period

The earliest Euro-American settlement in Clallam County and the Sequim area was known as Whiskey Flat, and was located on the cliffs above the Strait of Juan de Fuca in the 1850s (Morgan 1996). By the end of the nineteenth century, the settlement of New Dungeness had grown and the county courthouse was moved to Port Angeles. At this time, the Sequim area was a developing agricultural area. The Sequim Prairie irrigation ditch was completed in 1896, which allowed for expanded farming in the area (Morgan 1996).

Before being chosen as the site of the MSL, the location was home to the Bugge Clam Cannery, which had started business on the site in 1905. The cannery eventually expanded to processing salmon, produce, and added a creamery. The original cannery burned in 1929, but the Bugge family rebuilt and continued to operate the cannery until the land was purchased by Battelle in 1967 (Russell 1971).

In 1967, Battelle began to develop the MSL with the intention to "provide facilities for research projects which require ocean waters or oceanic environments" (Battelle-Northwest 1967). Most of the cannery and outbuildings were removed by the early 1970s for the construction of the MSL campus (Jamestown S'Klallam Tribe 2018).

IT'S BATTELLE!

-To Operate Laboratories At Hanford

Offer Described As Outstanding; Objectives Met

Chance Seen As Challenge

Reactions

Tri-City Growth Seen

Tri-City Herald

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2.0 COMPLIANCE SUMMARY

Operations at PNNL are conducted in compliance with all applicable federal, state, and local environmental laws, regulations, and guidance; presidential Executive Orders; and DOE Orders, directives, policies, and guidance. PNNL endeavors to conduct operations in a sustainable manner that is protective of the environment. Table 2.1 summarizes PNNL's compliance, and subsequent sections provide brief descriptions of each statute or regulation.

2.1 Sustainability and Environmental Management System

The DOE-Battelle Prime Contract for the management and operation of PNNL (DOE-PNSO 2019) incorporates applicable requirements from DOE Order 436.1, Departmental Sustainability, including associated performance goals, objectives, and systems. This Order and related Executive Orders are briefly discussed in the following sections.

2.1.1 DOE Order 436.1, Departmental Sustainability

DOE Order 436.1 was approved on May 2, 2011. The purpose of this Order is to

> "…1) ensure the Department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient and reliable energy for the future,
>
> 2) institute wholesale cultural change to factor sustainability and greenhouse gas (GHG) reductions into all DOE corporate management decisions, and
>
> 3) ensure DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan pursuant to applicable laws, regulations and Executive Orders (EO[s]), related performance scorecards, and sustainability initiatives…."

PNNL has incorporated these requirements by modifying the DOE-Battelle Prime Contract to include the development of a site sustainability plan (e.g., DOE 2018), incorporation of sustainable acquisition requirements into applicable processes, and the development of an environmental management system (EMS) that is certified to meet the requirements of the International Organization for Standardization (ISO) 14001:2015 standards.

The PNNL FY 2019 Site Sustainability Plan (DOE 2018) identifies the status and accomplishments of sustainability projects related to DOE's sustainability goals. Prepared and submitted to DOE annually, the PNNL site sustainability plan includes Pollution Prevention Program activities, accomplishments, and continuous improvement opportunities. Section 3.0 provides further information concerning PNNL's EMS and the status of PNNL's sustainability goals.

2.1.2 Executive Order 13834, "Efficient Federal Operations"

Executive Order 13834 of May 17, 2018, (83 FR 23771) requires that federal agencies meet statutory requirements to increase energy efficiency, improve performance, eliminate resource use when unnecessary, and protect the environment. The Order revokes Executive Order 13693 of March 19, 2015 (80 FR 15871), "Planning for Federal Sustainability in the Next Decade," which established goals and requirements in the areas of greenhouse gas reduction and promoted sustainable buildings, clean and renewable energy, water-use efficiency and management, fleet management, sustainable acquisition, pollution prevention and waste reduction, energy performance contracts, and electronic stewardship.

Table 2.1. Status of Federal and State Environmental Laws and Regulations Applicable to PNNL, 2018

Statute/Regulation	2018 Status	Report Section(s)
Federal		
Environmental Safety and Health Reporting		
DOE Order 231.1B, *Environment, Safety, and Health Reporting* requires the gathering, analysis, and reporting of information about environmental safety and health issues.	PNNL monitors and conveys information via reports, emails, LabWeb News articles, and staff meetings. The PNNL Annual Site Environmental Report is a requirement of this Order.	1.0
DOE Order 414.1D, *Quality Assurance* states the roles and requirements for providing quality assurance (QA) for work performed by DOE and its contractors.	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 staff, conforming to DOE Order 414.1D requirements.	7.0
Air Quality and Protection		
The *Clean Air Act* and its Amendments regulates the release of air pollutants from facilities and unmonitored sources through permitting and air-quality restrictions.	PNNL conducted operations under permits issued by the Washington State Department of Health, Washington State Department of Ecology, Benton Clean Air Agency, and Olympic Region Clean Air Agency. No events were reported for emissions of regulated substances to the air or substances of concern. Radioactive air emissions were more than 10,000 times lower than the regulatory standard of 10 mrem/yr (0.1 mSv/yr) at both the PNNL Richland Campus and the Marine Sciences Laboratory (MSL).	2.4.1, 2.4.2
Cultural and Historic Resources		
The *Antiquities Act of 1906*; *Archeological and Historic Preservation Act of 1974*; *Archaeological Resources Protection Act of 1979*; and *National Historic Preservation Act of 1966* require the establishment of programs to preserve and protect historical and cultural resources including sites, documents, buildings, artifacts, and records using permits, access restrictions, and other means.	Five *National Historic Preservation Act* Section 106 cultural resource reviews were conducted for PNNL projects. No cultural/historical resource compliance issues were identified. In addition, 27 projects were reviewed by cultural resource staff to assure that they were covered by previously conducted Section 106 cultural resource reviews.	2.7.2

Statute/Regulation	2018 Status	Report Section(s)
The *American Indian Religious Freedom Act* and their Amendments of 1994 provide for the protection of traditional cultural and ceremonial practices. The *Native American Graves Protection and Repatriation Act of 1990* requires the return of human remains and other culturally sensitive articles to Native Americans.	PNNL cultural resource specialists and staff reviewed research and support activities that may impact cultural or Native American resources and/or practices.	2.7.2
Hazardous Materials and Waste Management		
The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) provides regulations for the identification, assessment, and remediation of sites contaminated by hazardous materials.	The PNNL Richland Campus is not part of any Hanford CERCLA operable unit and had no continuous releases.	2.6.2
The *Emergency Planning and Community Right-to-Know Act of 1986* stipulates the public's right to information about hazardous materials in the community and the establishment of emergency planning procedures.	PNNL submitted two Tier Two reports, providing information concerning potential hazards. PNNL was not required to submit a Toxic Release Inventory Report.	2.6.8
The *Federal Facility Compliance Act of 1992* amends the *Resource Conservation and Recovery Act of 1976* (RCRA) and CERCLA and establishes new mixed waste reporting requirements.	PNNL provided information as part of the Hanford Site Mixed Waste Land Disposal Restrictions Summary Reports pursuant to Tri-Party Agreement Milestone M-26.	2.6.5
The *Federal Insecticide, Fungicide, and Rodenticide Act* regulates the storage and use of pesticides.	Licensed PNNL staff or certified commercial applicators were used to purchase, store, and apply pesticides on the PNNL Richland Campus and at MSL.	2.6.7
The *Resource Conservation and Recovery Act of 1976* (RCRA) tracks hazardous waste from generation to treatment, storage, or disposal (referred to as cradle-to-grave management).	PNNL is responsible for one RCRA-permitted storage and treatment unit. PNNL generates hazardous waste in eight RCRA facilities (EPA Site ID#s). Washington State Department of Ecology personnel inspected seven of PNNL's eight facilities. Three minor noncompliances were identified and corrected.	2.6.4

Statute/Regulation	2018 Status	Report Section(s)
The *Superfund Amendments and Reauthorization Act of 1986* amends and reauthorizes CERCLA.	PNNL Richland Campus areas near the Hanford Site have been evaluated and require no further action. Groundwater near the PNNL Richland Campus is monitored for Hanford Site contaminant migration. No contamination was identified at MSL that would require response under CERCLA or the *Superfund Amendments and Reauthorization Act*.	2.6.2
The *Toxic Substances Control Act* regulates and tracks regulated hazardous chemicals, primarily polychlorinated biphenyls (PCBs).	PNNL contributed to the 2017 PCB annual document log report for the Hanford Site and 2017 PCB annual report; both were submitted to the U.S. Environmental Protection Agency as required.	2.6.6
Environment and Wildlife		
The *Bald and Golden Eagle Protection Act* provides for the protection of bald and golden eagles.	Biological resource reviews provided assurance that proposed actions did not adversely affect bald or golden eagles.	2.7.1
The *Coastal Zone Management Act of 1972* encourages the development of coastal zone management plans to preserve, protect, and enhance natural coastal resources and the wildlife using coastal habitats.	PNNL considers coastal resources and the fish and wildlife that use those habitats when evaluating proposed actions. No federal consistency determinations were acquired by PNNL.	2.7.1
The *Endangered Species Act of 1973* (ESA) provides for the protection of threatened and endangered plant and animal species.	No endangered or threatened species were observed during biological field surveys of the PNNL Richland Campus. Ten ESA authorizations were acquired and three no effect determinations were made for offsite scientific research studies.	2.7.1
The *Forest Service Organic Administration Act of 1897* provides for the protection and administration of U.S. Forest Service lands.	One nominal effects letter was acquired for an offsite scientific research study.	2.7.1
The *Magnuson–Stevens Fishery Conservation and Management Act* governs marine fisheries management.	Three essential fish habitat authorizations were acquired and one no effect determination was made for offsite scientific research studies.	2.7.1
The *Marine Mammal Protection Act of 1972* provides for the protection of all marine mammals.	One *Marine Mammal Protection Act* no effect determination was made for an offsite scientific research study.	2.7.1

Statute/Regulation	2018 Status	Report Section(s)
The *Migratory Bird Treaty Act* makes it illegal to take, capture, or kill migratory birds or their feathers, nests, or eggs.	A number of migratory birds were observed during the biological field survey of the PNNL Richland Campus and the lands encompassing MSL. PNNL biologists resolved 19 inquiries concerning migratory birds on the PNNL Richland Campus and at MSL.	2.7.1
The *National Environmental Policy Act of 1969* (NEPA) requires the formulation of an environmental impact statement, environmental assessment, or categorical exclusion for federal projects that have the potential to affect the quality of the human environment.	PNNL environmental compliance representatives and NEPA staff conducted 1,161 NEPA reviews during CY 2018 for research and support activities. The U.S. Department of Energy (DOE)-Richland Operations Office approved nine generic categorical exclusions; one activity-specific categorical exclusion was revised and approved by the DOE Pacific Northwest Site Office.	2.3
The *National Park Service Organic Act* provides for the management of national parks and monuments.	Two scientific research and collecting permits were acquired for offsite studies.	2.7.1
The *National Wildlife Refuge System Administration Act of 1966* provides administrative and management directives for refuges under the jurisdiction of the U.S. Fish and Wildlife Service.	One special use permit was acquired for an offsite scientific research study.	2.7.1
The *Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990* prevents the spread of nonindigenous aquatic nuisance species to non-infested waters.	An aquatic invasive plant and animal species interception program has been developed and implemented by PNNL.	2.7.1
The *Rivers and Harbors Appropriation Act of 1899* prohibits obstruction or alteration of navigable waters.	No Section 10 permits were acquired for offsite scientific research.	2.7.1
Executive Order 11988, "Floodplain Management," requires federal agencies to evaluate the potential effects of any actions within a floodplain.	No activities were performed that required a floodplain evaluation.	2.7.1

Statute/Regulation	2018 Status	Report Section(s)
Executive Order 11990, "Protection of Wetlands," requires federal agencies to minimize the loss or degradation of wetlands and to preserve and enhance their natural and beneficial values.	Two offsite activities were performed that required wetland evaluations.	2.7.1
Energy Independence		
The *Energy Independence and Security Act of 2007* (EISA) encourages United States energy independence and security, while promoting energy efficiency, conservation, and savings.	PNNL evaluated one building under EISA energy and water evaluation requirements in fiscal year (FY) 2018. PNNL also implemented stormwater management practices to promote water drainage and reduce runoff.	2.2, 2.5.2, 3.0
DOE Order 436.1, *Departmental Sustainability*, establishes implementation requirements that include the preparation of a site sustainability plan and an environmental management system (EMS).	PNNL has developed and implements a site sustainability plan that incorporates the annual status and strategy for achieving the goals and objectives of DOE Order 436.1. PNNL has a fully integrated EMS that is certified to meet International Organization for Standardization (ISO) 14001:2015 standards.	2.1.1, 2.7.2, 3.0
Executive Order 13834, "Efficient Federal Operations," establishes goals and requirements related to energy and environmental performance with respect to facilities, vehicles, and overall operations.	PNNL produced the *Pacific Northwest National Laboratory FY 2018 Site Sustainability Plan*, which focuses on the goals and requirements of Executive Order 13834.	2.1.2, 3.0
Radiation Protection		
DOE Order 435.1, *Radioactive Waste Management*, establishes requirements for managing high-level waste, transuranic waste, low-level waste, and mixed wastes.	PNNL's Radioactive Waste Management Basis Program identifies and implements radioactive waste-management controls through internal workflows and procedures.	2.8.2, 2.8.3
DOE Order 458.1, *Radiation Protection of the Public and the Environment*, establishes requirements related to radiation protection of the public and the environment, including estimating radiological dose.	PNNL implements programs to assure that facilities, emissions, effluents, and wastes are protective of the public, workers, and the environment.	2.8.1, 2.8.2, 2.8.3, 4.1.1, 4.3, 4.4

Statute/Regulation	2018 Status	Report Section(s)
The *Atomic Energy Act of 1954* encompasses the management of low-level and mixed low-level wastes and radioactive materials.	PNNL's Radiation Protection Management and Operation Program includes safeguarding and monitoring radioactive materials through work controls, dosimetry, bioassay, and safety information.	2.8.3
Water Quality and Protection		
The *Clean Water Act* seeks to maintain and improve surface water quality through criteria and permitting, including point-source discharges to United States surface waters and indirect discharges to sewer systems, as well as the discharge of dredged or fill material into U.S. waters and/or wetlands.	PNNL conducted operations under permits issued by the Washington State Department of Ecology and the City of Richland. MSL operated under a National Pollutant Discharge Elimination System (NPDES) permit issued by the Washington State Department of Ecology. One NPDES permit and two Nationwide Permits were acquired for offsite scientific research studies.	2.5.1, 2.7.1, 7.3
The *Safe Drinking Water Act of 1974* establishes standards and requirements for public drinking water systems.	The PNNL Richland Campus receives all drinking water for use in laboratory and nonlaboratory spaces from the City of Richland. The City is responsible for meeting water-quality standards under the *Safe Drinking Water Act of 1974*. At MSL, water is provided exclusively from onsite wells and PNNL is considered the water purveyor.	2.5.2, 2.5.3, 7.4
Washington State		
The *Hazardous Waste Management Act of 1976* provides for safe planning, regulation, control, and management of hazardous waste.	PNNL manages hazardous wastes in a safe and responsible manner. Inventories and storage methods are regulated, and reports are submitted as required.	2.6.1
The Washington *State Environmental Policy Act* (SEPA) identifies environmental impacts of state and local decisions and gives agencies the authority to deny a proposal when adverse environmental impacts are identified.	PNNL environmental compliance representatives and staff review research and support activities, completing SEPA checklists as required.	2.3
The *Shoreline Management Act of 1971* establishes guidelines for shoreline use, environmental protection, and public access.	Eleven Shoreline Substantial Development Permit Exemptions were obtained for offsite scientific research studies.	2.7.1
The *Washington Clean Air Act* implements and supplements the federal *Clean Air Act*, overseeing state air quality.	PNNL operated under permits issued by the Washington State Department of Health, Washington State Department of Ecology, Benton Clean Air Agency, and Olympic Region Clean Air Agency. No events were reported for air emissions of regulated substances or substances of concern.	2.4.1

Statute/Regulation	2018 Status	Report Section(s)
The *Washington Pesticide Application Act* provides for the control of pesticide application and use to protect public health and welfare.	Licensed PNNL staff or certified commercial applicators are used to apply pesticides.	2.6.7
The *Washington Pesticide Control Act* establishes guidelines for proper use and control of pesticides.	Licensed PNNL staff or certified commercial applicators are used to apply pesticides.	2.6.7

Executive Order 13834 (83 FR 23771) establishes goals and requirements for reducing building energy use, implementing energy efficiency measures, reduction of potable and non-potable water consumption, stormwater and wastewater management, increasing energy, water, and building modernization to comply with building energy efficiency requirements and sustainable design principles, pollution prevention and waste diversion, and electronics stewardship. PNNL has developed detailed plans and milestones for achieving energy efficiency objectives and goals as directed by Executive Order 13834; details are available in Section 3.0.

2.2 Energy Independence and Security Act of 2007

The *Energy Independence and Security Act of 2007* (EISA) (42 U.S.C. § 17001) was enacted "to move the United States toward greater energy independence and security." It promotes the production of clean, renewable fuels, R&D of biofuels, improved vehicle technology, energy savings through improved standards including those for appliances and lighting, improved energy savings in buildings and industry, the reduction of stormwater runoff and water conservation and protection, the development and extension of new technologies (including solar, geothermal, marine and hydrokinetic, and energy storage), carbon capture and sequestration research, and energy transportation and infrastructure provisions. In fiscal year (FY) 2018, PNNL completed an evaluation for one building subject to EISA Section 432 continuous (4-year cycle) comprehensive energy and water requirements. To date, 66% of PNNL buildings have met the criteria for DOE Federal Energy Management Program Guiding Principles for high-performance sustainable buildings (HPSBs), far exceeding the 2025 goal of 17% (DOE 2018).

Whole-building metering for electricity, natural gas, and water have been completed for all viable buildings, enabling facility system analyses, as needed. Stormwater management practices are implemented to promote water drainage and reduce runoff (see Section 2.5.2). Also, a 125 kW photovoltaic array continued operation in 2018, contributing to onsite energy generation and, together with a solar water heater, additional small photovoltaic arrays on monitoring stations, and renewable energy certificate purchases, provided 44% of the PNNL electricity consumption from renewables (DOE 2018). Further details are available in Section 3.0.

2.3 National Environmental Policy Act of 1969

The *National Environmental Policy Act of 1969* (NEPA) (42 U.S.C. § 4321 *et seq.*) was enacted to assure that potential environmental impacts, as well as technical factors and costs, are considered during federal agency decision-making. The PNNL NEPA Compliance Program supports Laboratory compliance with NEPA and the Washington *State Environmental Policy Act* (SEPA) (Revised Code of Washington [RCW] 43.21C, as amended). Program activities include preparing sitewide and activity-specific categorical exclusions, environmental assessments, and Washington SEPA checklists. NEPA reviews of PNNL activities are conducted by both PNSO and DOE-RL NEPA compliance staff. The DOE office responsible for concurring with and approving the NEPA documentation depends on the proposed project location and source of funding. NEPA compliance is verified through assessments conducted by PNNL and DOE.

PNNL environmental compliance representatives and NEPA staff conducted 1,161 NEPA reviews during CY 2018 for research and support activities (765 Electronic Prep and Risk System reviews, 380 William R. Wiley Environmental Molecular Sciences Laboratory [EMSL] user proposals, and 16 facility-modification permits). NEPA staff reviewed Electronic Prep and Risk reviews to verify that potential project environmental impacts were adequately considered, and NEPA (and as appropriate, SEPA) coverage was correctly applied. In nearly every case, activities were adequately addressed in previously approved NEPA

documentation, such as generic categorical exclusions, environmental assessments, environmental impact statements, and supplement analyses. When there was no adequate previously approved documentation, PNNL staff prepared additional NEPA documentation, such as project-specific categorical exclusions, for approval by DOE.

No environmental assessments or environmental impact statements were published by PNSO during 2018.

Categorical exclusions represent an effective and necessary means of addressing activities that 1) clearly fit within a class of actions that DOE has determined do not individually or cumulatively have a significant effect on the environment, 2) do not have extraordinary circumstances that may affect the environment, and 3) are not "connected" to other actions that may have potentially significant impacts. A single determination for a generic categorical exclusion is allowed for recurring activities undertaken during a specified time period.

There were no new PNSO-approved generic categorical exclusions in 2018. A total of 16 generic categorical exclusions have been previously approved by PNSO to cover PNNL research and operations activities. When projects clearly are within the definition of a categorical exclusion, but a generic categorical exclusion is not applicable, a project- or activity-specific categorical exclusion is prepared. There was one activity-specific PNSO-approved categorical exclusion in 2018, covering the proposed tribal mitigation activities in the Preservation Designated Area on the Richland Campus. A list of all PNSO-approved categorical exclusions is available at http://science.energy.gov/pnso/nepa-documents/categorical-exclusion-determinations/.

A total of nine PNNL-related generic categorical exclusions were approved by DOE-RL in 2018, covering areas such as routine maintenance, small-scale R&D, site characterization, construction of small structures, environmental monitoring, use of nanoscale materials, and biomedical research. These activities are relevant to PNNL projects conducted in facilities located in the 300 Area of the Hanford Site and field work occurring on the Hanford Site; the list of DOE-RL-approved categorical exclusions is available at http://www.hanford.gov/page.cfm/CategoricalExclusions.

2.4 Air Quality

Federal regulations that apply to air quality at the PNNL Richland Campus and MSL site and the permits necessary to maintain compliance are discussed in this section.

2.4.1 Clean Air Act

The *Clean Air Act* (42 U.S.C. § 7401 *et seq.*) is administered by EPA. It regulates air emissions from stationary and mobile sources, both criteria and hazardous air pollutants. The Act authorized EPA to establish National Ambient Air Quality Standards for the protection of public health and welfare. The establishment of these pollutant standards was combined with state implementation plans to facilitate attainment of the standards. The *Washington Clean Air Act* (RCW 70.94), which implements and supplements the federal law, has been revised periodically to keep pace with changes at the federal level. The Washington State Department of Ecology is responsible for developing most statewide air-quality rules, and enforces Title 40 of the *Code of Federal Regulations* Part 52 (40 CFR Part 52), 40 CFR Part 60, 40 CFR Part 61, 40 CFR Part 63, 40 CFR Part 68, 40 CFR Part 82, and 40 CFR Part 98, as well as the state requirements in WAC 173-400, WAC 173-441, WAC 173-460, and WAC 173-480.

The Benton Clean Air Agency (BCAA) implements and enforces most federal and state requirements on the PNNL Richland Campus through BCAA Regulation 1 (BCAA 2018). Requirements applicable to the PNNL Richland Campus include Article 4, "General Standards for Particulate Matter;" Article 5, "Outdoor Burning;" Article 8, "Asbestos;" Article 9, "Source Registration;" and Article 10, "Fees and Charges." The Olympic Region Clean Air Agency (ORCAA) implements and enforces most federal and state requirements at MSL through ORCAA Regulations (ORCAA 2019). Requirements applicable to MSL include Regulation 4, "Registration;" Regulation 6, "Required Permits;" Regulation 7, "Prohibitions;" and Regulation 8, "Performance Standards."

2.4.2 Clean Air Act Amendments of 1990 and the National Emissions Standards for Hazardous Air Pollutants

Section 112 of the *Clean Air Act* addresses emissions of hazardous air pollutants. The *Clean Air Act Amendments of 1990* revised Section 112 to require standards for major and certain specific stationary source types. The amendments also revised the National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulations (40 CFR Part 61, Subpart H) that govern emissions of radionuclides from DOE facilities. These regulations address the measurement of point-source emissions, but incorporate fugitive emissions with regard to complying with established regulations for radioactive air emissions, including standards, monitoring provisions, and annual reporting requirements. The NESHAP regulations cover all pollutants not regulated by the National Ambient Air Quality Standards that are classified as hazardous. PNNL is in compliance with all NESHAP requirements at both the PNNL Richland Campus and MSL.

2.4.3 Radioactive Emissions

Federal regulations in 40 CFR Part 61, Subpart H, require the measurement and reporting of radionuclides emitted from DOE facilities and the resulting maximum public dose from those emissions. These regulations impose a standard of 10 mrem/yr (0.1 mSv/yr) effective dose equivalent (EDE), which is not to be exceeded. Washington State adopted the 40 CFR Part 61 standard in its regulations (WAC 246-247) that require the calculation and reporting of the EDE to the maximum exposed individual (MEI) from point-source emissions and from radon and fugitive source emissions. While the WAC 246-247 receptor location considers whether an individual resides or abides at the evaluated location, an additional assessment is performed for the location with maximum offsite nuclide air concentrations whether or not the reside/abide criterion is met (WAC 173-480).

On the PNNL Richland Campus, the Physical Sciences Facility (PSF), Research Technology Laboratory (RTL), and Life Sciences Laboratory 2 (LSL2) have the potential to emit radionuclides.[1] Radioactive emission point sources at the PNNL Richland Campus are actively ventilated stacks that use electrically powered exhausters and from which emissions are discharged under controlled conditions. The sources are major, minor, and fugitive emissions units. In addition, several PNNL Richland Campus sitewide radioactive air permits, commonly called Potential Impact Category 5 (PIC-5) permits (Barnett 2018), were used to assign dose from very low potential emissions sources associated with campus-wide operations. The low-level radioactive sources permitted under PIC-5 include emissions for instrument and operational checks, nondispersible radioactive materials, volumetrically released radioactive materials, and certain facility restoration activities.

Details regarding ambient air, stack emissions monitoring, and PIC-5 permit programs for the PNNL Richland Campus and MSL are reported annually. Richland Campus data for 2018 are available in the PNNL Richland Campus Radionuclide Air Emissions Report for Calendar Year 2018 (Snyder et al. 2019).

[1] As a group of research buildings, the PSF expects to host changing types of research over time. Research at the RTL has ended and the facility was demolished in 2018. The LSL2 has no new or planned radiological operations other than the removal of radiologically contaminated ductwork from past operations.

MSL has one minor fugitive emission unit that has the potential to emit radionuclides. Radioactive air emissions results for MSL are available in the Marine Sciences Laboratory Radionuclide Air Emissions Report for Calendar Year 2018 (Snyder and Barnett 2019). During CY 2018, the PNNL Richland Campus and MSL maintained compliance with state and federal regulations and with issued air emissions permits, as described below. In particular, radioactive air emissions were more than 10,000 times lower than the regulatory standard of 10 mrem/yr (0.1 mSv/yr) EDE for the period at each facility.

2.4.4 Air Permits

PNNL has several permits that control airborne emissions from facilities within the PNNL Richland Campus boundary. Permits for radioactive air emissions are issued by the Washington State Department of Health (WDOH) as a Radioactive Air Emissions License (RAEL). For the PNNL Richland Campus, WDOH has issued RAEL–005 which was last renewed on June 17, 2015; the renewal cycle for a WDOH RAEL is every 5 years. Permits for nonradiological air emissions at the PNNL Richland Campus are issued by the BCAA as an Order of Approval; they can cover particulate, volatile organic compound, and toxic air pollutant emissions. The current Orders of Approval issued by the BCAA to the PNNL Richland Campus are listed below:

- Environmental Molecular Sciences Laboratory (Order of Approval No. RO 2012-0009)
- Life Sciences Laboratory 2 (Order of Approval No. 2007-0006, Revision 1 and Order of Approval No. 2016-0008)
- Physical Sciences Facility (Order of Approval No. 2007-0013, Revision 1 and Order of Approval No. 2017-0008)
- Richland North Building Support (Order of Approval No. 2012-0017)
- Richland North Research (Order of Approval No. 2012-0016).

MSL has two air permits for airborne emissions: RAEL–014 issued by the WDOH and a nonradiological regulatory order issued by the ORCAA (Order of Approval 13NOI968).

2.5 Water Quality and Protection

Federal regulations that apply to water quality at the PNNL Richland Campus and MSL are discussed in this section, which addresses wastewater, drinking water, and stormwater regulations and permitting processes.

2.5.1 Clean Water Act

The *Clean Water Act* (33 U.S.C. § 1251 et seq.) establishes the basic structure for regulating discharges of pollutants into the waters of the United States as well as quality standards for surface waters. The basis of the *Clean Water Act* was enacted in 1948 and was called the *Federal Water Pollution Control Act*. Significantly reorganized and expanded with amendments in 1972, it became commonly known as the *Clean Water Act*. Under the *Clean Water Act*, the EPA has implemented pollution control programs such as setting wastewater standards for industry and implementing water-quality standards for all contaminants in surface waters. The *Clean Water Act* made it unlawful to discharge any pollutant from a point source into navigable waters unless a permit is obtained. The EPA's National Pollutant Discharge Elimination System (NPDES) permit program controls these point-source discharges. Point sources are discrete conveyances such as pipes or manmade ditches. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. The EPA delegated responsibility for the Washington State NPDES permit program to the Washington State Department of Ecology in August 1989.

The Washington State Department of Ecology has issued Permit No. WA0020419 to the City of Richland for discharges from its Publicly Owned Treatment Works to the Columbia River. To assure that it meets its NPDES permit conditions, the City of Richland issues industrial wastewater discharge permits to industrial users that discharge process wastewater to the City of Richland sanitary sewer system, as codified in Richland Municipal Code Chapter 17.30.

On the PNNL Richland Campus, the discharge of process wastewater to the City of Richland sanitary sewer system is governed by three City of Richland industrial wastewater discharge permits. Industrial wastewater discharge permit CR-IU001 regulates discharges from facilities on the PNNL Richland Campus and leased facilities, and requires monitoring at one discharge point, Outfall CS-001. Permit CR-IU005 regulates discharges from EMSL to Outfall 001. Permit CR-IU011 regulates process wastewater discharged from PSF. All process wastewater from PSF is monitored at a single compliance point (Outfall PS-001). All waste streams regulated by these permits are reviewed by PNNL staff and evaluated for compliance with the applicable permit prior to being discharged.

Process wastewater from MSL facilities is discharged directly to Sequim Bay under the authorization of Washington State Department of Ecology NPDES Permit No. WA0040649, after treatment by an onsite wastewater treatment system. The wastewater treatment system consists of particulate filters, ultra-violet lamps, and granulated activated carbon. All waste streams regulated by this permit are reviewed by PNNL staff and evaluated for compliance prior to being discharged.

2.5.2 Stormwater Management

Stormwater on the PNNL Richland Campus is primarily managed via underground injection control wells and grassy swales. The underground injection control wells are registered with the Washington State Department of Ecology as required by WAC 173-218. Best management practices are used to minimize pollution in stormwater. These practices include storing chemicals inside or under cover when possible to prevent contact with stormwater, routinely sweeping and cleaning parking lots, prompt notification of spills, spill cleanup, and conducting good housekeeping.

Stormwater at MSL is managed via a stormwater drain system that includes grated drain boxes for paved areas and a trench that drains to an infiltration pond. Drain boxes provide simple oil separation through the use of a submerged discharge outlet. In addition, separate drain boxes in the boat storage yard and in the wastewater treatment system area contain multimedia filtration systems (sedimentation chamber, oil adsorbent, and granular activated carbon adsorbent). The infiltration pond is an engineered stormwater collection basin with an overflow trench.

Stormwater discharges from the PNNL Richland Campus and MSL are not subject to federal or state NPDES stormwater regulations. However, stormwater management practices that promote water drainage and reduce runoff as outlined under EISA Section 438 are considered and implemented as part of PNNL sustainability practices (DOE 2018). The registrations of underground injection wells for stormwater and injection of ground-source heat pump return flow water (see Section 6.0) have been completed as required by *Safe Drinking Water Act of 1974*.

2.5.3 Safe Drinking Water Act of 1974

The *Safe Drinking Water Act of 1974* (42 U.S.C. § 300f *et seq.*) is the main federal law that assures the quality of drinking water in the United States. Under the Act, the EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. The *Safe Drinking Water Act of 1974* was originally passed by Congress to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996, and requires many actions to protect drinking water and its sources—rivers, lakes, reservoirs, springs, and groundwater wells.

The Act focuses on all waters actually or potentially designated for use as drinking water, whether from aboveground or underground sources. The Act authorizes the EPA to establish minimum standards to protect tap water, and requires all owners or operators of public water systems to comply with these primary (health-related) standards. State governments, which can be approved to implement these rules for EPA, also encourage attainment of secondary standards.[2] Under the *Safe Drinking Water Act of 1974*, EPA also established minimum standards for state programs to protect underground sources of drinking water from endangerment by underground injection of fluids.

The PNNL Richland Campus receives all drinking water for uses in laboratory and nonlaboratory spaces from the City of Richland drinking water supply, and is not subject to the *Safe Drinking Water Act of 1974*.

Water for MSL facilities is provided exclusively from Battelle Land–Sequim onsite wells. PNNL is considered the water purveyor, and is responsible for all monitoring and sampling of the drinking water distribution system. All drinking water parameters sampled met compliance requirements.

2.6 Environmental Restoration and Waste Management

This section describes PNNL activities conducted to protect the environment through the proper management of waste.

2.6.1 Tri-Party Agreement

The "Hanford Federal Facility Agreement and Consent Order" (also known as the Tri-Party Agreement [Ecology et al. 1989]) is an agreement among the Washington State Department of Ecology, EPA, and DOE (the Tri-Party Agreement agencies) to achieve compliance on the Hanford Site with the treatment, storage, and disposal unit regulations and corrective action provisions of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) (42 U.S.C. § 9601 *et seq.*) and the *Resource Conservation and Recovery Act of 1976* (RCRA) (42 U.S.C. § 6901 *et seq.* and 42 U.S.C. § 6927(c) *et seq.*). The Tri-Party Agreement is an interagency agreement (also known as a federal facility agreement) under Section 120 of CERCLA, a corrective action order under RCRA, and a consent order under the Washington State *Hazardous Waste Management Act of 1976* (RCW 70.105). The Agreement 1) defines RCRA and CERCLA cleanup commitments, 2) establishes responsibilities, 3) provides a basis for budgeting, and 4) reflects a concerted goal to achieve regulatory compliance and remediation with enforceable milestones.

The Tri-Party Agreement is available on the DOE Hanford Site website at http://www.hanford.gov/?page=81. Printed copies of the Tri-Party Agreement, which is current as of August 17, 2017, are publicly available at DOE's Public Reading Room, located in the Washington State University–Tri-Cities Consolidated Information Center, 2770 University Drive, Richland, Washington, and at public reading rooms in Seattle and Spokane, Washington, and Portland, Oregon.

Under the Tri-Party Agreement, Hanford waste sites were grouped into "operable units" based on geographic proximity or similarity of waste-disposal history. The PNNL Richland Campus is not part of any Hanford Site CERCLA operable unit or subject to any cleanup action under the Tri-Party Agreement. PNNL maintains administrative controls similar to those at adjacent uncontaminated portions of the Hanford Site 300 Area; e.g., access control and groundwater use restrictions. PNNL provides information to DOE-RL and its contractors with regard to the facilities it occupies on the Hanford Site to support the preparation of the annual land disposal restrictions report required by the Tri-Party Agreement M-26 milestone series. Some wells located on the PNNL Richland Campus are monitored by Hanford Site

[2] Secondary standards are established to give operators of public water systems guidance about removing contaminants that may cause the water to appear cloudy or colored, or to taste or smell bad, even though the water is actually safe to drink.

contractors as part of the regional groundwater monitoring network. Sampling data are available in the *Hanford Site Groundwater Monitoring Report for 2017* (DOE-RL 2018a).

The Tri-Party Agreement only applies to PNNL facilities operating on the Hanford Site. It does not apply to MSL or PNNL Richland Campus facilities.

2.6.2 Comprehensive Environmental Response, Compensation, and Liability Act of 1980

CERCLA was promulgated to address response, compensation, and liability for past releases or potential releases of hazardous substances, pollutants, and contaminants to the environment. CERCLA was amended by the *Superfund Amendments and Reauthorization Act of 1986* (42 U.S.C. § 9601 *et seq.*), which made several important changes and additions, including clarification that federal facilities are subject to the same provisions of CERCLA as any nongovernmental entity. Executive Order 12580 of January 23, 1987, "Superfund Implementation" (52 FR 2923), directs that DOE, as the lead agency, must conduct CERCLA response actions (i.e., removal and remedial actions). Such actions would be subject to oversight by EPA and/or the Washington State Department of Ecology.

Two Hanford 300 Area operable units, listed on the National Priorities List on November 3, 1989, are located near the PNNL Richland Campus.

A portion of the PNNL Richland Campus located north of Horn Rapids Road was investigated as part of the Hanford 300-FF-2 Operable Unit in the late 1990s. Site characterization efforts found vestiges of petroleum hydrocarbons, irrigation canals, and recent debris (windblown garbage, porcelain china, battery cores, cans, and glass). After a site evaluation, EPA issued a CERCLA Final Record of Decision (EPA and DOE-RL 2013) that concluded that PNNL Richland Campus areas north of Horn Rapids Road require no further remedial action under CERCLA.

Groundwater under the northern portion of the PNNL Richland Campus is routinely monitored for contaminants migrating from Hanford Site contamination plumes as well as nitrates migrating from offsite locations. See Section 6.0 for further information concerning groundwater monitoring on the PNNL Richland Campus.

No MSL facilities require action under CERCLA guidelines.

2.6.3 Washington State Dangerous Waste/Hazardous Substance Reportable Releases to the Environment

The Washington State Dangerous Waste Regulations (WAC 173-303-145) require that spills or non-permitted discharges of dangerous waste or hazardous substances to the environment be reported to the Washington State Department of Ecology. This requirement applies to discharges to soil, surface water, groundwater, or air when such discharges threaten human health or the environment, regardless of the quantity of the dangerous waste or hazardous substance released.

During CY 2018, no spills or non-permitted discharges that posed a threat to human health or the environment occurred at the PNNL Richland Campus or MSL. Minor spills were cleaned up immediately and disposed of in accordance with applicable requirements.

2.6.4 Resource Conservation and Recovery Act of 1976

RCRA was enacted to protect human health and the environment through cradle-to-grave management of hazardous waste from its generation through treatment, storage, and disposal. The Washington State Department of Ecology has the authority to enforce RCRA requirements in the state under WAC 173-303, "Dangerous Waste Regulations."

PNNL, in cooperation with DOE-RL, operates one RCRA-permitted storage and treatment unit group—the 325 Hazardous Waste Treatment Units. This unit

group is located in the Radiochemical Processing Laboratory in the Hanford 300 Area, and is permitted as part of the Hanford Facility RCRA Permit. The Hanford Facility RCRA Permit expired on September 27, 2004. However, DOE and PNNL continue to operate in compliance with the expired permit until the permit is reissued, as authorized by WAC 173-303-806(7) and the Washington State Department of Ecology. The Hanford RCRA Permit may be viewed at https://fortress.wa.gov/ecy/nwp/permitting/hdwp/rev/8c/index.html.

With the exception of the 325 Hazardous Waste Treatment Units, PNNL Richland Campus and MSL facilities operate under the generator requirements of WAC 173-303. During CY 2018, PNNL facilities followed the generator requirements for waste management and shipped nonradioactive waste to offsite facilities for proper disposal.

RCRA and WAC 173-360 also include requirements for the proper management of underground storage tanks. Battelle administers two underground storage tanks for the storage of diesel fuel for backup generators on the PNNL Richland Campus in Richland —a 20,000-gallon tank and a 600-gallon tank. The tanks are routinely monitored and no problems were observed in CY 2018. No underground tanks are used at MSL.

Washington State Department of Ecology and EPA personnel inspected seven PNNL facilities for RCRA compliance in 2018 (PNNL Hanford Site facilities, Battelle-owned Richland Campus buildings, DOE-owned Richland Campus buildings, leased facilities at 2400 Stevens, the Applied Process Engineering Laboratory, the Bioproducts Sciences and Engineering Laboratory, and the Port of Pasco facility). One noncompliance was identified at the 2400 Stevens building and two noncompliances were found during the PNNL Hanford Site facilities inspection. Two of the noncompliances were simple field errors and were corrected immediately. The other noncompliance resulted from a new regulatory interpretation. Corrective actions were implemented quickly to implement the new regulatory position.

2.6.5 Federal Facility Compliance Act of 1992

The *Federal Facility Compliance Act of 1992* (42 U.S.C. 6939c and 6961), enacted by Congress on October 6, 1992, amended Section 6001 of RCRA to specify that the United States waives sovereign immunity from civil and administrative fines and penalties for RCRA violations. In addition, RCRA requires EPA to conduct annual inspections of all federal facilities. Authorized states are also given authority to conduct inspections of federal facilities to enforce compliance with state hazardous waste programs. A portion of the Act also requires DOE to provide mixed waste information to EPA and the states. PNNL provides this information as part of the *Hanford Site Mixed Waste Land Disposal Restrictions Summary Report* (DOE-RL 2015), pursuant to Tri-Party Agreement Milestone M-26.

2.6.6 Toxic Substances Control Act

Requirements of the *Toxic Substances Control Act* (15 U.S.C. § 2601 *et seq.*) that apply to PNNL primarily involve regulation of polychlorinated biphenyls (PCBs). Federal regulations for PCB use, storage, and disposal are provided in 40 CFR Part 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." PCB wastes at PNNL are stored and/or disposed of in accordance with this regulation; however, some radioactive PCB waste must be transferred to extended storage at the Hanford Site, pending the development of adequate treatment and disposal technologies and capacities.

The *2017 Hanford Site Polychlorinated Biphenyl Annual Document Log* (DOE-RL 2018b) and the *2017 Hanford Site Polychlorinated Biphenyl Annual Report* (DOE-RL 2018c) were produced in 2018 and describe the PCB waste-management and disposal activities that occur on the Hanford Site, including PNNL Richland Campus activities related to PCBs. The Annual Report is provided to EPA as required by 40 CFR 761.180. MSL did not generate enough PCB waste to require reporting under 40 CFR 761.180 in 2018.

2.6.7 Federal Insecticide, Fungicide, and Rodenticide Act

The *Federal Insecticide, Fungicide, and Rodenticide Act* (7 U.S.C. § 136 *et seq.*) is administered by EPA. Washington State Department of Agriculture rules implementing the Act requirements include the *Washington Pesticide Control Act* (RCW 15.58), the *Washington Pesticide Application Act* (RCW 17.21), and rules related to general pesticide use codified in WAC 16-228, "General Pesticide Rules." In 2018, commercial pesticides used at the PNNL Richland Campus and at MSL were managed in accordance with these rules and applied either by licensed PNNL staff or by a licensed commercial applicator.

2.6.8 Emergency Planning and Community Right-to-Know Act of 1986

The *Emergency Planning and Community Right-to-Know Act of 1986* (EPCRA) (42 U.S.C. § 11001 *et seq.*) requires each state to establish an emergency response commission and local emergency planning committees, and develop a process for gathering and distributing information about hazardous chemicals present in local facilities. These local emergency planning committees develop emergency plans for local planning districts. Facilities that produce, use, release, or store toxic or hazardous substances in quantities above threshold levels must submit information about the chemicals to local emergency planning committees.

EPCRA has four major provisions: emergency planning, emergency release notification, hazardous chemical inventory reporting, and toxic chemical release inventory reporting. Each provision requires reporting when thresholds are exceeded (Table 2.2).

PNNL EPCRA reporting combines the quantities of chemicals in the Hanford 300 Area facilities that PNNL occupies and those present in PNNL Richland Campus facilities.

PNNL electronically submitted a Tier Two report to the Washington State Emergency Response Commission, Benton County Emergency Management, and the Richland Fire Department on February 7, 2019. The report provided updated inventories of urea, diesel fuel, and lead-acid batteries (which contain sulfuric acid, an extremely hazardous substance)—the only chemicals exceeding the combined reporting threshold at the PNNL Richland Campus during CY 2018. Battelle also filed a Tier Two report to the Washington State Emergency Response Commission, Clallam County Emergency Management, and Clallam Fire District 3 on February 5, 2019, for diesel fuel stored at MSL—the only hazardous substance stored in excess of reporting thresholds. Diesel fuel is used to power generators during electrical service interruptions.

Neither the PNNL Richland Campus nor MSL was required to submit a Toxic Release Inventory Report for 2018, because no releases of Toxic Release Inventory chemicals occurred in excess of reporting thresholds.

Table 2.3 provides an overview of PNNL reporting under EPCRA for CY 2018.

Table 2.2. Provisions of the *Emergency Planning and Community Right-to-Know Act of 1986*

Section	CFR Section	Reporting Criteria	Due Date	Agencies Receiving Report
302	40 CFR Part 355: Emergency Planning	The presence of an extremely hazardous substance in a quantity equal to or greater than the threshold planning quantity at any one time.	Within 60 days of threshold planning quantity exceedance.	SERC; LEPC
302	40 CFR Part 355: Emergency Planning	Change occurring at a facility that is relevant to emergency planning.	Within 30 days after the change has occurred.	LEPC
304	40 CFR Part 355: Emergency Release Notification	Release of an extremely hazardous substance or a CERCLA hazardous substance in a quantity equal to or greater than the reportable quantity.	Initial notification: immediate (within 15 minutes of knowledge of reportable release). Written follow-up within 14 days of the release.	SERC; LEPC
311	40 CFR Part 370: Reporting Requirements – Material Safety Data Sheet Reporting	The presence at any one time at a facility of an OSHA hazardous chemical in a quantity equal to or greater than 4,500 kg (10,000 lb) or an extremely hazardous substance in a quantity equal to or greater than the threshold planning quantity or 230 kg (500 lb), whichever is less.	Revised list of chemicals due within 3 months of a chemical exceeding a threshold.	SERC; LEPC; local fire departments
312	40 CFR Part 370: Reporting Requirements – Tier Two Report	The presence at any one time at a facility of an OSHA hazardous chemical in a quantity equal to or greater than 4,500 kg (10,000 lb), or an extremely hazardous substance in a quantity equal to or greater than the threshold planning quantity or 230 kg (500 lb), whichever is less.	Annually by March 1.	SERC; LEPC; local fire departments
313	40 CFR Part 372: Reporting Requirements – Toxic Release Inventory Report	Manufacture, processing, or use at a facility of any listed Toxic Release Inventory chemical in excess of its threshold amount during the course of a calendar year. Thresholds are 11,300 kg (25,000 lb) for manufactured or processed chemicals or 4,500 kg (10,000 lb) for chemicals otherwise used, except for persistent, bio-accumulative, toxic chemicals, which have thresholds of 45 kg (100 lb) or less.	Annually by July 1.	EPA; SERC

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980;* CFR = *Code of Federal Regulations;* EPA = U.S. Environmental Protection Agency; LEPC = Local Emergency Planning Committee; OSHA = Occupational Safety and Health Administration; SERC = State Emergency Response Commission.

Table 2.3. *Emergency Planning and Community Right-to-Know Act of 1986* Compliance Reporting, 2018

Section	Description of Reporting	Reporting Status	Notes
302	Emergency planning notifications	Not required	No changes in previously reported inventories of sulfuric acid and no new extremely hazardous substances managed in excess of thresholds.
304	Extremely hazardous substance release notification	Not required	No releases occurred.
311	Material Safety Data Sheet	Yes	No changes to previously reported inventories.
312	Chemical inventory	Yes	The CY 2018 Tier Two reports for the PNNL Richland Campus and MSL were submitted to the Washington State Department of Ecology, the LEPC, and the local fire department in February 2019.
313	Toxic release inventory	Not required	No releases were greater than the reporting threshold requirement.

CY = calendar year; LEPC = Local Emergency Planning Committee; MSL = PNNL Marine Sciences Laboratory; PNNL = Pacific Northwest National Laboratory.

2.7 Natural and Cultural Resources

The *Pacific Northwest Site Office Cultural and Biological Resources Management Plan* (CBRMP; DOE-PNSO 2015) provides direction and guidance related to protecting and managing biological and cultural resources on the PNNL Richland Campus in accordance with applicable laws and regulations. The CBRMP was developed as a requirement of DOE Policy 141.1, "Department of Energy Management of Cultural Resources," to provide for the protection and management of cultural and biological resources, identify impacts of unauthorized public use on prehistoric sites, identify actions that will protect sensitive sites, and provide details of annual monitoring activities to identify potential impacts. The CBRMP is implemented by application of PNNL's internal cultural and biological resource protection procedures, which are updated regularly to reflect relevant changes in applicable laws and regulations and compliance methods.

PNNL conducts field research for which environmental permits are required, often at locations throughout the Pacific Northwest other than the PNNL Richland Campus or MSL. The Environmental Research Permitting (ERP) program was established in 2016 to centralize the acquisition of permits and authorizations in compliance with laws and regulations applicable to PNNL research projects. The ERP program also maintains a searchable permit database and tracks reporting requirements. The Environmental Permitting Information Center is the information repository and database for environmental permits.

The following sections describe the laws and regulations applicable to biological and cultural resources on the PNNL Richland Campus, at MSL, and at offsite research locations, as well as PNNL activities conducted to protect and manage biological and cultural resources, including environmental permitting for research projects.

2.7.1 Biological Resources

A number of federal and state laws, Executive Orders, regulations, and related memoranda contain requirements for protecting biological resources both on the PNNL Richland Campus, at MSL, and at offsite locations where PNNL research projects are conducted. This section and Table 2.4 summarize the requirements and catalog PNNL's compliance activities related to biological resources in 2018.

Federal Statutes and Regulations

The ESA (16 U.S.C. § 1531 *et seq.*) contains requirements for the designation and protection of wildlife, fish, plant, and invertebrate species that are in danger of becoming extinct due to natural or manmade factors, and the conservation of habitats upon which they depend. Under Section 7(a)(2) of the Act, federal agencies are required to evaluate actions that they perform, fund, or permit to determine whether they would affect any species listed as endangered or threatened or impact designated critical habitat. Consultation with the U.S. Fish and Wildlife Service (USFWS) and/or the National Marine Fisheries Service (NMFS) is required if the action may affect listed species or critical habitat. The biological resource review process and consultation with USFWS and/or NMFS are the primary means by which PNNL determines whether any listed species or critical habitat may be affected by a proposed action.

The *Migratory Bird Treaty Act* (16 U.S.C. § 703 *et seq.*) makes it illegal to take, capture, or kill any migratory bird, or to take any part, nest, or egg of any such birds. A Department of the Interior Office of the Solicitor Memorandum (M-37050 issued in December 2017 [DOI 2017]) and subsequent explanatory Memorandum (issued in June 2018 [DOI 2018]) clarified that an active nest of a migratory bird may be destroyed while conducting any activity where the intent of the action is not to kill migratory birds or destroy their nests or contents (incidental take). Although incidental take by PNNL projects would not constitute a violation of the MBTA, PNNL projects that have a potential to affect avian species listed under the Act use the PNNL biological resource review process as described in the CBRMP (DOE-PNSO 2015) and implemented by PNNL's internal biological resource protection procedures to protect migratory birds. In 2018, PNNL biologists resolved 19 inquiries concerning migratory birds on the PNNL Richland Campus and at MSL, and installed deterrents in areas of habitual nesting to avoid potential impacts on active bird nests.

The *Bald and Golden Eagle Protection Act* (16 U.S.C. § 688 *et seq.*) prohibits anyone without a permit from disturbing, wounding, killing, harassing, or taking bald eagles or golden eagles (*Aquila chrysaetos*), alive or dead, including their parts, nests, or eggs. The Act also applies to impacts made around previously used nest sites, if, upon an eagle's return, normal breeding, feeding, or sheltering habits are influenced negatively. The PNNL biological resource review process provides assurance that a proposed action will not adversely affect bald or golden eagles. Mitigation includes performing work according to the spatial and timing restrictions established for seasonal use locations, such as nest sites and communal night roosts in applicable jurisdictional management plans for the species.

The *Magnuson–Stevens Fishery Conservation and Management Act* (16 U.S.C. § 1801 *et seq.*) is the primary law governing marine fisheries management in the United States. It provides a national program for the conservation and management of U.S. fishery resources in order to prevent overfishing, rebuild overfished stocks, assure conservation, and facilitate long-term protection of essential fish habitats (waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity). Under Section 305(b)(2) of the Act, federal agencies must consult with the NMFS about any action that might adversely affect essential fish habitat. The PNNL biological resource review process and consultation with NMFS are the primary means by which PNNL determines whether any essential fish habitat may be affected by a proposed action.

Table 2.4. Environmental Research Permits Obtained in 2018 for PNNL Research Activities

Issuer and Permit Type	Regulatory Driver(a)	Number of Permits
Bonneville Power Administration		
No Effect Determination (ESA)	ESA	1
City of Tacoma		
Shoreline Substantial Development Permit Exemption	SMA	1
Clallam County		
Shoreline Substantial Development Permit Exemption	SMA	1
Clark County		
Shoreline Substantial Development Permit Exemption	SMA	1
Columbia County		
Shoreline Substantial Development Permit Exemption	SMA	1
Environmental Agency of Iceland		
Research Permit	N/A	1
Environmental Protection Agency		
National Pollutant Discharge Elimination System Permit	CWA	1
Franklin County		
Shoreline Substantial Development Permit Exemption	SMA	1
Garfield County		
Shoreline Substantial Development Permit Exemption	SMA	1
Grant County		
Shoreline Substantial Development Permit Exemption	SMA	1
King County		
Shoreline Substantial Development Permit Exemption	SMA	1
Mission Support Alliance		
Hanford Site Excavation Permit	WAC	1
National Marine Fisheries Service		
ESA Section 7/MSFCMA Essential Fish Habitat Informal Consultation	ESA, MSFCMA	3
Federal Columbia River Power System Biological Opinion – Determination of Take	ESA	1
Willamette Biological Opinion – Determination of Take	ESA	2
National Park Service		
Scientific Research and Collecting Permit	NPSOA, CFR	2
Oregon Department of Fish and Wildlife		
Fish Transport Permit	OAR	1
Scientific Taking Permit – Fish	OAR	4
Oregon Department of Transportation		
Permit to Occupy or Operate Upon a State Highway	OAR	1
Oregon Department of State Lands		
Short-Term Access Agreement	OAR	1
PNNL for DOE-PNSO		
No Effect Determination (ESA)	ESA	1
No Effect Determination (ESA/EFH)	ESA, MSFCMA	1
No Effect Determination (ESA/MMPA)	ESA, MMPA	1

Issuer and Permit Type	Regulatory Driver(a)	Number of Permits
Private Landowner		
Property Access	N/A	2
Skamania County		
Shoreline Substantial Development Permit Exemption	SMA	1
U.S. Army Corps of Engineers		
Nationwide Permit 5 – Scientific Measurement Devices	RHA, CWA	2
Nationwide Permit 6 – Survey Activities	RHA, CWA	2
U.S. Coast Guard		
Private Aids to Navigation – Local Notice to Mariners	CFR	2
U.S. Fish and Wildlife Service		
ESA Section 7 Informal Consultation	ESA	3
Special Use Permit	NWRSAA, CFR	1
U.S. Forest Service		
Nominal Effects Letter	FSOA, CFR	1
Walla Walla County		
Shoreline Substantial Development Permit Exemption	SMA	1
Washington Department of Fish and Wildlife		
Fish Transport Permit	WAC	11
Hydraulic Project Approval	WAC	2
Right of Entry	WAC	1
Scientific Collection Permit	WAC	1
Washington Department of Natural Resources		
Aquatic Lands Right of Entry License	WAC	3
Whitman County		
Shoreline Substantial Development Permit Exemption	SMA	1
Total		**64**

CFR = Code of Federal Regulations; CWA = *Clean Water Act*; EFH = Essential Fish Habitat; ESA = *Endangered Species Act of 1973*; FSOA = *Forest Service Organic Administration Act of 1897*; MMPA = *Marine Mammal Protection Act of 1972*; MSFCMA = *Magnuson–Stevens Fishery Conservation and Management Act*; NPSOA = *National Park Service Organic Act*; NWRSAA = *National Wildlife Refuge System Administration Act of 1966*; OAR = Oregon Administrative Rules; RHA = *Rivers and Harbors Appropriation Act of 1899*; SMA = *Shoreline Management Act of 1971*; WAC = *Washington Administrative Code*.
N/A = not applicable

The *Marine Mammal Protection Act of 1972* (16 U.S.C. § 1361 *et seq.*) provides a program for the protection of all marine mammals based on some species or stocks being in danger of extinction or depletion due to human activities. The purpose of the Act is to assure that actions that may affect marine mammal species or stocks do not cause them to fall below their optimum sustainable population levels. Consultation with the NMFS is required if an action may affect any marine mammal species. The biological resource review process and consultation with NMFS are the primary means by which PNNL determines whether marine mammal species may be affected by a proposed action.

The *Rivers and Harbors Appropriation Act of 1899* (RHA; 33 U.S.C. § 403 *et seq.*) is the oldest federal environmental law in the United States. Section 10 of the Act prohibits the creation of any obstruction, excavation, or fill within a navigable waterway without a permit, including but not limited to the building of any wharfs, piers, jetties, or other structures. Authorization for issuing permits under both RHA Section 10 and *Clean Water Act* Section 404 (Section 2.5.1) is delegated to the U.S. Army Corps of

Engineers (USACE), within the Department of the Army. One of several permit types may be issued depending on the type of use and the project's impacts on navigable waters. The USACE has established a system of Nationwide Permits to streamline permitting certain activities known to have minimal impacts. Nationwide Permits are often acquired for PNNL research projects; two Nationwide Permits were issued in 2018 (Table 2.4). PNNL evaluates the need for Department of the Army permits for each project as part of its biological resource review process and corresponds with USACE under the auspices of its ERP program.

The *Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990* (16 U.S.C. § 4701 *et seq.*) provides for the development and execution of environmentally sound control methods that prevent the unintentional introduction and dispersal of nonindigenous aquatic nuisance species into waters of the United States. PNNL has developed and implements an aquatic invasive plant and animal species interception program to comply with this Act. The program details mechanisms for controlling nuisance species on aquatic equipment used in affected waters to prevent accidental introduction of those species into uninfested waters.

Executive Order 11990 of May 24, 1977, "Protection of Wetlands" (42 FR 26961), requires federal agencies to minimize the destruction, loss, or degradation of wetlands on federal lands, and to preserve and enhance the natural and beneficial values of wetlands on federal lands. The Order does not apply to non-federal property. The Order states that federal agencies should avoid undertaking or providing assistance for new construction located in wetlands unless the agency finds 1) that there is no practicable alternative to such construction, and 2) that the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use. Compliance with this Order, as well as the wetland provisions of the *Clean Water Act* (Section 2.5.1), is achieved through the biological resource review process at PNNL.

Executive Order 11988 of May 24, 1977, "Floodplain Management" (42 FR 26951), requires federal agencies to evaluate the potential effects of any actions within a floodplain to minimize any direct or indirect impacts on the floodplain's natural and beneficial values. Floodplain management and the consequences of flood hazards are considered when developing water- and land-use plans, as well as alternatives to floodplain use. Compliance with this Order is achieved through the biological resource review process at PNNL.

Executive Order 13112 of February 3, 1999,"Invasive Species" (64 FR 6183), establishes a National Invasive Species Council to oversee implementation of the Order and requires federal agencies to identify actions that may affect the status of invasive species; prevent introduction of invasive species; detect, respond to, monitor, and control populations of invasive species; provide for restoration of native species and habitats in ecosystems that have been invaded; and conduct research and public outreach to control and prevent the introduction of invasive species. See Section 2.7.1.1 for a description of the PNNL noxious weed control program.

Executive Order 13186 of January 10, 2001, "Responsibilities of Federal Agencies to Protect Migratory Birds" (66 FR 3853), requires agencies to avoid or minimize the adverse impact of their actions on migratory birds and to assure that environmental analyses under NEPA evaluate the effects of proposed federal actions on such species. A Memorandum of Understanding (MoU) between DOE and the USFWS regarding implementation of Executive Order 11386, identifies specific areas in which enhanced collaboration between DOE and the USFWS will substantially contribute to the conservation and management of migratory birds and their habitats (DOE and USFWS 2013). Compliance with the Order and MoU are assured by PNNL's biological resource review process as described in the CBRMP (DOE-PNSO 2015) and implemented by PNNL's internal biological resource protection procedures.

The *Coastal Zone Management Act of 1972* (16 U.S.C. § 1451 *et seq.*) establishes two national programs, the National Coastal Zone Management Program and the National Estuarine Research Reserve System, and is administered by the National Oceanic and

Atmospheric Administration (NOAA) Office of Ocean and Coastal Resource Management. The Act encourages and provides for federal assistance to states and/or Native American tribes to voluntarily develop a coastal zone management program to preserve, protect, develop, and where possible, restore or enhance valuable natural coastal resources such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as the fish and wildlife using those habitats. The Act considers ecological, cultural, historical, and aesthetic values, need for compatible economic development, and the siting of major facilities in or adjacent to areas of existing development. The Act outlines a national estuarine research reserve system, which serves as a field laboratory to promote greater understanding of estuaries and anthropogenic impacts on them. The *Coastal Zone Act Reauthorization Amendments of 1990* include Section 6217, which calls upon states and/or Native American tribes with federally approved coastal zone management programs to develop coastal nonpoint pollution control programs to improve, safeguard, and restore the quality of coastal waters. Section 6217 is administered jointly by EPA and NOAA. PNNL maintains compliance with this Act through its biological resource review process and its ERP program.

The U.S. Coast Guard (USCG) administers 33 CFR Part 66, *Navigation and Navigable Waters*, "Private Aids to Navigation." For the safe navigation of watercraft, the installation of a fixed structure or floating object in any navigable water of the United States requires review by the USCG to determine whether a permit and/or private aid to navigation (a buoy, light, or day beacon owned and maintained by a private organization or individual [PATON]) is necessary. The USCG also publishes a Local Notice to Mariners (LNM) weekly, which provides information about the location of structures to facilitate navigational safety in marine environments. Permits, PATONs, and LNMs allow research projects to be located in navigable waters without posing undue hazard to watercraft. PNNL maintains compliance with these regulations through its ERP program.

The *Forest Service Organic Administration Act of 1897* (formally titled the *Sundry Civil Appropriations Act of 1897*, but commonly called the *Forest Service Organic Act*) specified the purpose for establishing forest reserves and their administration and protection. The U.S. Forest Service, within the U.S. Department of Agriculture, administers the use of national forests, including for scientific research, under 36 CFR Part 251. Uses such as scientific research and specimen collecting are deemed "special uses" and require a permit. PNNL maintains compliance with these regulations through its ERP program.

The *National Park Service Organic Act* established the National Park Service in 1916 to oversee management of national parks and monuments. The National Park Service, within the U.S. Department of the Interior, administers the use of such lands under Chapter 1 of 36 CFR, which governs parks, forests, and public property. A Scientific Research and Collecting Permit is required for activities pertaining to natural resources that involve fieldwork, specimen collection, or that may potentially disturb resources or visitors. PNNL maintains compliance with these regulations through its ERP program.

The *National Wildlife Refuge System Administration Act of 1966* formally established the National Wildlife Refuge System and provided administration and management directives under the jurisdiction of the USFWS. The USFWS, in accordance with 50 CFR, issues permits for uses, including scientific research, deemed compatible with the purposes of specific refuge areas. PNNL maintains compliance with these regulations through its ERP program.

The *Columbia River Gorge National Scenic Area Act* (16 U.S.C. § 544 *et seq.*) was enacted to protect and enhance the scenic, recreational, and natural resources and to support the economy of the Columbia River Gorge. The Act is implemented through a Gorge Management Plan (CRGC 2011) overseen by the U.S. Forest Service and an Oregon-Washington bi-state Columbia River Gorge Commission. The U.S. Forest Service conducts consistency reviews for proposed projects that are to be located within designated management areas. PNNL maintains compliance with this Act through its ERP program.

State Statutes and Regulations

PNNL conducts biological research studies at locations throughout the Northwest and must also comply with applicable state and local statutes, regulations, and directives at those sites. Principal relevant rulings are summarized in the following paragraphs.

The Washington State *Shoreline Management Act of 1971* (RCW 90.58, as amended) establishes policy for shoreline use and environmental protection along shorelines that include rivers and streams with a mean annual flow greater than 0.6 m3/s (21 ft3/s), which includes the Columbia River in Benton and Franklin Counties. The shoreline jurisdiction extends 61 m (200 ft) landward of these waters, and includes associated wetlands, floodways, and up to 61 m (200 ft) of floodway-contiguous floodplains. The Act requires that shoreline uses be consistent with the control of pollution and the prevention of damage to the natural environment, and requires protection of natural resources, including the land, vegetation, wildlife, water, and aquatic life from adverse effects. County Shoreline Master Programs (Ecology 2019) implement the policies of the Washington State *Shoreline Management Act of 1971* at the local level and establish a shoreline-specific combined comprehensive plan, zoning ordinance, and development permit system. PNNL maintains compliance with the Act by complying with the provisions of County Shoreline Master Programs through PNNL's ERP program.

Several chapters and sections of the Washington Administrative Code (WAC) govern activities that affect fish and wildlife or their habitat, aquatic lands, and excavation activities in the state of Washington. WAC 220-200-150 requires a Scientific Collection Permit from the WDFW for the collection of fish, shellfish, wildlife, or nests of birds for research purposes, as well as a Fish Transport Permit for transporting fish or the viable eggs/gametes of fish into or through Washington. WAC 220-660 requires a Hydraulic Project Approval from the WDFW for construction or projects that will use, divert, obstruct, or change the natural flow or bed of any waters of the state (see RCW 77.55). WAC 332-30 governs the use of state-owned aquatic lands and outlines necessary use authorizations from the Washington State Department of Natural Resources. WAC 296-155-655 requires that utility companies or land owners be contacted prior to excavation activities, resulting in the issuance of an Excavation Permit. PNNL maintains compliance with these regulations through its ERP program.

PNNL regularly conducts research activities in the state of Oregon and must comply with state regulations involving fish and wildlife or their habitat, and aquatic lands as governed by the Oregon Administrative Rules (OARs). OAR 635-007 and OAR 635-043 direct the administration of Scientific Taking Permits for fish and for wildlife, respectively, under the jurisdiction of the Oregon Department of Fish and Wildlife. OAR 141-082 governs the use of state-owned submerged land and OAR 141-089 governs removal/fill activities within waters of the state under the jurisdiction of the Oregon Department of State Lands. PNNL maintains compliance with these regulations for research activities through its ERP program.

PNNL Programs

Programs and activities performed to assure compliance with the preceding biological resource statutes and drivers are discussed in the following paragraphs.

PNSO prepared the CBRMP (DOE-PNSO 2015) in response to the direction and guidance provided in DOE Policy 141.1, "Department of Energy Management of Cultural Resources," related to protecting and managing cultural and biological resources. The plan provides direction on the requirements for annual surveys and monitoring for species of concern, review of project activities for environmental impacts, and identification and control of invasive species. The CBRMP is implemented by application of PNNL's internal cultural and biological resource protection procedures.

As stipulated in the CBRMP (DOE-PNSO 2015), projects involving soil or vegetation disturbance or work outdoors are routinely evaluated to determine

their potential to affect biological resources prior to implementation. Forty-four biological resource reviews were conducted for PNNL projects in CY 2018—30 on the Richland Campus, 12 at MSL or for MSL-related projects, and 2 at other locations.

Potential project impacts were evaluated for plant or animal species protected under the ESA, species proposed or candidates for such protection, and species of concern; species listed by the state of Washington as threatened, endangered, sensitive, candidate, or monitor; Washington State priority habitats; and bird species protected under the *Migratory Bird Treaty Act* and *Bald and Golden Eagle Protection Act*. No projects violated related federal or state laws, regulations, or conservation priority guidance.

Staff ecologists performed pedestrian and visual reconnaissance surveys of biological resources found on the undeveloped portions of the PNNL Richland Campus from May through August 2018, which included the riparian zone adjacent to the Columbia River. The primary objective of the field surveys was to determine the occurrence of the plant and animal species and habitats of interest for project-specific biological resource reviews. Lists of plant and animal species identified on the undeveloped portions of the PNNL Richland Campus from 2009 to 2018, and at MSL from 2013 to 2015 (except for avian surveys, which were also conducted from 2016 to 2018) and their status are provided in Appendix A and Appendix B, respectively.

2.7.1.1 Noxious Weed Control

Several non-native plant species listed as Class B and Class C noxious weeds (as classified by the state of Washington, WAC 16-750-011 and 16-750-015, respectively) have been identified on the PNNL Richland Campus (Larson and Downs 2009; Duncan et al. 2018). Class B noxious weeds are species designated for control where they are not yet widespread, to prevent new infestations (WNWCB 2019). On the PNNL Richland Campus, Class B species include diffuse knapweed (*Centaurea diffusa*), Russian knapweed (*Rhaponticum [Acroptilon] repens*), skeletonweed (*Chondrilla juncea*), burning-bush (*Bassia* [*Kochia*] *scoparia*), puncturevine (*Tribulus terrestris*), broadleaf pepperweed (*Lepidium latifolium*), yellow starthistle (*Centaurea solstitialis*), and cotton [Scotch] thistle (*Onopordum acanthium*). Class C noxious weeds are already widespread and control is determined on a case-by-case basis at the county level (WNWCB 2019). Class C species include heart-podded hoarycress (*Lepidium draba*), creeping thistle (*Cirsium arvense*), bindweed (*Convolvulus arvensis*), Russian olive (*Elaeagnus angustifolia*), tree-of-heaven (*Ailanthus altissima*), common St. John's-wort (*Hypericum perforatum*), Himalayan blackberry (*Rubus bifrons*), baby's-breath (*Gypsophila paniculata*), common groundsel (*Senecio vulgaris*), and reed canarygrass (*Phalaris arundinacea*) (Appendix A).

Since 2010, PNNL has carried out a noxious weed control program on the PNNL Richland Campus. Certified Facilities and Operations staff, in coordination with staff ecologists, use hand-spraying methods (spot-spraying of individual weeds within a surveyed/traversed area) to control populations of Class B noxious weeds in upland areas of natural vegetation. The hand-spraying method facilitates avoidance of non-target species. The herbicide applied is Milestone™ (along with water conditioner, drift control agent, surfactant, and blue dye).

Control efforts in 2018 and recent years have shown progress in reducing the occurrence and preventing the spread of noxious weeds on the PNNL Richland Campus (Figure 2.1). Rush skeletonweed occurs throughout areas of natural vegetation on the PNNL Richland Campus and is most prevalent in previously disturbed areas or along road edges. It spreads by

seed and by root, forming dense stands if left unchecked. Focused control efforts over the past several years have greatly reduced its density. Diffuse knapweed occurs sporadically throughout areas of natural vegetation and reproduces primarily by seed. Focused control efforts over the past several years have reduced its prevalence. Russian knapweed reproduces by seed and roots, and can form dense stands where water is adequate. Of several large patches, two were sprayed in 2018, which reduced their size and density. Yellow starthistle is an annual or biennial plant that reproduces by seed. Preventing flowering and/or removing the seed source is an effective control; several known locations have been reduced in size through control efforts in 2017 and 2018. Scotch thistle was just recently identified on the PNNL Richland Campus. It reproduces by seed and efforts were made in 2018 to prevent flowering of this weed.

The primary target species of the treatment program in 2018 were rush skeletonweed, diffuse knapweed, and Russian knapweed. Yellow starthistle and Scotch thistle were sprayed when encountered during herbicide application days. They were also hand-pulled (yellow starthistle) or hand-chopped to the ground (Scotch thistle), and flower heads were bagged and disposed when observed following the spray period (Figure 2.2). Hand-spraying was conducted on seven days between May 22 and June 27, 2018.

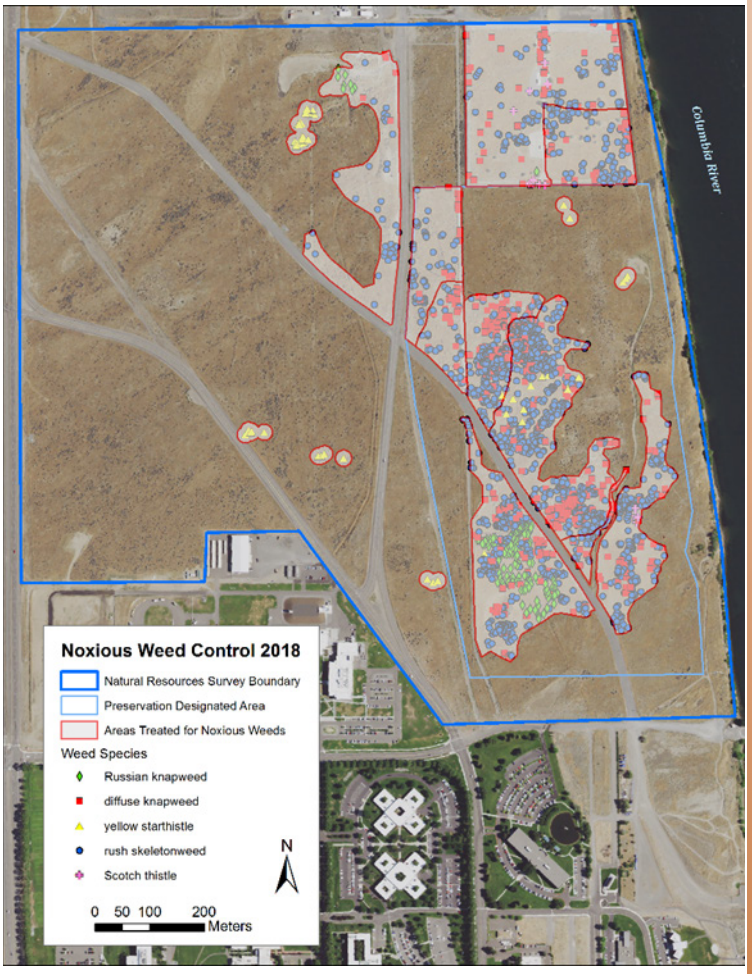


Figure 2.1. Areas Treated for Noxious Weeds on the PNNL Richland Campus in 2018

Figure 2.2. Scotch Thistle Before (left) and After (right) Hand Chopping for Removal and Disposal of Flower Heads

2.7.1.2 Habitat Mitigation

In 2013, PNNL began site preparation in support of Phase 2 construction of the PSF. The initial land clearing for this development phase resulted in the loss of approximately 6.6 ha (16.3 ac) of mature sagebrush steppe habitat. As stipulated in the mitigation action plan prepared for this activity (DOE-PNSO 2013), this habitat loss needed to be mitigated. PNNL performed compensatory mitigation for this habitat loss by working with the National Fish and Wildlife Foundation and the USFWS to establish replacement habitat on the Fitzner-Eberhardt Arid Lands Ecology Reserve, which is part of the Hanford Reach National Monument. The USFWS coordinated the planting of 112,158 shrub seedlings in three plots over approximately 321 ha (794 ac) in early December 2016. Approximately three-quarters of the shrub seedlings were big sagebrush, and the balance consisted of antelope bitterbrush, winterfat (*Krascheninnikovia lanata*), snow buckwheat, green rabbitbrush, gray rabbitbrush, spiny hopsage (*Grayia spinosa*), and purple sage (*Salvia dorrii*). Twenty-four monitoring transects were established in the spring of 2017 and the number of plants by species (composing greater than 1% of the total number of seedlings planted in 2016) was counted; survival was assessed in 2018. Sagebrush survival was approximately 30%, Snow buckwheat was approximately 60%, bitterbrush 50%, and rabbitbrush 18%. Survival will be assessed again in spring 2020 and 2022.

2.7.2 Cultural Resources

A number of federal Acts and Orders provide the framework for protection of cultural resources on the PNNL Richland Campus and at MSL. This section summarizes the requirements and catalogs PNNL's compliance activities in 2018.

The *National Historic Preservation Act of 1966* (54 U.S.C. § 300101 *et seq.*) and its amendments established historic preservation as a national policy and define it as the protection, rehabilitation, restoration, and reconstruction of districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, or engineering. The Act also expanded the National Register of Historic Places (NRHP) listing to include resources of state and local significance, and it established the Advisory Council on Historic Preservation as an independent federal agency. As a result of Public Law 113-287 (enacted on December 19, 2014), the *National Historic Preservation Act of 1966* (NHPA) was repealed from 16 U.S.C. § 470 *et seq.*, and reenacted in 54 U.S.C. § 300101 *et seq.*, *Historic Preservation Programs*. Section 106 of the NHPA specifically requires federal agencies to consider the impact of federally funded, permitted projects or projects occurring on federally managed lands on cultural resources that are eligible for listing or listed in the NRHP. At PNNL the cultural resources review process supports compliance with NHPA Section 106.

The *Antiquities Act of 1906* (54 U.S.C. § 320301–320303 and 18 U.S.C. § 1866(b)) provided for the protection of historic and prehistoric remains and structures on federal lands. It established a permit system for conducting scientific archaeological investigations and established criminal penalties and fines to manage looting and vandalism of archaeological sites on public lands. By the 1970s, the penalties were no longer commensurate with the severity of the offenses, and in 1974 the Ninth Circuit Court of Appeals proclaimed the Act to be unconstitutionally vague. In response, Congress enacted the *Archaeological Resources Protection Act of 1979* (16 U.S.C. § 470aa). As a result of Public Law 113-287 (enacted on December 19, 2014), the *Antiquities Act of 1906* was repealed from 16 U.S.C. § 431–433 and reenacted in 54 U.S.C. § 320301–320303, *Monuments, Ruins, and Objects of Antiquity,* and 18 U.S.C. § 1866(b), *Historic, Archeologic, or Prehistoric, Items and Antiquities.*

The *Archaeological Resources Protection Act of 1979* (16 U.S.C. § 470aa-mm) provides for the protection of archaeological resources and sites on federal and tribal lands. It also describes the conditions required preceding the issuance of a permit to excavate or remove any archaeological resource, the curation and record requirements for resource removal or excavation, and the penalties for convicted violators. At PNNL, the annual site monitoring activities support compliance with the *Archaeological Resources Protection Act of 1979*.

The *Native American Graves Protection and Repatriation Act of 1990* (25 U.S.C. § 3001 *et seq.*) established a means for Native Americans to request the return of human remains and other sensitive cultural articles held by federal agencies. It also contains provisions regarding the requirement to inventory any remains and associated funerary objects, the intentional excavation of remains or cultural items, and the illegal trafficking of those items.

The *American Indian Religious Freedom Act* (42 U.S.C. § 1996 *et seq.*) was established in 1978 for the protection and preservation of the traditional religious ceremonial rights and cultural practices of American Indians. These rights include access to sacred sites, repatriation of sacred items held in museums, and freedom to worship through traditional ceremonies. The Act also required governmental agencies not to interfere with Native American religious practices and to accommodate access to and use of religious sites to the extent that the use is practicable and consistent with an agency's essential functions. Because the *American Indian Religious Freedom Act* could not enforce its provisions, the *American Indian Religious Freedom Act Amendments of 1994* were established to provide for the management of federal lands "in a manner that does not undermine or frustrate traditional Native American religions or religious practices" (103 HR 4155).

The *Archeological and Historic Preservation Act of 1974* (54 U.S.C. § 312501–312508) provides for the preservation of historical American sites, buildings, objects, and antiquities of national significance. It also imparts the preservation of historical and archaeological data (including relics and specimens), which might otherwise be irreparably lost or destroyed, and requires preservation of significant historical and archaeological data affected by any federal or federally related land modification activity. As a result of Public Law 113-287 (enacted on December 19, 2014), the *Archeological and Historic Preservation Act of 1974* was repealed from 16 U.S.C. § 469–469c-2 and reenacted in 54 U.S.C. § 312501–312508, *Preservation of Historical and Archaeological Data*.

Executive Order 11593 of May 15, 1971, "Protection and Enhancement of the Cultural Environment" (36 FR 8921), requires federal agencies to inventory their cultural resources and establish policies and procedures to assure the protection, restoration, and maintenance of any sites, structures, or objects of historical, architectural, or archaeological significance.

Executive Order 13007 of May 29, 1996, "Indian Sacred Sites" (61 FR 26771), directs federal agencies to accommodate access to and ceremonial use of Indian sacred sites and to avoid adversely affecting the physical integrity of these sites. Where appropriate, agencies shall maintain the confidentiality of sacred sites.

Executive Order 13175 of November 6, 2000, "Consultation and Coordination with Indian Tribal Governments" (65 FR 67249), directs federal agencies to develop a process for assuring meaningful tribal input when developing regulatory policies that have tribal implications and to consult with tribal authorities.

Executive Order 13287 of March 3, 2003, "Preserve America" (68 FR 10635), directs federal agencies to increase their knowledge of historic resources in their care, enhance the management of these assets, and seek partnerships with state, tribal, and local governments to make more informed and efficient use of those resources.

DOE Policy 144.1, "Department of Energy Management of Cultural Resources," assures that DOE maintains a program that reflects the spirit and intent of cultural resource legal mandates. Two specific goals are to:

- assure that DOE programs and field elements integrate cultural resources management into their missions and activities, and
- raise the level of awareness within DOE concerning the importance of the Department's cultural resource-related legal and trust responsibilities.

The purpose of DOE Order 144.1, Admin Chg 1, *Department of Energy American Indian Tribal Government Interactions and Policy,* is to

communicate the departmental, programmatic, and field responsibilities for interacting with American Indian Governments and to communicate DOE's *American Indian and Alaska Native Tribal Government Policy*, including its Guiding Principles and implementation framework.

In consultation with tribal consulting parties and in response to the direction and guidance provided in DOE Policy 144.1, "Department of Energy Management of Cultural Resources," DOE Order 144.1, Admin Chg 1, *Department of Energy American Indian Tribal Government Interactions Policy*, DOE Order 436.1, *Departmental Sustainability*, and DOE Order 430.1B, Chg 2, *Real Property and Asset Management*, DOE-PNSO revised its CBRMP in 2015 (DOE-PNSO 2015). The CBRMP provides direction and guidance for the protection and long-term stewardship of cultural and biological resources on PNSO-managed lands in accordance with federal and state laws.

2.7.2.1 Cultural Resources Reviews

In accordance with NHPA Section 106 requirements (54 U.S.C. § 300101 *et seq.*), cultural resources reviews are conducted for all federal undertakings to identify their potential to affect cultural resources. If an undertaking is determined to be the type of activity that does not have the potential to affect historic properties (assuming such historic properties are present), the agency has no further obligations under NHPA Section 106 as defined by 36 CFR 800.3(1). In 2018, one project was reviewed and determined to have No Potential to Cause Effect on historic properties.

If the undertaking is determined to be the type of activity that has the potential to affect historic properties, the Section 106 process is initiated. The Section 106 review process results in one of three findings: 1) No Historic Properties Affected, 2) No Adverse Effect on Historic Properties, or 3) an Adverse Effect on Historic Properties. Seventeen Section 106 reviews were completed for PNNL projects in 2018: 14 on the PNNL Richland Campus, and 3 on the PNNL MSL site. Three of these reviews resulted in a finding of No Historic Properties Affected, while 13 resulted in a finding of No Adverse Effect on Historic Properties. One project resulted in a finding of Adverse Effect. In addition to these Section 106 reviews, five projects were reviewed by cultural resources staff to assure that the project activities were covered by previously conducted Section 106 cultural resource reviews.

2.7.2.2 Section 110 Activities

To assure that important cultural resources are protected on the PNNL Richland Campus and in accordance with NHPA Section 110 and the *Archaeological Resources Protection Act*, the CBRMP (DOE-PNSO 2015) requires annual monitoring of three NRHP-eligible properties to identify potential threats and recommend appropriate actions, if necessary. As stipulated in the CBRMP, trip results are analyzed and reported to consulting American Indian tribes and the Washington State Historic Preservation Office. The annual Section 110 monitoring was conducted on October 9, 2018. Monitoring was conducted by the PNNL cultural resources staff, with the participation of PNSO and tribal cultural resources staff. Photographs and field notes were taken at set points for each archaeological site to assess the site condition and identify potential changes to the site caused by human or natural causes. In addition, information was collected and added to file records to update the current knowledge of the sites.

No previously unrecorded impacts at any of the three sites were identified during the 2018 monitoring trip. Evidence of disturbance activities at the three sites appeared to be mostly related to past manmade disturbances. Most of the erosional and manmade impacts (roads, construction related impacts, etc.) appeared to be stabilizing, natural vegetation was thriving, and the overall condition was improving. In addition, native grasses and shrubs were found to be thriving in revegetation plots located within one of the sites. These areas will continue to be monitored.

2.7.2.3 Consultation and Public Involvement

PNSO routinely consults with various SHPOs, Tribes, and other interested parties about NHPA Section 106 activities. PNSO consulted with 11 American Indian tribes and the Washington SHPO with respect to NHPA Section 106 activities in 2018.

Tribal consultation and involvement at the PNNL Richland Campus and adjacent Hanford Site is focused on five American Indian tribes that have historical ties to the area. As such, PNSO routinely consults with the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, The Nez Perce Tribe, the Wanapum, and the Confederated Tribes of the Colville Reservation. In addition to NHPA Section 106 consultations, PNSO held seven meetings in 2018 with Tribal Cultural Resources staff. Discussions centered around cultural resources reviews on the PNNL Richland Campus and overviews of program tasks (such as a summary of NHPA Section 110 activities, etc.). In addition, several meetings were held to discuss NHPA Section 106 agreement documents being developed as part of the ongoing NHPA Section 106 Review for the PNNL Richland Campus Future Development project.

Tribal consultation and involvement at MSL is focused on six American Indian tribes that have historical ties to the MSL site, including the Makah Indian Tribe of the Makah Indian Reservation, the Jamestown S'Klallam Tribe of Washington, the Lower Elwha Klallam Tribe, the Port Gamble Indian Community of the Port Gamble Reservation, the Hoh Indian Tribe of the Hoh Indian Reservation, and the Quileute Nation. These tribes are consulted about the protection of biological, natural, and cultural resources related to MSL. In addition to NHPA Section 106 consultations, PNSO held one meeting in August 2018 with the Jamestown S'Klallam and discussed ongoing and future projects occurring at MSL.

In addition to tribal consultation, PNSO consulted with interested parties and the public regarding the ongoing NHPA Section 106 review for the Richland Campus Future Development project.

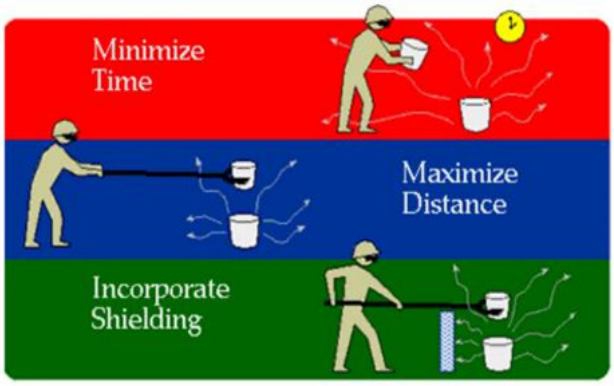
2.8 Radiation Protection

PNNL is subject to the radiation protection statutes and regulations designed to protect the health and safety of the public, the workforce, and the environment.

2.8.1 DOE Order 458.1, Radiation Protection of the Public and the Environment

During the reporting period of this annual site environmental report, PNNL was working under the requirements of DOE Order 458.1, issued in February 2011 with changes in March 2011 (Admin Chg 1), June 2011 (Chg 2), and January 2013 (Admin Chg 3). Section 2.d (As Low As Reasonably Achievable [ALARA]), Section 2.g (Control and Management of Radionuclides from DOE Activities in Liquid Discharges), and Section 2.k (Release and Clearance of Property) of DOE Order 458.1 were added to PNNL's contract with PNSO in July 2011, and were fully implemented on September 1, 2012.

Section 2.d of DOE Order 458.1 requires each contractor to establish an environmental ALARA process to control and manage radiological activities so that doses to the public and releases to the environment are kept ALARA. The ALARA process must be applied to the design or modification of facilities and to the conduct of radiological work activities.



Section 2.g of DOE Order 458.1 requires each contractor to establish and implement procedures and practices related to control and management of radionuclides from DOE activities in liquid discharges.

Section 2.k of DOE Order 458.1 provides the requirements with which each contractor must comply when releasing property that potentially contains residual radioactivity. Dose constraints for the public are established based on the type of property (i.e., personal property and real property). Requirements for releasing property based on process knowledge, radiological surveys, or a combination of both are provided. The process of obtaining pre-approved release limits and activity-specific release limits for

releasing property is also described in the Order. The public is required to be notified annually of property released from contractor facilities.

PNNL radiation protection procedures implement Sections 2.d and 2.k of DOE Order 458.1. Procedures include guidance on the environmental ALARA program, the use of process knowledge and historical knowledge when releasing property, the preparation and approval of requests for authorized limits, and the preparation of an annual site environmental report. A description of PNNL programs that implement these sections of the Order is found in Section 4.3 of this report.

No property with detectable residual radioactivity above guideline limits was released in 2018.

A description of how PNNL complies with the liquid discharge requirements in Section 2.g of DOE Order 458.1 is found in Section 4.1 of this report.

2.8.2 DOE Order 435.1, Radioactive Waste Management

The purpose of DOE Order 435.1 is to establish requirements for assuring DOE radioactive waste is managed in a manner that is protective of workers public health and safety, and the environment. The Order takes a cradle-to-grave approach to managing waste and includes requirements for waste generation, storage, treatment, disposal, and post-closure monitoring of facilities.

Radioactive waste shall be managed such that the requirements of other DOE Orders, standards, and regulations are met, including the following:

- 10 CFR Part 835, "Occupational Radiation Protection"
- DOE Order 440.1B, Chg 2, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*
- DOE Order 458.1, Admin Chg 3, *Radiation Protection of the Public and the Environment.*

DOE Order 435.1 establishes requirements for the management of high-level waste, transuranic waste, and low-level waste. It also covers mixed waste (i.e., high-level waste, transuranic waste, or low-level waste that also contain chemically hazardous constituents). DOE Order 435.1 (approved in 1999) superseded a previous set of requirements (DOE Order 5820.2A, dated September 26, 1988) for managing radioactive waste. DOE Order 435.1, Chg 1, approved in 2001, includes minor revisions to the original Order and was formally certified again in 2007.

PNNL's Radioactive Waste Management Basis Program identifies the hazards associated with radioactive waste management at PNNL along with their potential impacts. Controls for the protection of the public, workers, and the environment are also presented. Controls are implemented through internal PNNL workflows and waste-management procedures.

2.8.3 Atomic Energy Act of 1954

The *Atomic Energy Act of 1954* (42 U.S.C. § 2011 *et seq.*) was promulgated to assure the proper management of radioactive materials. Through the Act, DOE regulates the control of radioactive materials under its authority, including the treatment, storage, and disposal of low-level radioactive waste from its operations, and establishes radiation protection standards for itself and its contractors. Accordingly, DOE promulgated a series of regulations (e.g., 10 CFR Part 820, 10 CFR Part 830, and 10 CFR Part 835) and directives (e.g., DOE Order 435.1, Chg 1 [Section 2.8.2] and DOE Order 458.1, Admin Chg 3 [Section 2.8.1]) to protect public health and the environment from potential risks associated with radioactive materials. PNNL complies with the *Atomic Energy Act of 1954* through its Radiation Protection Management and Operation Program and Radioactive Waste Management Basis Program.

2.9 Major Environmental Issues and Actions

Releases of radioactive and regulated materials to the environment are reported to DOE and other federal, state, and/or local agencies as required by law. The specific agencies notified depend on the type and amount of material released, and the location of each release event. This section describes any releases to the environment that occurred at PNNL during CY 2018.

2.9.1 Continuous Release Reporting

A continuous release is a hazardous release exceeding reporting thresholds under CERCLA regulations (40 CFR 302.8) that is "continuous" and "stable in quantity and rate" for which reduced reporting requirements apply. There were no continuous releases on the PNNL Richland Campus or at MSL in 2018.

2.9.2 DOE Order 232.2A, Occurrence Reporting and Processing of Operations Information

DOE Order 232.2A, requires the reporting of incidents that could adversely affect the public or workers, the environment, or the mission that occur at DOE sites and/or during DOE operations. Releases requiring regulatory agency notification (Section 2.9.3) and receipt of formal or informal regulator correspondence alleging violations (Section 2.6) are required to be reported to DOE through the reporting system. PNNL reports all incidents to DOE as required.

2.9.3 Unplanned Releases

No environmentally significant releases occurred at PNNL in 2018.

2.10 Summary of Permits

Table 2.5 summarizes air, liquid, and hazardous waste permits for the PNNL Richland Campus and MSL during 2018. Project-specific permits are also acquired but are not reflected in the table because they are usually of limited term and scope.

Table 2.5. PNNL Air, Liquid, and Hazardous Waste Permits, 2018

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[a]
Air Emissions				
Washington State Department of Health	FF-01[b]	PNNL-occupied locations on Hanford Site	Radioactive air emissions	10/20/2022
Washington State Department of Health	RAEL-005	PNNL Richland Campus	Radioactive air emissions	6/17/2020
Washington State Department of Health	RAEL-014	PNNL Marine Sciences Laboratory	Radioactive air emissions	1/1/2023
Washington State Department of Ecology	00-05-006, Renewal 2, Revision A	PNNL-occupied locations on Hanford Site	Radioactive and nonradioactive air emissions	3/31/2018
Benton Clean Air Agency	Order 2007-0013, Rev. 1	Physical Science Facility	Nonradioactive air emissions	None

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[a]
Benton Clean Air Agency	Order 2017-0008	Four hot water boilers in PSF buildings	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 2012-0017	PNNL Richland Campus – Building Operations	Nonradioactive air emissions	None
Benton Clean Air Agency	RO 2012-0009	W.R. Wiley Environmental Molecular Sciences Laboratory – Building Operations	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 2012-0016	PNNL Richland Campus – R&D Pilot Scale Processes and Field Experiments	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 2007-0006, Rev. 1	Life Sciences Laboratory II – Building Operations	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 2016-0008	Life Sciences Laboratory II – Halogenated Solvent Degreaser Operations	Nonradioactive air emissions	None
Washington State Department of Ecology	Order 02NWP-001	300 Area Standby Generators (Radiochemical Processing Laboratory & 331 Buildings)	Nonradioactive air emissions	None
Olympic Region Clean Air Agency	Order of Approval 13NOI968	PNNL Marine Sciences Laboratory Standby Generators	Nonradioactive air emissions	None
Liquid Effluents[c]				
City of Richland	CR-IU001	PNNL Richland Campus	Liquid effluent discharges to city sewer	4/1/2020
City of Richland	CR-IU005	W.R. Wiley Environmental and Molecular Sciences Laboratory	Liquid effluent discharges to city sewer	8/21/2022
City of Richland	CR-IU011	Physical Sciences Facility (new buildings north of Horn Rapids Road)	Liquid effluent discharges to city sewer	3/9/2023
City of Richland	CR-IU010[b]	PNNL-occupied locations on the Hanford Site	Liquid effluent discharges to city sewer	11/30/2021

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[a]
Washington State Department of Ecology	ST 4511[b]	PNNL-occupied locations in Hanford Site 300 Area	Discharge of wastewater from maintenance, construction, and hydro testing activities; allows for cooling water, condensate, and industrial stormwater discharges to ground	12/31/2019
Washington State Department of Ecology	ST-9274	Biological Sciences Facility and Computational Sciences Facility	Reinjection of well water used in ground-source heat pump	6/6/2020
Washington State Department of Ecology	WA0040649	PNNL Marine Sciences Laboratory	Treated liquid effluent discharges to Sequim Bay	11/30/2022
Washington State Department of Ecology	WA0026859	PNNL Scientific Focus Area Tracer Injection Project	Tracer injection into water sampling tubes to study the interaction of groundwater and surface water along the Columbia River shoreline	5/31/2023
Hazardous Waste				
Washington State Department of Ecology	WA7890008967	325 Hazardous Waste Treatment Units (located in the 300 Area)	Treatment and storage of dangerous waste (primarily mixed waste)	9/27/2004

(a) Expired permits generally remain in force while renewal applications are processed by the issuing agency.
(b) Permit is issued to DOE-Richland Operations Office and/or its contractor(s); PNNL is obligated to comply with these permits through an operating agreement between the DOE-Richland Operations Office and the Pacific Northwest Site Office.
(c) PNNL also conducts activities in leased facilities that have wastewater permits issued to the owner. These permits are not listed here, but compliance-related impacts from PNNL activities are included in this report.

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3.0 ENVIRONMENTAL MANAGEMENT SYSTEM

PNNL has a mature, robust EMS that has been certified to meet the requirements of ISO 14001 standards since 2002. The EMS is integrated into PNNL's Integrated Safety Management Program, which assures that staff are aware of project scope, risks/hazards, and controls available to address functions, processes, and procedures used to plan and perform work safely. The outcome of the integration is the accomplishment of PNNL missions while protecting the worker, the public, and the environment.

Management at PNNL periodically assesses environmental performance from a programmatic perspective to determine whether issues require attention and to facilitate the identification and communication of best management practices. PNNL management also routinely evaluates progress on key environmental improvement projects.

The EMS is audited annually to verify that it is operating as intended and in conformance with ISO 14001 standards. In early 2017, PNNL successfully transitioned its EMS to the latest ISO 14001:2015 Standards (Figure 3.1). In addition, the 2018 EMS performance data submitted to the Federal Facilities Environmental Stewardship & Compliance Assistance Center received a "Green" score for the EMS performance metrics listed below.

- Environmental aspects were identified or re-evaluated using an established procedure and updated as appropriate.
- Measurable environmental goals, objectives, and targets were identified, reviewed, and updated as appropriate.
- Operational controls were documented to address significant environmental aspects consistent with objectives, and targets were fully implemented.
- Environmental training procedures were established to assure that training requirements for individual competence and responsibility were identified, carried out, monitored, tracked, recorded, and refreshed as appropriate to maintain competence.
- EMS requirements were included in all appropriate contracts, and contractors fulfilled defined roles and specified responsibilities.
- EMS audit/evaluation procedures were established, audits were conducted, and nonconformities were addressed or corrected.
- Senior leadership review of the EMS was conducted and management responded to recommendations for continual improvement.

NSF ISR

Certificate of Registration

This certifies that the Environmental Management System of

Battelle - Pacific Northwest Division

Pacific Northwest National Laboratory
902 Battelle Boulevard
Mail Stop J2-25
Richland, Washington, 99354, United States

has been assessed by NSF-ISR and found to be in conformance to the following standard(s):

ISO 14001:2015

Scope of Registration:
Pacific Northwest National Laboratory, operated by Battelle for the U.S. Department of Energy: Research and development activities and associated facilities operations

ANAB ACCREDITED

IAF

Certificate Number: 6Z781-EM1
Certificate Issue Date: 02-FEB-2017
Registration Date: 26-JAN-2017
Expiration Date *: 25-JAN-2020

Carl Blazik,
Director, Technical Operations & Business Units,
NSF-ISR, Ltd.

NSF International Strategic Registrations

789 North Dixboro Road, Ann Arbor, Michigan 48105 | (888) NSF-9000 | www.nsf-isr.org

Figure 3.1. Certificate of Registration for PNNL Conformance with ISO-14001:2015 Standards

PNNL examines its operations to determine which categories of environmental impacts (referred to as "aspects" in the ISO 14001 standards) have the greatest potential to occur, and therefore, require consideration and control through the EMS process. PNNL performs annual environmental aspect and impact analyses, including risk analyses and work evaluations, to assure regulatory requirements and any concerns of the public or other interested parties are addressed. The 11 most significant aspects and the EMS controls used to minimize the potential impacts of each aspect are as follows:

- Chemical Use and Storage. As a research laboratory, PNNL has many buildings in which chemicals/biological materials are used and/or stored for research operations and maintenance activities. Controls used to avoid potential hazards include training, inventory control procedures, approvals prior to requisitioning, and work procedures for chemical/biological material use, as well as adequate safety requirements. PNNL implements a "ChemAgain" program, which redistributes surplus chemicals internally in an effort to reduce PNNL's chemical waste.
- Biological Material Use and Storage. As a research laboratory, PNNL has many buildings in which biological materials are used and/or stored for research activities. Controls used to avoid potential hazards include training and work procedures for biological material use and adequate safety requirements.
- Regulated Waste Generation. The use of chemical and radioactive materials creates waste streams that may be regulated as dangerous waste, radioactive waste, or both dangerous and radioactive (mixed) waste. Wastes within these categories are subject to the regulations of the Washington State Department of Ecology (for dangerous and mixed waste) and DOE (for radioactive and mixed waste). In addition to the controls imposed by these requirements, PNNL seeks to reduce generated wastes. Projects are regularly reviewed and procedures are scrutinized to minimize the production of regulated wastes. Any generated waste may be treated to be made less hazardous or nonhazardous for proper disposal.
- Radioactive Material Use and Storage. Research at PNNL may involve the use of radioactive materials. All radioactive materials are labeled and controlled. Controls include restricted access to radiation areas and special training requirements for staff requiring access.
- Emissions to Air. Potential air emissions are evaluated and permits are obtained when required. Active controls for the management of chemicals, radioactive materials, and regulated wastes seek to minimize PNNL air emissions. Sources of air emissions include boilers, diesel generators, vehicle exhaust, R&D activities, and facility and grounds maintenance and operations.
- Effluents to Water. PNNL seeks to minimize liquid discharges to the environment. Discharges include laboratory drain water to sewer systems and stormwater to dry wells in parking lots, which are regulated by state and local permits and/or regulations. Discharges are evaluated to assure they conform to regulations and permits.
- Energy Use. Using energy judiciously is a prime objective at PNNL. Energy reduction goals are established and activities to reduce energy consumption are implemented.
- Solid Waste Generation. The use of office products, electronics, and equipment, along with construction, demolition, and normal maintenance activities, create nonregulated solid waste streams. Reduction or elimination of environmental hazards, conservation of environmental resources, and maximization of operational sustainability are achieved through the incorporation of electronic stewardship practices, reuse of materials, and operation of recycling programs.
- Fuel Usage. PNNL seeks to minimize the use of petroleum-based fuels by purchasing vehicles that use alternative fuels, such as ethanol-85, and by acquiring high-fuel–efficiency vehicles, including hybrid and all-electric vehicles. PNNL has also acquired electric vehicles for on-campus transportation and has installed solar-powered electric vehicle charging stations across the

Richland Campus. In addition, PNNL was instrumental in obtaining the first biofuel service station in Richland, Washington, and when appropriate, uses bio-diesel to fuel generators.

- **Physical Interaction with the Environment.** Some PNNL projects are performed outdoors in direct contact with the environment. These projects include facility construction, maintenance, and modifications, as well as occasional R&D activities. Work proposed to be performed outdoors is reviewed to minimize potential impacts and assure the protection of workers, the public, and environmental resources.
- **Water Use.** PNNL recognizes the value of water in the eastern Washington environment. PNNL maintains water-use reduction goals and implements actions to reduce water consumption.

The benefits of implementing a well-performing EMS include enabling upfront planning to incorporate sustainability and pollution prevention opportunities, early identification of environmental requirements to avoid project delays, high-level integration with existing programs to improve efficiency, reduced operational costs, and enhanced public recognition as a "good neighbor."

PNNL has been using a multi-disciplinary Sustainability Core Team as a best practice to drive continuous improvement in its environmental performance with regard to sustainability and to enable an integrated approach to managing the environmental aspects and impacts. The Sustainability Core Team is a diverse, authorized working group composed of key EMS program leads and managers. Core Team members are held accountable for the successful execution of PNNL's sustainability goals and targets.

3.1 Sustainability Goals and Targets

Executive Order 13834 of May 17, 2018, "Efficient Federal Operations" (83 FR 23771), affirms that it is the policy of the United States that agencies meet energy and environmental performance statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects and environment. PNNL's comprehensive and diverse approach meets the principles of Executive Order 13834 requirements. Details about PNNL's plan to advance DOE's sustainability mission are captured in the PNNL *FY 2019 Site Sustainability Plan* (DOE 2018). The plan contains the annual status and strategy for achieving long-term goals in the areas of greenhouse gas (GHG) reduction, sustainable buildings, clean and renewable energy, water-use efficiency and management, fleet management, sustainable acquisition, pollution prevention and waste reduction, energy performance contracts, electronic stewardship, and climate change resilience.

Each sustainability goal, PNNL's performance status, and planned actions are detailed in Table 3.1.

3.2 Accomplishments, Awards, and Recognition

PNNL achieved several sustainability milestones in FY 2018, as highlighted in Figure 3.2, with the exception of energy use and irrigation water use. Our improvement strategy includes using PNNL's Building Operating Control Center automated controls to improve operations, and to add or upgrade building sensors to support energy conservation efforts. Other accomplishments include the following:

- Utility Energy Services Contract (UESC)

  PNNL solicited interest from serving utilities and selected Bonneville Power Administration (BPA) to provide a customized UESC program, based on their energy management services offerings, experience, and qualifications. Engineers from BPA began to evaluate both laboratory and office facilities at PNNL in FY 2017 and continued in FY 2018 to identify potential energy conservation measures (ECMs) for implementation. This partnership is expected to continue throughout 2019 until a project can be fully developed for implementation. Successful implementation of ECMs is expected to significantly reduce energy intensity at PNNL.

- Guiding Principles for Sustainable Construction

  In FY 2018, PNNL finished the certification process for the Laboratory's recently completed high-performance and sustainable building (HPSB), the 3860 Engineering and Analysis Building (EAB), using the Guiding Principles for Sustainable Construction. This was the second new facility at PNNL to use the Guiding Principles as a path toward HPSB status. The EAB included sustainable design elements such as a heating, ventilation, and air-conditioning system that uses advanced controls and incorporates energy recovery in both the heating and cooling season, low-flow plumbing fixtures, light-emitting diode lighting, and water efficient landscaping. With the addition of this building, more than 60% of PNNL's applicable buildings are compliant with the Guiding Principles. PNNL is currently documenting HPSB certification on another new facility, the 3400 (Discovery Hall), a collaboration center on the PNNL Richland Campus designed to meet the Guiding Principles.

Table 3.1. Status of PNNL Sustainability Goals through FY 2018 and Targets for FY 2019 (DOE 2018)

DOE Goal	FY 2018 Performance Status	FY 2019 Plans
Multiple Categories		
Achieve 50% Scope 1 & 2 greenhouse gas (GHG) emissions reduction by FY 2025 from a FY 2008 baseline.	Current Performance: -102%	Implement energy conservation measures when cost effective.
Energy Management		
Reduce energy intensity by 25% (Btu per gross square foot) in goal-subject buildings by FY 2025 from a FY 2015 baseline.	Current Performance: 1.0%	Since FY 2017, PNNL has replaced several large, energy inefficient chillers at multiple facilities. This effort will continue through FY 2019. PNNL is constructing a new building (up to 145,000 gross square feet) following the Guiding Principles for Sustainable Construction.
Evaluate energy and water usage per Section 432 of the *Energy Independence and Security Act of 2007* (EISA) on a continuous 4-year cycle.	Completed energy and water evaluations on the 325 (RPL) building in FY 2018 to stay compliant with EISA Section 432.	Complete energy and water evaluations for Buildings 331 and 3820, Life Sciences Laboratory 2, the Biological Sciences Facility /Computational Sciences Facility, William R. Wiley Environmental Molecular Sciences Laboratory, and the Physical Sciences Laboratory.
Meter all individual buildings for electricity, natural gas, steam and water where cost effective and appropriate.	All individual buildings were metered for electricity, natural gas, steam, and water where cost effective and appropriate.	PNNL will continue to meet metering requirements by installing the most appropriate meter for each asset. Data will be collected and analyzed to improve building performance.

DOE Goal	FY 2018 Performance Status	FY 2019 Plans
Water Management		
Reduce potable water intensity (gallons per gross square foot) 36% by FY 2025, from a FY 2007 baseline.	Current Performance: -77.2%	Continue to implement reduction opportunities for site water management.
Reduce water consumption (gal) from industrial, landscaping, and agricultural use 30% by FY 2025 from a FY 2010 baseline.	FY 2011 Baseline: 176,248,000 gal FY 2018 Actual: 193,700,000 gal Current Performance: +10% (FY 2011 baseline)	Continue to implement reduction opportunities for site water management.
Waste Management		
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition (C&D) debris.	Current Performance: 57%	Continue to expand nitrile glove recycling program; continue conducting assessments to identify waste reduction opportunities.
Divert at least 50% of C&D materials and debris.	Current Performance: 95%	Continue monitoring C&D recycling performance and raising awareness about waste diversion requirements.
Fleet Management		
Seventy-five percent of light-duty vehicle acquisitions must consist of alternative fuel vehicles.	100% of PNNL acquisitions during FY 2018 were alternative fuel vehicles.	PNNL will continue to work closely with the General Services Administration (GSA) to assure that all applicable PNNL vehicle orders are for alternatively fueled vehicles.
Fifty percent of passenger vehicle acquisitions consist of zero-emission or plug-in hybrid electric vehicles by FY 2025.	Two-passenger vehicles acquisitions were made in FY 2018. One was a plug-in hybrid.	Continue to work closely with GSA to acquire zero-emission or plug-in hybrid vehicles for all newly acquired passenger vehicles. Maintain the fleet of electric neighborhood vehicles for Operations & Maintenance staff
Clean and Renewable Energy		
"Clean Energy" requires that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not less than 25% by FY 2025 and each year thereafter.	Current Performance: 44%	Continue to meet the clean energy goal of 7.5% per 42 U.S.C. 15852 through onsite generation and Renewable Energy Certificates (RECs), when cost effective.
"Renewable Electric Energy" requires that renewable electric energy account for not less than 30% of a total agency electric consumption by FY 2025 and each year thereafter.	Current Performance: 60%	Continue to meet the renewable electric energy goal of 7.5% per 42 U.S.C. 15852 through onsite generation and RECs, when cost effective.

DOE Goal	FY 2018 Performance Status	FY 2019 Plans
Green Buildings		
At least 17% (by building count) of existing buildings greater than 5,000 gross square feet to be compliant with the revised Guiding Principles for high-performance and sustainable buildings by FY 2025, with progress to 100% thereafter.	Current Performance: 66%	Continue trending toward 100% of facilities meeting guidelines.
Acquisition and Procurement		
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring bio-preferred and bio-based provisions and clauses are included in 95% of applicable contracts.	Current Performance: 100%	Continue being proactive with sustainable acquisitions.
Measures, Funding, and Training		
Annual targets for performance contracting were implemented as part of Executive Order 13834.	Completed energy and water evaluations by the Utility Energy Services Contract (UESC) contractor; implemented projects for approved energy conservation measures.	Continue performing energy and water evaluations, and review energy conservations measure projects proposed by the UESC contractor.
Electronic Stewardship		
Purchases – 95% of eligible acquisitions each year are Electronic Product Environmental Assessment Tool (EPEAT)-registered products.	Current Performance: 96%	Continue to purchase EPEAT-registered products when available.
Power management – 100% of eligible PCs, laptops, and monitors have power management enabled.	Current Performance: 100%	Continue to implement power management features on initial setup.
Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled.	Current Performance: 90%	Continue to use duplex printing as the default configuration on capable units.
End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	Current Performance: 100%	Continue to reuse and recycle electronics.
Data Center Efficiency – Establish a power usage effectiveness target in the range of 1.2–1.4 for new data centers and less than 1.5 for existing data centers.	The normalized (weighted by Information Technology Load) power usage effectiveness across the PNNL Richland Campus is 1.35 for FY 2018.	Continue performing energy assessments and profiling of data centers.
Organizational Resilience		
Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols.	Climate resilience is integrated into response and operations through a Climate Resilience Action Plan. No further action is expected.	No significant changes in strategy.

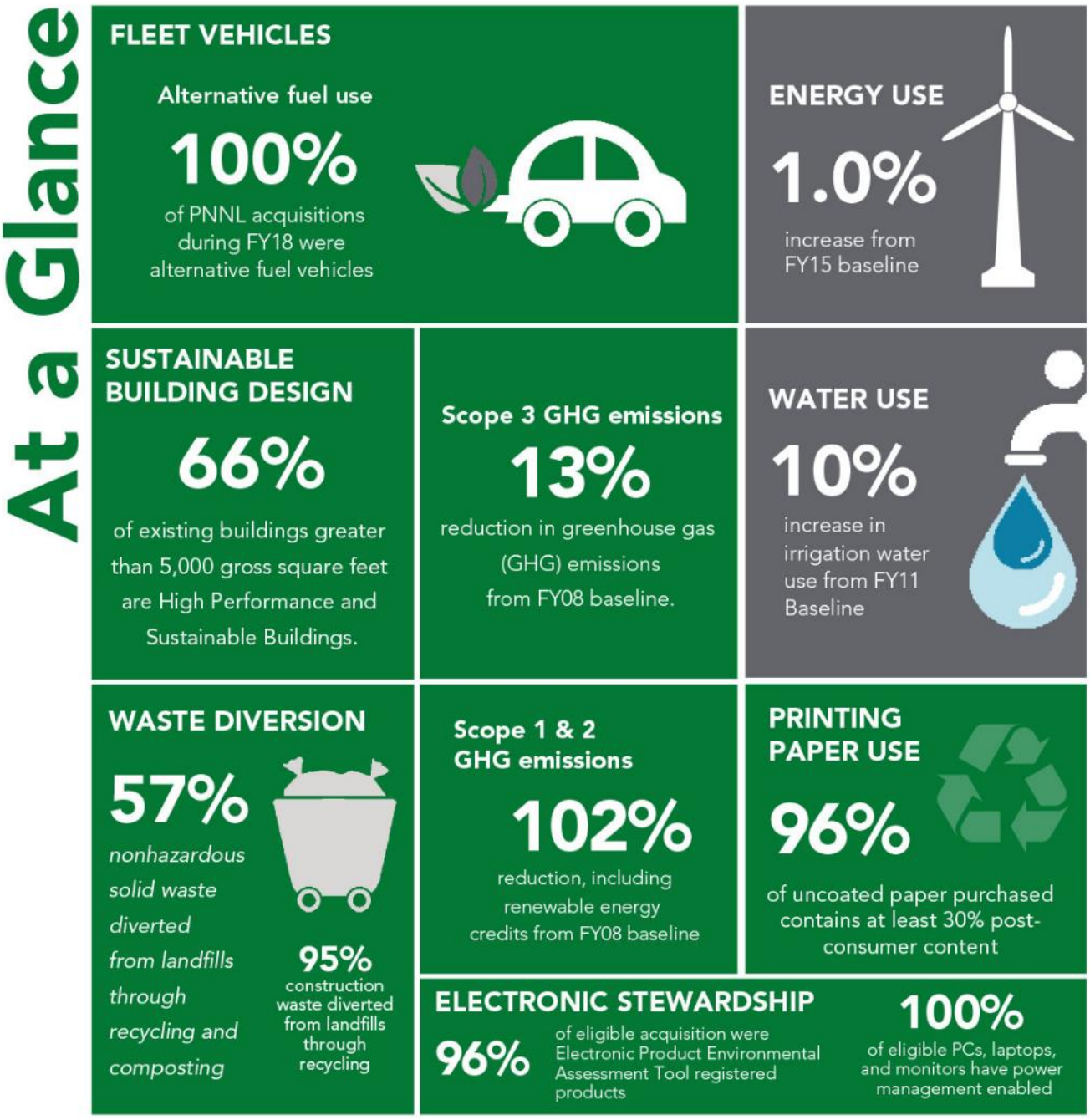

Figure 3.2. Summary of Key Environmental Sustainability Accomplishments, 2018

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4.0 RADIOLOGICAL ENVIRONMENTAL MONITORING AND DOSE ASSESSMENT

This section describes the environmental monitoring programs for radiological constituents and the associated estimated dose assessments for the PNNL Richland Campus and MSL.

4.1 Liquid Radiological Discharges and Doses

PNNL prohibits the discharge of liquid waste streams that contain radiological material to sanitary sewer systems, the ground, or surface water. Wastewater in PNNL facilities is expected to be free of radioactive materials, but may have the potential for contamination in the event of a failure of an engineered barrier or administrative control. In facilities in which wastewater generated in radiologically controlled areas has the potential to become contaminated, it is discharged to retention tanks. After each retention tank is filled, it is isolated and its contents are analyzed for radiological components. The results of the analyses are compared to screening limits in WAC 246-221-190, "Disposal by Release into Sanitary Sewerage Systems." If the analytical results indicate that the concentrations of radiological components in the wastewater are below the screening criteria, the wastewater is released to the City of Richland's sanitary sewer system. If the analytical results indicate that the concentrations of radiological components in the wastewater are above the screening criteria, the wastewater is transported to a waste treatment facility. These wastes may be transferred and discharged to a treatment facility authorized or permitted to receive radiological material. Further evaluation is then performed to determine the source of the radiological component in the discharge.

The City of Richland may authorize the discharge of individual waste streams that contain radiological material to the sewer system. As described in Section 4.1.1, there is currently only one authorized discharge of a liquid waste stream containing radiological material to the City of Richland sanitary sewer.

4.1.1 Annual Report for DOE Order 458.1

This report has been prepared in accordance with DOE Order 458.1 (4)(g)(8)(a)(7), which requires that the contractor prepare and provide a report that describes and summarizes discharges of liquids containing radionuclides from DOE activities into non-federally owned sanitary sewers. PNNL has one waste stream that has the potential for radionuclides that is approved for discharge to the City of Richland's sanitary sewer system. This waste stream is associated with fume hood washdown operations in PSF.

On November 2, 2010, the City of Richland authorized the release of "…very low levels of volumetrically released radioactive material." These volumetrically released radioactive materials can be handled without concern for measurable contamination and without radiological postings or labeling pursuant to 10 CFR Part 835.

The total amount of radioactive material used in each fume hood is very small. Each washdown is estimated to be 190 L (50 gal). The worst-case concentration of radioactivity in each washdown is estimated to be 7.1×10^{-7} pCi/L.

In 2018, the fume hoods were washed down an estimated total of 28 times. The screening criteria, as referenced in the City of Richland's Industrial Wastewater Discharge Permit CR-IU011 for PSF, are based on WAC 246-221-190, Appendix A, Table III. The screening limits for each washdown are 20 pCi/L for gross alpha activity and 100 pCi/L for beta/gamma activity. If all activity in each washdown is conservatively presumed to be alpha activity, the concentration of radioactive material is more than a million times less than the screening limit. This affirms that the washdowns are negligible in terms of the screening limits for discharge to the City of Richland's sewer systems.

4.2 Radiological Discharges and Doses from Air

The federal regulatory standard for a maximum dose to any member of the public is 10 mrem/yr (0.1 mSv/yr) EDE. The standard is set forth in 40 CFR Part 61, Subpart H, and applies to radionuclide air emissions other than radon from DOE facilities.

Washington State has adopted the federal dose standard of 10 mrem/yr (0.1 mSv/yr) EDE in WAC 246-247-040(1). In addition to the maximum dose attributable to radionuclides emitted from point sources, WAC 246-247-060(6) requires that the dose to the MEI include doses attributable to fugitive emissions, radon, and nonroutine events.

Radionuclide air emissions are routinely sampled and tracked at the PNNL Richland Campus and at MSL. Regulatory compliance reporting and monitoring results are reported in an annual air emission report for each location (Snyder et al. 2019; Snyder and Barnett 2019). CY 2018 data are summarized in the following sections.

4.2.1 Radiological Discharges and Doses from Air – PNNL Richland Campus

Operations are registered with the state of Washington under RAEL–005. For CY 2018, the PNNL Richland Campus MEI location was 0.64 km (0.40 mi) south-southeast of the PSF 3410 Building. Table 4.1 lists the relative contributions of each nuclide to the MEI dose.

There were no nonroutine emissions from the PNNL Richland Campus in CY 2018. Emissions were determined from both sampling and, for non-sampled emissions, by the 40 CFR Part 61, Appendix D method. The CAP88-PC Version 4 code was used for estimating dose. The dose of 1.8×10^{-5} mrem (1.8×10^{-7} mSv) effective dose[1] is more than 10,000 times smaller than the 10 mrem/yr WAC 246-247 compliance standard. This dose is many orders of magnitude below the average annual individual background dose of 310 mrem (3.1 mSv) from natural terrestrial and cosmic radiation and inhalation of naturally occurring radon (NCRP 2009). The maximum modeled air concentration for CY 2018 was a value of 2.1×10^{-5} mrem (2.1×10^{-7} mSv) effective dose at the Campus boundary 0.66 km (0.41 mi) northwest of the PSF.

The estimated regional collective dose from PNNL's Richland Campus air emissions in CY 2018 was estimated using CAP88-PC Version 4. Population exposure to radionuclide air emissions considers site-specific meteorology and population distributions. The population consists of approximately 432,000 people residing within an 80 km (50 mi) radius of the Hanford Site 300 Area (Hamilton and Snyder 2011), with one adjustment to add 640 residents in the sector that accounts for the two phases of apartment units constructed and occupied southwest of the former RTL Complex, which was demolished in 2018. The close proximity of the Hanford Site 300 Area and relatively rural region within 80 km (50 mi) of the PNNL Richland Campus permits the Hanford Site 300 Area 80 km (50 mi) population estimate to be applicable. Pathways evaluated for population exposure include inhalation, air submersion, ground shine, and consumption of food. The CY 2018 total collective dose from radionuclide air emissions estimated from nuclides that originated from the PNNL Richland Campus was 7.6×10^{-5} person-rem (7.6×10^{-7} person-Sv).

No operations from the storage and disposal of radium-bearing material that result in radon emissions are conducted at the PNNL Richland Campus; therefore, 40 CFR Part 61, Subpart Q, does not apply to PNNL Richland Campus operations. In addition, no uranium milling or uranium ore processing activities are conducted at the PNNL Richland Campus; therefore, 40 CFR Part 61, Subpart T, does not apply to PNNL Richland Campus operations.

[1] The EDE and effective dose units can be considered equivalent for the purposes of this report and reflect the units calculated by the software used.

Table 4.1. PNNL Richland Campus Emissions and Dose Contributions by Radionuclide, 2018 (Snyder et al. 2019)

Radionuclide	Releases (Ci)	Campus MEI Dose (mrem EDE)	Percent of Total EDE
Hydrogen-3 (tritium)	1.2×10^{-4}	1.9×10^{-8}	<1
Sodium-24	1.3×10^{-8}	1.5×10^{-10}	<1
Manganese-54	1.5×10^{-12}	5.3×10^{-13}	<1
Cobalt-57	1.7×10^{-10}	8.5×10^{-14}	<1
Cobalt-60	3.3×10^{-8}	1.0×10^{-7}	1
Bromine-82	1.3×10^{-8}	1.8×10^{-10}	<1
Cadmium-109	8.4×10^{-10}	9.6×10^{-11}	<1
Iodine-131	2.2×10^{-10}	4.5×10^{-10}	<1
Xenon-131m	6.7×10^{-6}	5.1×10^{-11}	<1
Xenon-133	2.4×10^{-5}	3.2×10^{-10}	<1
Cesium-137	2.5×10^{-8}	5.2×10^{-6}	29
Barium-133	1.0×10^{-10}	2.8×10^{-10}	<1
Lanthanum-140	3.9×10^{-8}	5.2×10^{-10}	<1
Europium-152	6.0×10^{-10}	5.8×10^{-9}	<1
Lutetium-177	1.1×10^{-5}	4.9×10^{-8}	<1
Lead-210	1.6×10^{-10}	3.2×10^{-9}	<1
Radon-222	1.4×10^{6}	5.6×10^{-10}	<1
Radium-226	1.2×10^{-9}	8.4×10^{-8}	<1
Uranium-233/234	1.4×10^{-9}	1.1×10^{-8}	<1
Uranium-235	4.0×10^{-11}	5.7×10^{-10}	<1
Plutonium-238	1.6×10^{-8}	6.7×10^{-7}	4
Plutonium-239/240	1.6×10^{-7}	7.6×10^{-6}	43
Plutonium-241	3.0×10^{-11}	9.8×10^{-11}	<1
Americum-241	8.8×10^{-9}	7.8×10^{-7}	4
Americum-243	3.6×10^{-8}	1.4×10^{-6}	8
Curium-243/244	1.1×10^{-9}	3.2×10^{-8}	<1
All other nuclides	4.2×10^{-8}	8.0×10^{-10}	<1
PIC-5 emissions – VRRM	N/A	$9.4 \times 10^{-7(a)}$	5
PIC-5 emissions – Facilities Restoration	N/A	$8.4 \times 10^{-7(a)}$	5
PIC-5 emissions – NDRM	N/A	$6.6 \times 10^{-8(a)}$	<1
PIC-5 emissions – LLS	-	0	0
Total	1.6×10^{-4}	1.8×10^{-5}	100

(a) The PIC-5 emission doses are assigned based on permit value except for the LLS, which is assigned based on calculations from actual emissions.

To convert Ci to GBq, multiply Ci by 37. To convert mrem to mSv, multiply mrem by 0.01.
LLS = low-level sources; N/A = not applicable; NDRM = nondispersible radioactive material; VRRM = volumetrically released radioactive material.

4.2.2 Radiological Discharges and Doses from Air – PNNL Marine Sciences Laboratory

MSL operations for the sitewide minor, fugitive, nonpoint source emission unit (Figure 1.3) is registered with the state of Washington under RAEL–014. For CY 2018, the MSL MEI location was 0.23 km (0.15 mi) west of a Central MSL emission location (coordinates: 48.078, -123.047). This Central MSL location is central to all operations areas at MSL. Radiological operations at MSL emit very low levels of radioactive materials. Table 4.2 lists the relative contributions to the MEI dose. The 40 CFR Part 61, Appendix D method was used to determine the routine emissions from MSL in CY 2018. There were no unplanned emissions from the site during the year. The COMPLY Code (a computerized screening tool for evaluating radiation exposure from atmospheric releases of radionuclides) Version 1.7 (Level 4) was used for estimating dose (EPA 1989).

Table 4.2. Marine Sciences Laboratory Emissions and Dose Contributions, 2018 (Snyder and Barnett 2019)

Radionuclide	Releases[(a)] (Ci)	Dose to MEI (mrem EDE)	Percent of Total EDE (Percent)
Iodine-125	1.0×10^{-6}	1.1×10^{-4}	25
Thorium-232	1.0×10^{-9}	5.9×10^{-5}	13
Remaining alpha (as americum-241)	1.7×10^{-8}	2.7×10^{-4}	61
Remaining beta (as cesium-137)	2.1×10^{-9}	1.3×10^{-6}	<1
Total	1.0×10^{-6}	4.5×10^{-4}	100

(a) Emissions based on 40 CFR Part 61, Appendix D methods.
To convert Ci to GBq, multiply Ci by 37; to convert from mrem to μSv, multiply mrem by 10.

The dose to the MSL MEI was 4.5×10^{-4} mrem (4.5×10^{-6} mSv) EDE. This dose is many orders of magnitude below the average annual individual background dose from natural terrestrial and cosmic radiation and inhalation of naturally occurring radon. The maximum modeled air concentration for CY 2018 was 1.0×10^{-3} mrem (1.0×10^{-5} mSv) effective dose where no members of the public routinely inhabit the shore, at the boundary location 0.13 km (0.08 mi) east-northeast of the Central MSL location.

Collective dose was determined for the estimated 2.35 million people who live within 80 km (50 mi) of MSL; about 362,000 of them reside in Canada (Zuljevic et al. 2016). Victoria, British Columbia, is the only major Canadian city within 80 km (50 mi) of MSL and is more than 32 km (20 mi) from MSL. The maximum collective dose was determined assuming the total CY 2018 MSL curies released dispersed in a single direction resulting in the maximum collective dose. This direction was determined to be toward the west, which only contains U.S. populations. The MEI dose was multiplied by a population-weighted air concentration for a collective dose of 5.0×10^{-4} person-rem (5.0×10^{-6} person-Sv). If the release were dispersed only to the maximum Canadian sector (north-northwest), the maximum estimated Canadian collective dose would be 2.0×10^{-4} person-rem (2.0×10^{-6} person-Sv).

No storage or disposal of radium-bearing materials occurs at MSL; therefore, 40 CFR Part 61, Subpart Q, does not apply to MSL operations. No uranium mill tailings or ore disposal activities have been conducted at MSL; therefore, 40 CFR Part 61, Subpart T, does not apply to MSL operations.

4.3 Release of Property Having Residual Radioactive Material

Principal requirements for the release of DOE property having residual radioactivity are set forth in DOE Order 458.1, Admin Chg 3, *Radiation Protection of the Public and the Environment*. These requirements are designed to assure the following:

- Property is evaluated, radiologically characterized, and—where appropriate—decontaminated before it is released.
- The level of residual radioactivity in property to be released is as near background levels as is reasonably practicable, as determined using DOE's ALARA process requirements, and it meets DOE-authorized limits.
- All property releases are appropriately certified, verified, documented, and reported; public participation needs are addressed; and processes are in place to appropriately maintain records.

Property as defined in DOE Order 458.1 consists of real property (i.e., land and structures), personal property, and material and equipment. PNNL has two paths for releasing property to the public: 1) pre-approved surface contamination guidelines for releasing property potentially contaminated on the surface, and 2) pre-approved volumetric release limits for releasing small-volume research samples. A summary of the two release paths is provided in the following sections. No property with detectable residual radioactivity above DOE-authorized levels was released from PNNL during CY 2018.

4.3.1 Property Potentially Contaminated on the Surface

PNNL uses the previously approved surface activity guideline limits (Table 4.3) derived from guidance in DOE Order 458.1 when releasing property potentially contaminated on the surface. As part of research activities conducted in PNNL facilities, PNNL releases hundreds of items of personal property annually for excess to the general public, including office equipment, office furniture, labware, and research equipment. The PNNL Radiation Protection organization has a documented process for releasing items based on process knowledge, radiological surveys, or a combination of both. No property with detectable residual radioactivity above the pre-approved surface activity guidelines was released from PNNL during CY 2018.

In 2013, in accordance with PNNL Prime Contract Section J, Appendix J, paragraph eight (DOE-PNSO 2019), PNNL (Battelle) initiated a survey program with an objective to release five Battelle Memorial Institute-owned buildings for unrestricted use. These facilities include the Engineering Development Laboratory (EDL), Physical Sciences Laboratory (PSL), and LSL2 on the PNNL Richland Campus, and the MSL-1 and MSL-5 facilities at MSL in Sequim, Washington. In September 2017, PNNL received authorization from PNSO to release EDL, PSL, and LSL2 for unrestricted use. During CY 2018, MSL-1 and MSL-5 underwent minor mitigation activities and radiological characterization consistent with the radiological clearance process, but was not formally cleared due to ongoing and future DOE radiological work scope.

Table 4.3. Pre-Approved Surface Activity Guideline Limits

Radionuclides	Allowable Total Residual Surface Contamination Limits (dpm/100 cm²)		
	Removable	Total	
		Average	Maximum
Uranium-natural, uranium-235, uranium-238, and associated decay products	1,000	5,000	15,000
Transuranic elements,[(a)] radium-226, radium-228, thorium-230, thorium-228, protactinium-231, actinium-227, iodine-125, iodine-129	20	100	300
Natural thorium, thorium-232, strontium-90, radium-223, radium-224, uranium-232, iodine-126, iodine-131, iodine-133	200	1,000	3,000
Beta/gamma-emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except strontium-90 and others noted above	1,000	5,000	15,000
Select hard-to-detect radionuclides (carbon-14, iron-55, nickel-59, nickel-63, selenium-79, technetium-99, palladium-107, and europium-155)	10,000	50,000	150,000
Tritium organic compounds; surfaces contaminated with tritium gas, tritiated water vapor, and metal tritide aerosols	10,000	N/A	N/A

(a) All transuranic elements except plutonium-241, which is treated as a beta/gamma-emitter.
dpm = disintegrations per minute
N/A = not applicable

In addition to the survey program of five Battelle Memorial Institute-owned buildings for unrestricted use, work continued on decommissioning the RTL. In CY 2018, PNNL subcontractors completed demolition activities and the demolition materials were shipped as waste to the Environmental Restoration Disposal Facility on the Hanford Site. The RTL property remains fenced, and is currently managed as a brown field. Completion of clearance activities in accordance with DOE-approved authorized limits is forecast for FY 2019.

4.3.2 Property Potentially Contaminated in Volume

PNNL received the final DOE-approved authorized limits for surface soil at the RTL site in 2017 (Table 4.4; DOE-PNSO 2017). To determine whether the surface soils at RTL were contaminated, final surface soil surveys were made using the Multi-Agency Radiation Survey and Site Investigation Manual process in accordance with DOE Order 458.1. Oak Ridge Institute for Science and Education conducted an independent verification and confirmed that all results were well below the DOE-approved authorized limits. PNNL will continue finalizing the documentation requirements for the DOE real property clearance approval process through CY 2019, and will ultimately transfer the property to DOE.

PNNL uses pre-approved volumetric release limits when releasing small-volume research samples and wastewater potentially contaminated in volume (Table 4.5). DOE approved these release limits in response to an authorized limits request submitted by PNNL in 2000 (DOE-RL 2001) and 2007 (DOE-PNSO 2007). During CY 2018, PNNL released hundreds of liquid research samples with a total volume on the order of 919 L (243 gal) using the pre-approved release limits in Table 4.5. The liquid samples were not released to the public, but were used without radiological controls by staff in PNNL facilities. When disposed of, the samples were treated as radioactive waste.

Table 4.4. Surface Soil Authorized Limits for Radiological Clearance of the Research Technology Laboratory Site

Radionuclide	Authorized Limit (pCi/g)
Cobalt-60	3.7
Plutonium-238	800
Plutonium-239/240	740
Plutonium-241	30,000
Uranium-234	700
Uranium-235	60
Uranium-238	280

4.4 Radiation Protection of Biota

DOE Order 458.1 (Admin Chg 3) indicates that DOE sites establish procedures and practices to protect biota. PNNL has adopted dose rate limits of 1 rad/d (10 mGy/d) for aquatic animals and terrestrial plants and 0.1 rad/d (1 mGy/d) for riparian and terrestrial animals for the demonstration of the protection of biota (DOE 2002). These limits are applied equally at the PNNL Richland Campus and MSL.

Table 4.5. Pre-Approved Volumetric Release Limits

Radionuclide Groups	Volumetric Release Limit (pCi/mL)
Transuranic elements, iodine-125, iodine-129, radium-226, actinium-227, radium-228, thorium-228, thorium-230, protactinium-231, polonium-208, polonium-209, polonium-210	1
Natural thorium, thorium-232	3
Strontium-90, iodine-126, iodine-131, iodine-133, radium-223, radium-224, uranium-232	9
Natural uranium, uranium-233, uranium-235, uranium-238	30
Beta/gamma-emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except strontium-90 and others noted in the rows above	45
Tritium	450

4.4.1 Radiation Protection of Biota – PNNL Richland Campus

Environmental media pathways were evaluated during the development of the PNNL Richland Campus data quality objectives (DQOs) in support of radiological emissions monitoring (Snyder et al. 2017). Potential media exposure pathways such as air, soil, water, and food were considered in conjunction with both gaseous and particulate radioactive contamination of the air pathway. The DQO process determined that only the air pathway necessitates monitoring (there are no radiological emissions via liquid pathways or directly to contaminated land areas). It also determined that the extremely small amount of emissions would be impossible to differentiate from background levels in nearby locations such as the Columbia River and food sources. While these measures are used primarily to demonstrate protection of the public, they also adequately demonstrate protection of biota. Therefore, biota monitoring for radionuclides both near and far from the PNNL Richland Campus is not conducted.

Routine operations were conducted on the PNNL Richland Campus during CY 2018—there were no unplanned radiological emissions. The resultant external dose rates were less than 8.9×10^{-3} rad/d (8.9×10^{-2} mGy/d) from contaminated water to aquatic animals and terrestrial plants and less than 7.8×10^{-2} rad/d (7.8×10^{-1} mGy/d) from contaminated soil to riparian and terrestrial animals (Table 4.6). These conservative dose rates are well below dose rate limits, which are based on the PNNL-reported total particulate radionuclide emissions for CY 2018 (Snyder et al. 2019). Assumptions are that all the particulate radioactive material is concentrated into either 1 m^3 (35 ft^3) of contaminated water or 1 m^2 (10.8 ft^2) of contaminated soil with a soil density of 224 kg m^2 (14 lb/ft^2) to a depth of 15 cm (6 in.) (Napier 2006). The screening-level dose coefficients used are found in DOE-STD-1153-2002, Module 3 (DOE 2002). The resulting water and soil concentrations are very conservative and used for basic screening and simplicity of calculation for comparison to the adopted biota dose rate limits.

4.4.2 Radiation Protection of Biota – PNNL Marine Sciences Laboratory

Environmental media pathways were evaluated during the development of MSL's DQOs in support of radiological emissions monitoring. Potential media exposure pathways such as air, soil, water, and food were considered in conjunction with potential releases of radioactive contamination to the air pathway.

Table 4.6. Screening-Level Dose Rates to Aquatic and Terrestrial Biota for the PNNL Richland Campus, 2018

Nuclide(a)	Particulate Emissions[a] (Bq/yr)	Screening-Level Dose Coefficient for Exposure to Aquatic Animals to Contaminated Water[b] (Gy/yr per Bq/m^3)	Screening-Level Dose Coefficient for Exposure to Terrestrial Biota to Contaminated Soil[b] (Gy/yr per Bq/kg)	Radionuclide Concentration in 1 m^3 Water[c] (Bq/m^3)	Radionuclide Concentration in 1 m^2 Soil[d] (Bq/kg)	Dose Rate for Aquatic Animals (mGy/d)	Dose Rate for Terrestrial Biota (mGy/d)
Gross alpha	5.9×10^{3}	6.8×10^{-9}	1.4×10^{-5}	5.9×10^{3}	2.6×10^{1}	1.1×10^{-4}	1.0×10^{-3}
Gross beta	4.1×10^{4}	6.6×10^{-9}	1.3×10^{-5}	4.1×10^{4}	1.8×10^{2}	7.4×10^{-4}	6.5×10^{-3}
Sodium-24	4.4×10^{6}	6.6×10^{-9}	1.3×10^{-5}	4.4×10^{6}	2.0×10^{4}	8.0×10^{-2}	7.1×10^{-1}
Manganese-54	5.6×10^{-2}	6.6×10^{-9}	1.3×10^{-5}	5.6×10^{-2}	2.5×10^{-4}	1.0×10^{-9}	8.8×10^{-9}
Cobalt-57	6.3×10^{0}	6.6×10^{-9}	1.3×10^{-5}	6.3×10^{0}	2.8×10^{-2}	1.1×10^{-7}	1.0×10^{-6}
Cobalt-60	1.2×10^{3}	6.6×10^{-9}	1.3×10^{-5}	1.2×10^{3}	5.4×10^{0}	2.2×10^{-5}	1.9×10^{-4}
Bromine-82	4.8×10^{2}	6.6×10^{-9}	1.3×10^{-5}	4.8×10^{2}	2.1×10^{0}	8.7×10^{-6}	7.6×10^{-5}
Yttrium-88	4.8×10^{1}	6.6×10^{-9}	1.3×10^{-5}	4.8×10^{1}	2.1×10^{-1}	8.7×10^{-7}	7.6×10^{-6}
Cadmium-109	3.1×10^{1}	6.6×10^{-9}	1.3×10^{-5}	3.1×10^{1}	1.4×10^{-1}	5.6×10^{-7}	4.9×10^{-6}
Iodine-131	8.1×10^{0}	1.4×10^{-9}	2.9×10^{-6}	8.1×10^{0}	3.6×10^{-2}	3.1×10^{-8}	2.9×10^{-7}
Cesium-137	9.3×10^{2}	2.0×10^{-9}	4.0×10^{-6}	9.3×10^{2}	4.1×10^{0}	5.1×10^{-6}	4.5×10^{-5}
Barium-133	3.7×10^{0}	6.6×10^{-9}	1.3×10^{-5}	3.7×10^{0}	1.7×10^{-2}	6.7×10^{-8}	5.9×10^{-7}
Europium-152	2.2×10^{1}	6.6×10^{-9}	1.3×10^{-5}	2.2×10^{1}	9.9×10^{-2}	4.0×10^{-7}	3.5×10^{-6}
Lutetium-177	4.1×10^{5}	6.6×10^{-9}	1.3×10^{-5}	4.1×10^{5}	1.8×10^{3}	7.4×10^{-3}	6.5×10^{-2}
Lead-210	5.9×10^{0}	1.1×10^{-9}	2.2×10^{-6}	5.9×10^{0}	2.6×10^{-2}	1.8×10^{-8}	1.6×10^{-7}
Radium-226	4.4×10^{1}	6.8×10^{-9}	1.4×10^{-5}	4.4×10^{1}	2.0×10^{-1}	8.3×10^{-7}	7.6×10^{-6}
Uranium-233/234	5.2×10^{1}	3.2×10^{-11}	6.5×10^{-8}	5.2×10^{1}	2.3×10^{-1}	4.5×10^{-9}	4.1×10^{-8}
Uranium-235	1.5×10^{0}	9.4×10^{-10}	1.8×10^{-6}	1.5×10^{0}	6.6×10^{-3}	3.8×10^{-9}	3.3×10^{-8}
Plutonium-238	5.9×10^{2}	2.5×10^{-11}	5.0×10^{-8}	5.9×10^{2}	2.6×10^{0}	4.1×10^{-8}	3.6×10^{-7}
Plutonium-239/240	2.7×10^{2}	2.5×10^{-11}	4.9×10^{-8}	2.7×10^{2}	1.2×10^{0}	1.9×10^{-8}	1.6×10^{-7}
Plutonium-241	1.1×10^{0}	1.3×10^{-11}	2.6×10^{-8}	1.1×10^{0}	5.0×10^{-3}	4.0×10^{-11}	3.5×10^{-10}
Americium-241	3.3×10^{2}	1.4×10^{-10}	2.9×10^{-7}	3.3×10^{2}	1.5×10^{0}	1.2×10^{-7}	1.2×10^{-6}
Americium-243	1.3×10^{3}	1.3×10^{-9}	2.5×10^{-6}	1.3×10^{3}	5.9×10^{0}	4.7×10^{-6}	4.1×10^{-5}
Curium-243/244	4.1×10^{1}	6.4×10^{-10}	1.3×10^{-6}	4.1×10^{1}	1.8×10^{-1}	7.1×10^{-8}	6.5×10^{-7}
					Total	8.9×10^{-2}	7.8×10^{-1}

(a) Data from Table 2.4 of Snyder et al. (2019).

(b) Data from DOE (2002). In cases in which a specific dose rate factor was not available, the radium-226 value was used as a conservative alpha surrogate and the cobalt-60 value was used as a conservative beta surrogate.

(c) The conservative dose rate is assumed to be from 1 m^3 (35 ft^3) of contaminated water.

(d) The conservative dose rate is assumed to be from 1 m^2 (10.8 ft^2) of contaminated soil with a soil density of 224 kg/m^2 (14 lb/ft^2) to a depth of 15 cm (6 in.) (Napier 2006).

Conversion factors: 1 Ci = 3.7 × 1010 Bq; 1 Gy = 100 rad.

The DQO process determined that, because of the low probability of potential air emissions and the absence of radiological emissions via liquid pathways or directly to land areas, no environmental monitoring would be required. Because emission levels at MSL are very low, it would be impossible to differentiate actual emissions from background levels in nearby locations such as Sequim Bay and those from food sources (Barnett et al. 2012a). Reported emissions from MSL are conservatively estimated, because neither environmental surveillance nor stack sampling is required. These conservatively estimated emissions are also adequate to demonstrate protection of the public and of biota; therefore, biota monitoring for radionuclides both near and far from MSL is not conducted.

Routine operations were conducted at MSL facilities during CY 2018—there were no unplanned radiological emissions. The external dose rates for operations in CY 2018 were less than 6.7×10^{-5} rad/d (6.7×10^{-4} mGy/d) from contaminated water to aquatic animals and terrestrial plants and less than 5.9×10^{-4} rad/d (5.9×10^{-3} mGy/d) from contaminated soil to riparian and terrestrial animals (Table 4.7). These conservative dose rates are well below dose rate limits, which are based on the PNNL-reported total particulate radionuclide emissions for CY 2018 (Snyder and Barnett 2019). Assumptions are that all the particulate radioactive material is concentrated into either 1 m^3 (35 ft^3) of contaminated water or 1 m^2 (10.8 ft^2) of contaminated soil with a soil density of 224 kg/m^2 (14 lb/ft^2) to a depth of 15 cm (6 in.) (Napier 2006). The screening-level dose coefficients used are found in DOE-STD-1153-2002, Module 3 (DOE 2002). The resulting water and soil concentrations are very conservative and used for basic screening and the simplicity of calculation for comparison to the adopted biota dose rate limits.

4.5 Unplanned Radiological Releases

No radiological releases to the environment exceeded permitted limits at the PNNL Richland Campus or MSL in 2018.

4.5.1 Environmental Radiological Monitoring

The DOE Handbook, *Environmental Radiological Effluent Monitoring and Environmental Surveillance*, provides information about basic program implementation requirements and activities (DOE-HDBK-1216-2015; DOE 2015). In addition, the WDOH may require an operator of any emission unit to conduct ambient air monitoring or other testing as necessary to demonstrate compliance with the WAC 246-247 standard; such requirements for a program would be included in the operator's license. The environmental radiological monitoring activities conducted by PNNL for both the PNNL Richland Campus and MSL are included in this report.

4.5.2 Environmental Radiological Monitoring – PNNL Richland Campus

A particulate air-sampling (environmental surveillance) network was established in 2010 to monitor radioactive particulates in ambient air near the PNNL Richland Campus as stipulated by WDOH in RAEL-005. As a result of changes in DOE-permitted operations in 2012, the air-sampling network was re-evaluated (Barnett et al. 2012b). In 2017, the particulate air-sampling network was again evaluated, because the Campus expanded to the north by 35 ha (85.6 ac) (Snyder et al. 2017). The current particulate air-sampling network consists of four Campus samplers—PNL-1, PNL-2, PNL-3, and PNL-4—and one background sampler—PNL-5 (Figure 4.1)—and co-located ambient external dose monitors.

Table 4.7. Screening-Level Dose Rates to Aquatic and Terrestrial Biota for the PNNL Marine Sciences Laboratory, 2018

Nuclide[a]	Particulate Emissions[a] (Bq/yr)	Screening-Level Dose Coefficient for Exposure to Aquatic Animals to Contaminated Water[b] (Gy/yr per Bq/m^3)	Screening-Level Dose Coefficient for Exposure to Terrestrial Biota to Contaminated Soil[b] (Gy/yr per Bq/kg)	Radionuclide Concentration in 1 m^3 Water[c] (Bq/m^3)	Radionuclide Concentration in 1 m^2 Soil[d] (Bq/kg)	Dose Rate for Aquatic Animals (mGy/d)	Dose Rate for Terrestrial Biota (mGy/d)
Iodine-125	3.7×10^{4}	6.6×10^{-9}	1.3×10^{-5}	3.7×10^{4}	1.7×10^{2}	6.7×10^{-4}	5.9×10^{-3}
Thorium-232	3.7×10^{1}	3.0×10^{-11}	6.1×10^{-8}	3.7×10^{1}	1.7×10^{-1}	3.0×10^{-9}	2.8×10^{-8}
Remaining alpha (as americium-241)	6.4×10^{2}	1.4×10^{-10}	2.9×10^{-7}	6.4×10^{2}	2.9×10^{0}	2.5×10^{-7}	2.6×10^{-6}
Remaining beta (as cesium-137)	7.7×10^{1}	2.0×10^{-9}	4.0×10^{-6}	7.7×10^{1}	3.4×10^{-1}	4.2×10^{-7}	3.7×10^{-6}
				Total		6.7×10^{-4}	5.9×10^{-3}

(a) Data from Table 3.3 of Snyder and Barnett (2019).
(b) Data from DOE (2002). In cases in which a specific dose rate factor was not available, the radium-226 value was used as a conservative alpha surrogate and the cobalt-60 value was used as a conservative beta surrogate.
(c) The conservative dose rate is assumed to be from 1 m^3 (35 ft^3) of contaminated water.
(d) The conservative dose rate is assumed to be from 1 m^2 (10.8 ft^2) of contaminated soil with a soil density of 224 kg/m^2 (14 lb/ft^2) to a depth of 15 cm (6 in.) (Napier 2006).
Conversion factors: 1 Ci = 3.7 × 1,010 Bq; 1 Gy = 100 rad.

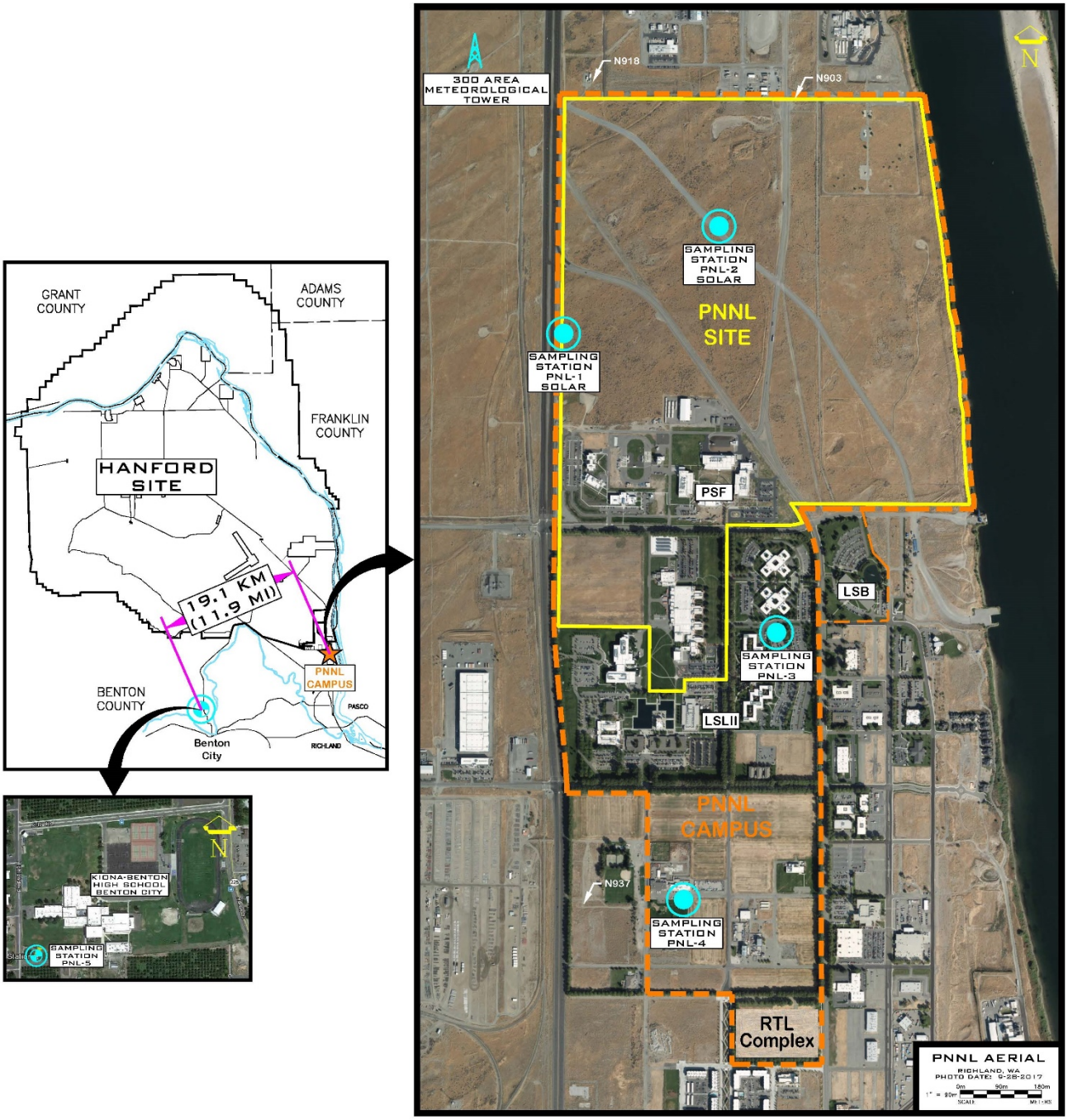

Figure 4.1. Air Surveillance Station Locations for the PNNL Richland Campus (based on Snyder et al. 2019)

During CY 2018, air samples were collected at all sampling stations and included sampling and analysis for airborne particulate radionuclides. Particulate air samples are routinely analyzed for gross alpha activity and gross beta activity. Semi-annually, filters are composited for specific radionuclide analysis. The required composite analyses include cobalt-60, uranium-233,[1] plutonium-238 and plutonium-239/240, americium-241 and americium-243, and curium-244.[2] Monitoring of ambient levels of external dose is done with aluminum oxide dosimeters read by optically stimulated luminescence; there is a 5 mrem (50 μSv) minimum detection level for these dosimeters and two control dosimeters are used in conjunction with the deployed ones.

No PNNL activities resulted in increased ambient air concentrations at the air-sampling locations in CY 2018 (Table 4.8). The gross alpha and gross beta results were comparable to background levels. All nuclide-specific results were less than the values in 40 CFR Part 61, Appendix E, Table 2, and there was no indication of elevated levels of monitored particulate radionuclides near the PNNL Richland Campus. The lack of overall detectable concentrations supports the results of stack effluent monitoring, and demonstrates that emissions from the PNNL Richland Campus are low and have minimal potential for dose to members of the public.

Quarterly monitoring of ambient levels of external dose from beta, gamma, and X-ray sources at the five particulate air-sampling stations during 2018 was conducted (Table 4.9). No current PNNL Richland Campus radioactive air emissions include significant quantities of external dose contributors. For CY 2018, the total annual doses at each Richland Campus monitoring location are similar to the PNL-5 background. However, the second quarter PNL-2 measurement result was somewhat unusual—elevated above other stations' results—and was assumed to be caused by measurement system uncertainty.

In addition to the boundary and background station ambient external dose monitoring discussed above, the PNNL Radiation Protection organization performs semi-annual external dose rate surveys and direct contamination surveys of the ground within 6 m (20 ft) of PNNL buildings that contain radiological areas. For CY 2018, survey results were at background levels in areas that could be occupied by the public.

[1] Only uranium-233 is required, but it is reported as uranium-233/234 because the naturally occurring uranium-234 emission peak overlaps with uranium-233.

[2] Only curium-244 is required, but it is reported as curium-243/244 because the curium-243 emission peak overlaps with curium-244.

Table 4.8. Summary of 2018 Air-Sampling Results for the PNNL Richland Campus (Snyder et al. 2019)

Nuclide	Location[a]	No. of Samples Analyzed	No. of Detections	Value ± 2σ Error (pCi/m³)[b]
Gross alpha	PNL-1	26	23	$9.4 \times 10^{-4} \pm 2.3 \times 10^{-3}$
	PNL-2	27	21	$9.5 \times 10^{-4} \pm 2.4 \times 10^{-3}$
	PNL-3	26	23	$8.6 \times 10^{-4} \pm 2.0 \times 10^{-3}$
	PNL-4	26	23	$7.4 \times 10^{-4} \pm 1.8 \times 10^{-3}$
	PNL-5	26	22	$8.9 \times 10^{-4} \pm 2.1 \times 10^{-3}$
Gross beta	PNL-1	26	26	$2.1 \times 10^{-2} \pm 7.7 \times 10^{-3}$
	PNL-2	27	27	$2.0 \times 10^{-2} \pm 7.6 \times 10^{-3}$
	PNL-3	26	26	$2.0 \times 10^{-2} \pm 7.3 \times 10^{-3}$
	PNL-4	26	26	$1.9 \times 10^{-2} \pm 6.5 \times 10^{-3}$
	PNL-5	26	26	$1.8 \times 10^{-2} \pm 6.5 \times 10^{-3}$
Cobalt-60	PNL-1	2	0	$2.2 \times 10^{-5} \pm 1.8 \times 10^{-4}$
	PNL-2	2	0	$5.8 \times 10^{-5} \pm 1.4 \times 10^{-4}$
	PNL-3	2	0	$7.2 \times 10^{-5} \pm 2.4 \times 10^{-4}$
	PNL-4	2	0	$2.9 \times 10^{-5} \pm 1.5 \times 10^{-4}$
	PNL-5	2	0	$8.8 \times 10^{-5} \pm 1.3 \times 10^{-4}$
Cesium-137	PNL-1	2	0	$3.7 \times 10^{-5} \pm 1.6 \times 10^{-4}$
	PNL-2	2	0	$3.7 \times 10^{-5} \pm 1.2 \times 10^{-4}$
	PNL-3	2	0	$9.3 \times 10^{-5} \pm 1.4 \times 10^{-4}$
	PNL-4	2	0	$3.7 \times 10^{-5} \pm 1.1 \times 10^{-4}$
	PNL-5	2	0	$1.3 \times 10^{-5} \pm 9.5 \times 10^{-5}$
Uranium-233/234	PNL-1	2	2	$4.9 \times 10^{-5} \pm 4.5 \times 10^{-5}$
	PNL-2	2	2	$3.3 \times 10^{-5} \pm 2.3 \times 10^{-5}$
	PNL-3	2	2	$4.6 \times 10^{-5} \pm 2.7 \times 10^{-5}$
	PNL-4	2	2	$4.0 \times 10^{-5} \pm 2.6 \times 10^{-5}$
	PNL-5	2	2	$5.3 \times 10^{-5} \pm 2.9 \times 10^{-5}$
Plutonium-238	PNL-1	2	0	$3.8 \times 10^{-6} \pm 9.1 \times 10^{-6}$
	PNL-2	2	0	$5.2 \times 10^{-7} \pm 4.0 \times 10^{-6}$
	PNL-3	2	0	$6.5 \times 10^{-8} \pm 8.1 \times 10^{-6}$
	PNL-4	2	0	$5.4 \times 10^{-7} \pm 7.6 \times 10^{-6}$
	PNL-5	2	0	$-5.1 \times 10^{-7} \pm 6.7 \times 10^{-6}$
Plutonium-239/240	PNL-1	2	0	$3.0 \times 10^{-6} \pm 1.1 \times 10^{-5}$
	PNL-2	2	0	$-2.0 \times 10^{-6} \pm 5.7 \times 10^{-6}$
	PNL-3	2	0	$2.0 \times 10^{-6} \pm 7.6 \times 10^{-6}$
	PNL-4	2	0	$1.0 \times 10^{-6} \pm 7.1 \times 10^{-6}$
	PNL-5	2	0	$-3.1 \times 10^{-6} \pm 7.2 \times 10^{-6}$
Americium-241	PNL-1	2	0	$4.9 \times 10^{-6} \pm 1.3 \times 10^{-5}$
	PNL-2	2	0	$1.1 \times 10^{-5} \pm 1.6 \times 10^{-5}$
	PNL-3	2	0	$1.5 \times 10^{-6} \pm 7.9 \times 10^{-6}$
	PNL-4	2	0	$5.0 \times 10^{-6} \pm 1.2 \times 10^{-5}$
	PNL-5	2	0	$5.1 \times 10^{-6} \pm 1.2 \times 10^{-5}$
Americium-243	PNL-1	2	1	$9.2 \times 10^{-6} \pm 1.2 \times 10^{-5}$
	PNL-2	2	0	$6.2 \times 10^{-7} \pm 1.5 \times 10^{-5}$
	PNL-3	2	0	$3.0 \times 10^{-6} \pm 8.5 \times 10^{-6}$
	PNL-4	2	0	$8.0 \times 10^{-6} \pm 1.4 \times 10^{-5}$
	PNL-5	2	0	$2.9 \times 10^{-6} \pm 7.7 \times 10^{-6}$
Curium-243/244	PNL-1	2	0	$2.7 \times 10^{-6} \pm 1.5 \times 10^{-5}$
	PNL-2	2	0	$3.3 \times 10^{-7} \pm 4.3 \times 10^{-6}$
	PNL-3	2	0	$1.9 \times 10^{-6} \pm 7.6 \times 10^{-6}$
	PNL-4	2	0	$1.1 \times 10^{-6} \pm 7.4 \times 10^{-6}$
	PNL-5	2	0	$1.2 \times 10^{-6} \pm 9.7 \times 10^{-6}$

(a) Refer to Figure 4.1 for PNL-1, PNL-2, PNL-3, PNL-4, and PNL-5 locations.
(b) The value is the average of samples collected throughout the year.
To convert pCi/m³ to Bq/m³, multiply pCi by 0.037.

Table 4.9. Summary of 2018 Reported Ambient External Dose Results (mrem) for the PNNL Richland Campus (Snyder et al. 2019)

2018 Quarter	PNL-1[a]	PNL-2[a]	PNL-3[a]	PNL-4[a]	PNL-5[a, b]
Q1	28	28	26	29	29
Q2	26	35	25	23	26
Q3	30	30	30	27	31
Q4	24	25	26	26	27
Annual Total	**108**	**118**	**107**	**105**	**113**

(a) Refer to Figure 4.1 for the physical location.
(b) PNL-5 is the background station; no background value results were subtracted from the perimeter station results (PNL-1 through PNL-4).
To convert mrem to µSv, multiply mrem by 10.

4.5.3 Environmental Radiological Monitoring – PNNL Marine Sciences Laboratory

Emissions at MSL are low, the radionuclide inventory is relatively small, and radiological impact estimates are well below regulatory limits, even when highly over-estimating assumptions are applied (Barnett et al. 2012a). The emissions at MSL have historically met requirements for dose limit compliance based on estimates derived using the COMPLY Code (EPA 1989). COMPLY is applicable to sites that have low levels of releases (i.e., releases that result in an MEI dose below the minor emissions unit limit of 0.1 mrem/yr [1 µSv/yr]) (Barnett et al. 2012a). For this reason, particulate air sampling is not required at MSL.

The PNNL Radiation Protection organization performs semi-annual external dose rate surveys at MSL-5 exterior door locations. For CY 2018, survey results were at background levels in areas that could be occupied by the public.

4.6 Future Radiological Monitoring

In 2018, the MSL RAEL-014 was renewed with an effective date of January 1, 2018. The renewal resulted in a single MSL sitewide minor, fugitive, nonpoint source emission unit, thereby eliminating specific building emission units and reducing the permit complexity. A re-evaluation of the MSL for environmental surveillance began in 2018 and is expected to conclude during CY 2019 with the recommendation to initiate baseline ambient air sampling and environmental dosimetry.

5.0 ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

The Effluent, Waste, and Transportation Programs Group within the PNNL Environmental Protection and Regulatory Programs Division establishes or provides reference to already established discharge limits for toxic and radiological effluents to air and water. Specific effluent management services include establishing monitoring and sampling programs to characterize effluents from PNNL facilities including those at MSL, verifying compliance with effluent standards and controls, assisting facility operations, and monitoring compliance with air and water permits.

The Effluent, Waste, and Transportation Programs Group provides the interface between regulatory agencies and PNNL to prepare and submit required environmental permitting documentation, and reports spills and releases to regulatory agencies. A detailed description of the responsibilities assigned to the group and interactions with other PNNL organizations is provided in the internal *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan* (Ballinger and Beus 2016). The ALARA principle is applied to effluent activities to minimize the potential effects of emissions on the public and the environment.

5.1 Liquid Effluent Monitoring

Wastewater from the PNNL Richland Campus is discharged directly to the City of Richland's Publicly Owned Treatment Works. Wastewater discharges are regulated by the City of Richland under three industrial wastewater discharge permits. All waste streams regulated by these permits are reviewed by PNNL staff and evaluated relative to compliance with the applicable permit prior to their discharge. Sampling and monitoring of these waste streams are done in accordance with the permits, and the results are reported as required to the City of Richland.

Process wastewater from MSL is discharged to an onsite wastewater treatment plant and then directly discharged to Sequim Bay under the authorization of Washington State Department of Ecology NPDES Permit No. WA0040649. This permit identifies effluent limitations and monitoring requirements for this facility. Monitoring data required by the NPDES permit for 2018 are listed in Table 5.1. One grab sample was taken each month from Outfall 008 and analyzed for the parameters identified in Table 5.1. All parameters met the NPDES permit effluent limitations. There were no regulated discharges from Outfall 007 during this time period.

Table 5.1. PNNL Marine Sciences Laboratory 2018 NPDES Monitoring Results for Outfall 008[a]

Parameter	Total Samples	Quantity Found Below Method Reporting Limit	Method Reporting Limit[b]	Maximum Value
Maximum flow (gpd)	N/A	N/A	N/A	179,900
Chlorine, total residual (µg/L)	12	12	50	<50
Antimony (µg/L)	1	1	0.5	<0.5
Arsenic (µg/L)	1	0	5	5.1
Beryllium (µg/L)	1	1	0.2	<0.2
Cadmium (µg/L)	1	1	0.2	<0.2
Chromium (µg/L)	1	1	2	<2
Copper (µg/L)	12	5	4	11.8
Lead (µg/L)	12	9	0.4	0.53
Mercury (µg/L)	1	0	0.0005	0.00142
Nickel (µg/L)	1	1	2	<2
Selenium (µg/L)	1	0	10	12
Silver (µg/L)	1	1	0.2	<0.2
Thallium (µg/L)	1	1	0.2	<0.2
Zinc (µg/L)	12	11	40	92
pH[c]	12	N/A	N/A	7.7

(a) There were no regulated discharges from Outfall 007 during this time period.
(b) The highest Method Reporting Limit reported for all months is listed.
(c) pH limits of 6–9 standard units are specified in the current permit.
gpd = gallons per day; N/A = not applicable; µg/L = micrograms per liter.

5.2 Air Effluent

While PNNL is not a large source of nonradiological air emissions, past and present emissions include GHGs, ozone-depleting substances (primarily refrigerants), hazardous air pollutants, and criteria air pollutants. The air effluent program does not monitor any stacks for nonradiological constituents, and compliance is assured by complying with regulatory standards for equipment and permit conditions. Complying typically involves activities such as using clean fuels and monitoring fuel use, adhering to required operating hours for boilers and diesel engines, and adhering to maintenance and operating requirements. Permit applications contain emission estimates based on vendor data (e.g., emission rate/hour), so monitoring of run time or fuel use is an acceptable method of determining permit compliance. In addition, reviews of research and facility construction/renovation projects are conducted to maintain compliance with all applicable requirements.

Nonradiological atmospheric effluent is tracked and reported according to standards established by the Global Reporting Initiative (GRI) (Table 5.2). The GRI is a non-profit organization that promotes economic, environmental, and social sustainability by providing companies and organizations with a comprehensive sustainability reporting framework that is extensively used around the world. PNNL's approach to reducing emissions of ozone-depleting substances includes administrative controls implemented through procedures for maintenance, repair, and disposal, as well as minimizing procurement of ozone-depleting substances for new and replacement refrigeration systems.

Table 5.2. PNNL Richland Campus Nonradiological Atmospheric Emissions for 2018 Reported in Accordance with the Global Reporting Initiative (GRI) Standards

GRI Indicator	Indicator Title	2018 Emissions	Units
EN15	Direct greenhouse gas emissions	7,767	metric tons of carbon dioxide equivalent
EN16	Energy indirect greenhouse gas emissions	28,195	metric tons of carbon dioxide equivalent
EN17	Other relevant indirect greenhouse gas emissions	21,054	metric tons of carbon dioxide equivalent
EN20	Ozone-depleting substance R12	0.01179	metric tons
	Ozone-depleting substance R22	0.00442	metric tons
	Ozone-depleting substance R123	0	metric tons
	Ozone-depleting substance 403B	0	metric tons
	Ozone-depleting substance 414B	0	metric tons
	Ozone-depleting substance 502	0.00003	metric tons
	Emissions of ozone-depleting substances in CFC-11 Equivalent	0.0162	metric tons
EN21	Nitrogen oxides	3,756	kilograms
	Sulfur dioxide	35	kilograms
	Volatile organic compounds	743	kilograms
	Hazardous air pollutants	287	kilograms
	Particulate matter	480	kilograms
	Carbon monoxide	6,268	kilograms

To convert metric tons to U.S. tons multiply by 1.1.
To convert kilograms to pounds multiply by 2.2.

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6.0 GROUNDWATER PROTECTION PROGRAM

Groundwater under the PNNL Richland Campus is monitored routinely through seven groundwater monitoring wells. Monitoring of the groundwater under the PNNL Richland Campus was initiated under the direction of the Washington State Department of Ecology through temporary State Waste Discharge Permit ST-9274 for the BSF/CSF ground-source heat pump. Pursuant to the permit, groundwater is primarily monitored for temperature, pH, dissolved oxygen, conductivity, turbidity, and total dissolved solids. Groundwater is also analyzed for other parameters that are associated with underlying contamination plumes. These include nitrate, tritium, uranium, and trichloroethylene.

The BSF/CSF uses a novel technology for heating and cooling the buildings that relies on a ground-source heat pump. Water is pumped from four extraction wells, passed through a non-contact heat exchanger, and returned to the aquifer through four injection wells. In February 2011, the Washington State Department of Ecology issued a water right for the nonconsumptive use of groundwater for the ground-source heat pump, allowing the withdrawal and use of groundwater by the four extraction wells at flow rates up to 7,200 L/min (1,900 gpm) and requiring injection of the water back to the aquifer.

Because the water is re-injected back into the ground, the Washington State Department of Ecology issued temporary State Waste Discharge Permit ST-9274 to have the groundwater monitored for temperature changes and potential influence on pollutants from underground contamination plumes.

The groundwater is sampled and analyzed in accordance with the sampling and analysis plan for the ground-source heat pump (Fritz and Moon 2010). The discharge permit requires sampling and analysis of seven groundwater monitoring wells that are downgradient from the injection site in addition to the extraction and injection wells. Three of the monitoring wells located on the PNNL Richland Campus are existing wells previously associated with the Hanford Site monitoring network. The other four monitoring wells were constructed and developed in accordance with the sampling and analysis plan (Fritz and Moon 2010). The sampling data are reported monthly to the Washington State Department of Ecology. Table 6.1 provides a summary of the monitoring results for the BSF/CSF ground-source heat pump for 2018. PNNL is in compliance with all sampling and monitoring requirements of the discharge permit, and results show no concern with respect to the ground-source heat pump water affecting movement of the contaminant plumes. No other groundwater sampling at either the PNNL Richland Campus or MSL is required for environmental compliance.

In August 2018, the Washington State Department of Ecology[1] approved the reduction or elimination of the following monitoring, sampling, and reporting requirements:

- Eliminate reporting of the outside average ambient air temperature.
- Eliminate sampling/reporting of all wells (production, injection, and monitoring) for turbidity, total dissolved solids, nitrate + nitrite, uranium, tritium, and trichloroethylene.
- Reduce the monitoring frequency for temperature and depth-to-groundwater at the seven groundwater monitoring wells from six times per day to once weekly.
- Reduce the sampling/reporting frequency for pH, conductivity, and dissolved oxygen to one production well, and discharge to the injection wells and all monitoring wells from quarterly to semi-annually.
- Modify Discharge Monitoring Reports for production and injection well flow and temperature from a daily minimum/maximum/average to a single monthly maximum and monthly average.

As a result of this approval, sampling and monitoring for uranium, tritium, nitrate, and trichloroethylene were discontinued after August 2018. Sampling and analysis for pH, conductivity, and dissolved oxygen is performed semi-annually.

[1] Letter from M. Durkee, Washington State Department of Ecology, to T. Moon, Pacific Northwest National Laboratory, RE: Monitoring Reduction Request, Battelle Memorial Institute Biological Sciences Facility Permit No. WA0009274, dated August 2, 2018.

Table 6.1. Biological Sciences Facility/Computational Sciences Facility Ground-Source Heat Pump Monitoring Results, 2018

Parameter	Number of Samples Analyzed	Quantity Found Below Method Reporting Limit	Method Reporting Limit	Minimum Reported Value	Maximum Reported Value
Injection Wells					
Flow (gpm)	N/A	N/A	N/A	0	916
Temperature (°C)	N/A	N/A	N/A	18.3	25.3
pH (pH units)	9	N/A	N/A	7.4	7.5
Dissolved oxygen (mg/L)	9	N/A	N/A	7.0	7.6
Conductivity (µS/cm)	9	N/A	N/A	714	720
Turbidity (NTU)	1	0	0.2	N/A	0.59
Total dissolved solids (mg/L)	1	0	10	N/A	483
Nitrate-nitrite (mg/L)	1	0	0.5	N/A	20.5
Uranium (µg/L)	1	0	0.02	N/A	6.54
Tritium (pCi/L)	1	1	1,000	ND	ND
Trichloroethylene (µg/L)	1	1	5	ND	ND
Monitoring Wells Downgradient of the Injection Wells					
Temperature (°C)	N/A	N/A	N/A	13.2	18.8
pH (pH units)	21	N/A	N/A	7.0	7.6
Dissolved oxygen (mg/L)	21	N/A	N/A	6.3	10.1
Conductivity (µS/cm)	21	N/A	N/A	714	1549
Turbidity (NTU)	7	0	0.2	0.27	0.62
Total dissolved solids (mg/L)	7	0	10	480	863
Nitrate-nitrite (mg/L)	7	0	0.5	1.69	20.3
Uranium (µg/L)	7	0	0.02	5.1	11.0
Tritium (pCi/L)	7	7	1,000	ND	ND
Trichloroethylene (µg/L)	7	7	5	ND	ND

gpm = gallons per minute; N/A = not applicable; ND = nondetectable; NTU = nephelometric turbidity unit; µS = microsiemens.

7.0 QUALITY ASSURANCE

The PNNL Quality Assurance (QA) Program is based on the requirements defined in DOE Order 414.1D, *Quality Assurance*, and 10 CFR Part 830, *Energy/ 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 2001)
- ASME NQA-1-2000, Part II, Subpart 2.7, "Quality Assurance Requirements for Computer Software for Nuclear Facility Applications," including problem reporting and corrective actions (ASME 2001)
- ASME NQA-1-2000, Part IV, Subpart 4.2, "Guidance on Graded Application of Quality Assurance (QA) for Nuclear-Related Research and Development" (ASME 2001).

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 described in the standards identified above 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.

7.1 Environmental Monitoring Program

Environmental sampling and monitoring activities were performed under PNNL's Environmental Management Program. These activities included sampling of water, wastewater, radiological air emissions, ambient air, and environmental dosimeters. Sampling is conducted by the Effluent Management Group or its delegates under the *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan (EM QAP)*, EM-QA-01 (Ballinger and Beus 2016), and the related quality requirements documents that describe the specific QA elements applicable to each activity (Table 7.1).

Table 7.1. Effluent Management Quality Assurance Requirements Documents

Document Title
Effluent Management Quality Assurance Plan (EM-QA-01)
Quality Requirements for Air Chemical Emissions Management
Quality Requirements for Biological Sciences Facility/Computational Sciences Facility (BSF/CSF) Ground Source Heat Pump Monitoring to State Waste Discharge Permit ST-9274
Quality Requirements for Facility Effluent Management Planning
Quality Requirements for Industrial Wastewater Discharge Permit Sampling and Monitoring for the PNNL Campus (CR-IU001), Environmental Molecular Sciences Laboratory (CR-IU005), and Physical Sciences Facility (CR-IU011)
Quality Requirements for Marine Sciences Laboratory Monitoring to National Pollutant Discharge Elimination System Permit WA 0040649
Quality Requirements for Radionuclide Air Emissions Sampling and Monitoring
Quality Requirements for Radionuclide Air Environmental Surveillance Monitoring

The EM QAP addresses the requirements in DOE Order 414.1D and the guidance in EPA QA/G-5 (EPA 2002). 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 those 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), were evaluated before contracts were awarded.

Radiological environmental air monitoring activities were determined using the DQO process described in the EPA *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA 2006) for the PNNL Operations in Richland and Sequim and were documented in DQO reports supporting air monitoring by Snyder et al. (2019) and Snyder and Barnett (2019), respectively. 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; Snyder et al. (2017) determined and documented the environmental sampling and monitoring requirements necessary to comply with applicable regulations at PNNL's Richland Campus. As determined in the DQO process for the Richland Campus (Snyder et al. 2017), PNNL has established an environmental surveillance program that samples particulate radionuclides in ambient air. The Environmental Management Plan (EMP) (Snyder et al. 2011) with its attachments—the *Sampling and Analysis Plan*, *Data Management Plan*, and *Dose Assessment Guidance*—provides a comprehensive approach to environmental radioactive air monitoring of PNNL operations. A similar DQO process was performed for MSL in Sequim, Washington (Barnett et al. 2012a), where it was decided that air emissions are so low that environmental monitoring currently is not required. Potential MSL radioactive air emissions are permitted under the current radioactive air emissions license, and compliance is demonstrated through calculated emission rates. The renewed Sequim Site – MSL license (RAEL-014, Renewal 1) became effective on January 1, 2018. It differs from the original permit in that it consolidates the former MSL-1 and MSL-5 emission units under expanded permit operations into a single sitewide emission unit. This change was a cooperative effort between WDOH, PNSO, and PNNL and simplifies the overall approach to working with radioactive material at the facility. As result of this permit change the DQO report for the PNNL Sequim Site was revised (Snyder et al. 2019).

In 2018, an ambient external dose surveillance program was performed at the five particulate air monitoring stations associated with the PNNL Richland Campus. The program established baseline ambient external dose levels at the perimeter and background sampling stations, because the PNNL Richland Campus currently has no significant quantities of external dose contributors. Monitoring is done using aluminum oxide dosimeters read by optically stimulated luminescence. Details and results can be reviewed in the *PNNL Richland Campus Radionuclide Air Emissions Report for Calendar Year 2018* (Snyder et al. 2019).

Water and wastewater sampling and monitoring at the PNNL Richland Campus were performed to meet requirements in permits issued by the City of Richland for discharges to the sewer and by the Washington State Department of Ecology for discharges to the ground. At MSL, water and wastewater sampling and monitoring are performed to comply with NPDES and Group A Drinking Water permits. QA requirements for these activities have been integrated into the EM QAP (Ballinger and Beus 2016) and related QA documents (see Table 7.1), and include specific requirements such as sampling locations, quality objective criteria, analytical methods, and detection limits.

Chemical air emission monitoring is performed by complying with PNNL's air permits, primarily by limiting the hours of operation, using ultra-low sulfur diesel fuel when operating on diesel, and operating and maintaining PNNL combustion units (e.g., backup generators, boilers, water heaters) as described in the notice of construction application and in accordance with the manufacturer's emission-related instructions. Each research project or Facilities and Operation activity that has the potential for generating air emissions is subject to an air emissions review to identify compliance actions and administrative controls necessary to assure compliance with existing air permits.

7.2 Sample Collection Quality Assurance

Samples are collected by personnel trained to conduct environmental sampling according to approved and documented procedures. Sampling protocols include use of appropriate sampling

methods and equipment, a defined sampling frequency, specified sampling locations, and procedures for sample handling (which may include storage, packaging, and shipping) to maintain sample integrity. Chain-of-custody processes are used to track the transfer of samples from the point of collection to the analytical laboratory. QA program requirements are integrated into the statement of work for subcontracted analytical laboratories and include analyses of laboratory method blanks to evaluate sources of contamination, laboratory duplicates to evaluate method precision, and laboratory control samples/blank spike samples and sometimes matrix spikes and/or surrogates to assess accuracy. A description of these quality control (QC) terms is provided in Table 7.2.

In August 2018, due to heavy smoke in the air from regional wildfires, particulate ambient air sampling in several cases was increased from a two-week to one-week sampling frequency to avoid overloading the sample filter paper and the equipment. Samples were evaluated and composited as usual. Air sample filters were sampled for each event and the results for gross alpha and beta radioactivity indicated no noticeable increases in the presence of any radiological analytes.

Water and wastewater samples are analyzed using EPA-approved methods or methods specified by the applicable regulatory agency. Some samples are required to be analyzed in the field at the time of sample collection because of short holding time limits. These analyses (e.g., pH, conductivity, dissolved oxygen) are performed using controlled procedures to meet QC acceptance criteria, thereby demonstrating compliance with method requirements.

Table 7.2. Quality Control Terms

Quality Control Type	Description
Laboratory method blank	Control sample containing no analyte of interest; used to monitor for bias or contamination introduced during processing and analysis in the laboratory.
Duplicate	Field Duplicate: An additional sample collected as closely as possible to the same time and location to measure sources of error from field sampling activities when compared to laboratory duplicate precision results. (PNNL did not sample field duplicates.) Laboratory Duplicate: An additional aliquot or split sample from the same sample that is analyzed by the laboratory to measure analytical precision.
Matrix spike or surrogate samples	An aliquot of actual sample spiked with a known concentration of target analytes and processed in the same manner as the sample; used to determine the extent to which matrix bias or interferences affect the results when compared to a blank spike result. Instead of target analytes, surrogate analytes can be used. The surrogates are similar compounds that behave analytically like the target analyte in the specific analytical process.
Blank spike or reagent spike samples	A known concentration of target analyte added to the sample matrix or the reagents used to process the sample prior to analysis. Blank or reagent spike samples are used to determine the accuracy associated with measuring a specific analyte by a specific method.
Laboratory control samples (LCSs)	A certified reference material or a prepared sample (created from an analyte-free sample matrix spiked with a known amount of analyte), which may be carried through the preparation and analysis procedures as if it were a sample or inserted at various points in sample processing to identify sources of error/contamination. The recovery of the target analytes in the LCS is used to indicate process or method error and may be useful in assessing accuracy, and, if repeated measures are made, to estimate precision.

7.3 Quality Assurance Analytical Results

The following laboratories conducted the analyses of environmental samples (i.e., stack air emissions, ambient air, water, wastewater, and environmental dosimeters) from the PNNL Richland Campus and MSL during 2018:

- Radiological air emission filter samples were analyzed by PNNL's Analytical Support Operations (ASO) laboratory in the Radiochemical Processing Laboratory.

- Ambient air samples were analyzed for radioactivity by General Engineering Laboratories (GEL), LLC, Charleston, South Carolina.
- Environmental dosimeters were read using optically stimulated luminescence technology by Landauer®, Glenwood, Illinois.
- Water and wastewater samples were analyzed by
  - ALS Environmental, Kelso, Washington;
  - Benton-Franklin Health District Laboratory, Kennewick, Washington;
  - an in-house MSL accredited laboratory; and
  - Spectra Laboratories, Port Orchard, Washington.

Analyses were performed according to a statement of work or contract, which described the activities necessary to assure that the analysis results were of high and verifiable quality. These activities included calibration and performance testing of analytical equipment; implementing a QA program; maintaining analytical and support equipment and facilities; handling, protecting, and analyzing samples; checking data traceability, validity, and quality; recording all analytical data; participating in the analysis of performance evaluation programs; and communicating and reporting to the Effluent Management Group. Each analytical data package is validated prior to using and reporting data. In all cases where identified quality issues resulted in invalid data (e.g., missed hold times; laboratory blanks, spikes, or duplicates did not meet QC criteria), the issue was documented and corrective actions were taken.

- The ASO laboratory analyzed all airborne filter samples for radioactivity according to the criteria in their statements of work and contracts. The analytical activities included use of daily calibration and verification QC samples (e.g., blanks, spiked samples, and sample duplicate pairs) and precision and accuracy targets that require the analysis method to meet quality performance limits. A blank and an instrument control sample were measured against known standards for each batch of routine samples analyzed for alpha and beta activity. In addition, a spiked sample and a blank were included with each batch of composite analyses and were analyzed for specific isotopes in addition to alpha and beta activity. The QC sample results indicated that the sample batches had no measurable contamination from sample preparation activities, and no issues were identified in the sample preparation process. ASO's quality assurance plan is guided by Nuclear Quality Assurance standard NQA-1 requirements, which direct the facility and management to maintain a high level of analytical testing rigor giving special attention to radiological safety and environmental protection. ASO meets assessments that address maintaining analytical instruments, checking data traceability and validity, and communicating results to the client on time. Any corrective actions are addressed by the quality engineer and laboratory management.
- GEL analyzed all particulate ambient air filters for radioactivity according to the criteria in their statement of work. The analytical activities included use of calibration and verification QC samples (e.g., blanks, spiked samples, and sample duplicate pairs) with precision and accuracy targets that require that the analysis method meets quality performance limits. A blank sample was analyzed for each analytical batch analyzed for alpha and beta activity. In addition, each analytical batch reporting composite result included a blank, a duplicate, and a laboratory control sample. The QC sample results indicated that the sample batches had no measurable contamination from sample preparation activities. The integrity and validity of analytical test results are maintained by GEL through the implementation of an internal QC program, while meeting the requirements of 40 CFR Part 61 and the U.S. Department of Defense (DoD)/DOE Consolidated Quality Systems Manual for Environmental Laboratories (DoD and DOE 2017).

- Landauer® provided dosimetry services for ambient air external dose monitoring. Services included providing an aluminum oxide dosimeter in a waterproof pouch at the frequency requested by PNNL, reading the exposed dosimeter using optically stimulated luminescence technology, and providing dose results for the deployment period in an electronic format. Landauer® provided 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. The total annual dose at each Campus monitoring location was similar to that at the background station, and no control or background value was subtracted from the PNNL Richland Campus value. The Landauer® environmental dosimeter is designed to meet ANSI N545 and ANSI/HPS N13.37 (ANSI/HPS 2014).

ALS Environmental, the Benton-Franklin Health District Laboratory, Spectra Laboratories, and an in-house laboratory at MSL analyzed all water and wastewater samples from the PNNL Richland Campus and MSL during 2018. All analytical laboratories are accredited by the Washington State Department of Ecology (C544, H408, C575, C1003, and C560, respectively) for the analysis of water and wastewater samples. To receive accreditation, a laboratory must implement a QA plan, perform periodic proficiency testing, and be periodically inspected by the Washington State Department of Ecology to assure that it is operating within regulatory and QA requirements. Each time a laboratory is selected to perform analyses for PNNL, the PNNL Acquisition Quality Support Services group evaluates whether the lab is either accredited or currently listed on PNNL's Evaluated Supplier List. ALS Environmental and the in-house MSL laboratory are also accredited by the National Environmental Laboratory Accreditation Conference Institute, which requires adherence to a uniform and robust laboratory program that has been implemented consistently nationwide. All wastewater analyses are performed using approved *Clean Water Act* methods specified by EPA in "Guidelines Establishing Test Procedures for the Analysis of Pollutants" (40 CFR Part 136). QA/QC requirements in the contract with PNNL for wastewater analyses include the measurement or assessment of sample accuracy, precision, reliability, representativeness, completeness, and comparability. Measurements are reviewed for each analytical data package to verify that the data are valid. Analytical methods, method detection limits (MDLs), holding times, sample containers, and sample preservation must meet 40 CFR Part 136 requirements and are verified for each sample collected. All of the analytical methods, MDLs, and holding times were met in 2018 for samples submitted by PNNL. If analytical methods, MDLs, or holding times are not met, PNNL rejects the results and resamples, if possible.

7.4 Inter-Laboratory Performance Programs

The annual Mixed-Analyte Performance Evaluation Program (MAPEP, a performance testing program) is managed by the Radiological and Environmental Sciences Laboratory (RESL) at the Idaho National Laboratory. RESL is a government-owned and operated DOE laboratory facility that provides unbiased technical DOE oversight to assure the quality and stability of analytical chemistry, radiation calibrations, and measurements. As an ISO/IEC (International Organization for Standardization/ International Electrotechnical Commission) 17043 accredited laboratory, RESL complies with the requirements of DOE Order 414.1D, *Quality Assurance*; ISO 9001:2015, *Quality Management Systems – Requirements;* and ISO/IEC 17025:2017, *General Requirements for the Competence of Testing and Calibration Laboratories*. MAPEP provides samples of environmental media, including air filter samples containing specific amounts of one or more radionuclide unknown to the participating laboratory. After analysis, the results are evaluated against a stated reference value and acceptance range. For 2018, MAPEP studies 38 and 39 were issued.

- GEL participated in both performance evaluation studies (MAPEP 38 and 39); 100% of air filter results for radiological analysis were within acceptable or acceptable with warning (manganese-54 only) control limits. Per the requirements of the DOE Consolidated Audit Program and normal accreditation cycles, GEL maintained laboratory accreditation, which provides added confidence in the data reported by the laboratory.
- ASO participated in MAPEP 39. Samples were received by the laboratory in August/September 2018 and final results were provided by MAPEP in May 2019. All of the reported results were found to be acceptable based on the limits established by MAPEP for sample result scoring.

The requirements for inter-laboratory performance do not apply to dosimetry.

Participation in inter-laboratory performance programs for the analysis of water and wastewater samples is not required pursuant to permits issued under the *Safe Drinking Water Act* or the *Clean Water Act*. PNNL considers the following standards in their review of commercial analytical laboratories for use: ISO/IEC Standard 17025 and Standard 17043. Standard 17025 contains the general requirements for the competence of testing and calibration laboratories. Standard 17043 provides the general requirements for proficiency testing. ALS Environmental (Kelso, Washington), Benton-Franklin Health District Laboratory, PNNL MSL, and Spectra Laboratories (Tacoma, Washington) are evaluated suppliers and use an ISO/IEC 17043 accredited proficiency testing company.

7.5 Data Management and Calculations

Quality assurance is integrated into data management processes and calculations through the EM QAP and related QA documents, the EMP Data Management Plan, and staff procedures; parameters for dose calculations are documented as a component of the EMP. Software QA processes are used to verify the accuracy of databases used for analytical results. Procedures identify the process for developing, testing, maintaining, and using spreadsheets to perform calculations that support or relate to a regulatory compliance, permit, or safety requirement; procedures also contain the basis for parameters and methods used in estimating environmental releases, as well as checklists used to verify and validate analytical results. For 2018, the processes for managing data and calculations were followed.

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APPENDIX A

PLANT AND ANIMAL SPECIES FOUND ON THE UNDEVELOPED UPLAND PORTIONS AND IN THE RIPARIAN AREA OF THE PNNL RICHLAND CAMPUS, 2009–2018

APPENDIX A

PLANT AND ANIMAL SPECIES FOUND ON THE UNDEVELOPED UPLAND PORTIONS AND IN THE RIPARIAN AREA OF THE PNNL RICHLAND CAMPUS, 2009–2018

Table A.1. Plant Species Observed on the Undeveloped Upland Portions of the PNNL Richland Campus, 2009–2018

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Achillea millefolium	common yarrow			
Achnatherum hymenoides	Indian ricegrass			
Agoseris glauca	pale agoseris			
Agoseris grandiflora	large-flowered agoseris			
Agoseris heterophylla	annual agoseris			
Agropyron cristatum	crested wheatgrass			
Ailanthus altissima	tree-of-heaven			C
Allium schoenoprasum	chives			
Amaranthus albus	white pigweed			
Ambrosia acanthicarpa	bur ragweed			
Amsinckia lycopsoides	tarweed fiddleneck			
Amsinckia tessellata	tessellate fiddleneck			
Aphyllon corymbosum	flat-topped broomrape			
Artemisia campestris	Pacific sagewort			
Artemisia dracunculus	tarragon			
Artemisia ludoviciana	prairie sage			
Artemisia tridentata	big sagebrush			
Asclepias speciosa	showy milkweed			
Asparagus officinalis	garden asparagus			
Astragalus caricinus	buckwheat milkvetch			
Avena sativa	cultivated oats			
Balsamorhiza careyana	Carey's balsamroot			
Bassia scoparia	burning-bush			B
Bromus tectorum	cheatgrass			
Calochortus macrocarpus	sagebrush mariposa lily			
Capsella bursa-pastoris	shepherd's purse			
Centaurea diffusa	diffuse knapweed			B
Centaurea solstitialis	yellow starthistle			B
Chaenactis douglasii	hoary false yarrow			
Chamaesyce serpyllifolia	thymeleaf sandmat			
Chenopodium album	white goosefoot			
Chenopodium leptophyllum	slimleaf goosefoot			
Chondrilla juncea	skeletonweed			B
Chorispora tenella	chorispora			
Chrysothamnus viscidiflorus	green rabbitbrush			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Cichorium intybus	chicory			
Cirsium arvense	creeping thistle			
Clematis ligusticifolia	western clematis			
Comandra umbellata	bastard toadflax			
Convolvulus arvensis	bindweed			C
Conyza canadensis	Canadian horseweed			
Coreopsis tinctoria	Columbia coreopsis			
Crepis atribarba	slender hawksbeard			
Cryptantha flaccida	weak-stemmed cryptantha			
Cryptantha fendleri	Fendler's cryptantha			
Cryptantha pterocarya	winged cryptantha			
Cymopterus terebinthinus	turpentine spring parsley			
Cynodon dactylon	cynodon			
Dalea ornata	western prairie clover			
Delphinium nuttallianum	upland larkspur			
Descurainia pinnata	western tansymustard			
Descurainia sophia	flixweed			
Dieteria canescens	hoary-aster			
Draba verna	spring Whitlow-grass			
Elaeagnus angustifolia	Russian olive			C
Eleocharis sp.	Spike-rush			
Elymus elymoides	bottlebrush squirreltail			
Elymus lanceolatus	thickspike wheatgrass			
Epilobium brachycarpum	tall annual willow-herb			
Equisetum sp.	horsetail			
Ericameria nauseosa	common rabbitbrush			
Erigeron filifolius	thread-leaf fleabane			
Eriogonum niveum	snow buckwheat			
Eriogonum vimineum	broom buckwheat			
Erodium cicutarium	redstem stork's bill			
Erysimum asperum	wallflower			
Fallopia convolvulus	climbing bindweed			
Fritillaria pudica	yellow bell			
Gaillardia aristata	blanket-flower			
Gilia sinuata	rosy gilia			
Gilia sp.	gilia			
Gratiola neglecta	common American hedge-hyssop			
Grayia spinosa	hopsage			
Greeneocharis circumscissa	matted cryptantha			
Grindelia hirsutula	hairy gumweed			
Gypsophila paniculata	baby's-breath			C
Hesperostipa comata	needle-and-thread			
Holosteum umbellatum	jagged chickweed			
Hordeum jubatum	foxtail barley			
Hymenopappus filifolius	hymenopappus			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Hypericum perforatum	common St. John's-wort			C
Iris missouriensis	Rocky Mountain iris			
Juniperus scopulorum	Rocky Mountain juniper			
Koeleria macrantha	junegrass			
Lactuca serriola	prickly lettuce			
Ladeania lanceolata	lance-leaf scurf-pea			
Lagophylla rammosissima	hareleaf			
Lamium amplexicaule	common dead-nettle			
Layia glandulosa	tidytips			
Lepidium draba	heart-podded hoarycress			C
Lepidium densiflorum	common pepperweed			
Lepidium latifolium	broadleaf pepperweed			B
Lepidium perfoliatum	clasping pepperweed			
Leymus cinereus	Great Basin wildrye			
Linanthus pungens	granite prickly-phlox			
Logfia gallica	daggerleaf cottonrose			
Lomatium macrocarpum	bigseed biscuitroot			
Malus pumila	cultivated apple			
Malva neglecta	common mallow			
Medicago sativa	alfalfa			
Melilotus officianalis	common yellow sweet-clover			
Mentzelia albicaulis	small-flowered mentzelia			
Microsteris gracilis	microsteris			
Morus alba	white mulberry			
Narcissus sp.	daffodil			
Oenothera pallida	pale evening primrose			
Onopordum acanthium	cotton-thistle			B
Opuntia polyacantha	starvation pricklypear			
Phacelia hastata	silverleaf phacelia			
Phacelia linearis	threadleaf phacelia			
Phalaris arundinacea	reed canarygrass			C
Phlox longifolia	longleaf phlox			
Plantago lanceolata	English plantain			
Plantago patigonica	Indian-wheat			
Plectritis macrocera	longhorn plectritis			
Poa bulbosa	bulbous bluegrass			
Poa pratensis	Kentucky bluegrass			
Poa secunda	Sandberg's bluegrass			
Polemonium micranthum	annual Jacob's ladder			
Prunus virginiana	chokecherry			
Pseudognaphalium stramineum	cottonbatting plant			
Pseudoroegneria spicata	bluebunch wheatgrass			
Purshia tridentata	bitterbrush			
Rhaponticum repens	hardheads (Russian knapweed)			B
Ribes aureum	golden currant			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Robinia pseudoacacia	black locust			
Rosa woodsii	rose			
Rubus bifrons	Himalayan blackberry			C
Rumex salicifolius	willow dock			
Rumex venosus	veiny dock			
Salix exigua	coyote willow			
Salsola tragus	Russian thistle			
Senecio vulgaris	common groundsel			C
Sisymbrium altissimum	tall tumblemustard			
Sisymbrium loeselii	Loesel tumblemustard			
Solidago lepida	western Canada goldenrod			
Solanum dulcamara	climbing nightshade			
Solanum triflorum	cut-leaved nightshade			
Sonchus arvensis	sow-thistle			
Sphaeralcea munroana	Munro's globemallow			
Sporobolus cryptandrus	sand dropseed			
Stephanomeria paniculata	stiff-branched wirelettuce			
Taraxacum officinale	common dandelion			
Toxicoscordion venenosum	meadow death-camas			
Tragopogon dubius	yellow salsify			
Tribulus terrestris	puncturevine			B
Triteleia grandiflora	Large-flowered triteleia			
Ulmus pumila	Siberian elm			
Ulmus americana	American elm			
Verbascum thapsus	common mullein			
Verbena bracteata	bracted verbena			
Vulpia microstachys	small fescue			
Vulpia octoflora	six-weeks fescue			
Vulpia sp.	fescue			

(a) Nomenclature according to Hitchcock, CL and A Cronquist. 2018. *Flora of the Pacific Northwest: An Illustrated Manual, 2nd Edition*. Edited by DE Giblin, BS Legler, PF Zika, and RG Olmstead. University of Washington Press, Seattle, Washington. 936pp.

(b) Noxious Weed Class: B = Prevent spread and contain or reduce existing populations; C = Weeds widespread, control methods available but not normally required.

Table A.2. Bird Species Observed on the Undeveloped Upland Portions of the PNNL Richland Campus, 2009–2018

Species Name	Common Name	State Status	Federal Status
Agelaius phoeniceus	red-winged blackbird		
Artemisiospiza nevadensis	sagebrush sparrow	Candidate	
Anas platyrhynchos	mallard		
Asio flammeus	short-eared owl		
Branta canadensis	Canada goose		
Buteo jamaicensis	red-tailed hawk		
Buteo swainsoni	Swainson's hawk		
Callipepla californica	California quail		
Carpodacus mexicanus	house finch		
Carduelis tristis	American goldfinch		
Charadrius vociferus	killdeer		
Chordeiles minor	common nighthawk		
Chondestes grammacus	lark sparrow		
Circus cyaneus	northern harrier		
Colaptes auratus	northern flicker		
Columbus livia	rock pigeon		
Corvus brachyrhynchos	American crow		
Corvus corax	common raven		
Eremophila alpestris	horned lark		
Haliaeetus leucocephalus	bald eagle		Species of Concern
Hirundo pyrrhonota	cliff swallow		
Hirundo rustica	barn swallow		
Icterus bullockii	Bullock's oriole		
Numenius americanus	long-billed curlew		
Pandion haliaetus	osprey		
Passer domesticus	house sparrow		
Phasianus colchicus	ring-necked pheasant		
Pica pica	black-billed magpie		
Riparia riparia	bank swallow		
Sturnella neglecta	western meadowlark		
Sturnus vulgaris	European starling		
Tachycineta thalassina	violet-green swallow		
Turdus migratorius	American robin		
Tyrannus verticalis	western kingbird		
Zenaida macroura	mourning dove		
Zonotrichia leucophrys	white-crowned sparrow		

Table A.3. Mammal Species Observed on the Undeveloped Upland Portions of the PNNL Richland Campus, 2009–2018

Species Name	Common Name	State Status	Federal Status
Canis latrans	coyote		
Castor canadensis	beaver		
Erithizon dorsatum	porcupine		
Lepus californicus	black-tailed jackrabbit	Candidate	
Odocoileus hemionus	mule deer		
Perognathus parvus	Great Basin pocket mouse		
Sylvilagus nutalli	mountain cottontail		
Taxidea taxus	badger		
Thomomys talpoides	northern pocket gopher		

Table A.4. Plant Species Observed in the Riparian Area of the PNNL Richland Campus in 2015 and 2017–2018

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Achillea millefolium	common yarrow			
Achnatherum hymenoides	Indian ricegrass			
Agropyron cristatum	crested wheatgrass			
Ailanthus altissima	tree-of-heaven			C
Allium schoenoprasum	chives			
Ambrosia acanthicarpa	bur ragweed			
Amsinckia lycopsoides	tarweed fiddleneck			
Apocynum cannabinum	clasping-leaved dogbane			
Artemisia campestris	Pacific sagewort			
Artemisia dracunculus	tarragon			
Artemisia ludoviciana	prairie sage			
Artemisia tridentata	big sagebrush			
Asclepias speciosa	showy milkweed			
Asparagus officinalis	garden asparagus			
Bromus tectorum	cheatgrass			
Centaurea diffusa	diffuse knapweed			B
Chamaesyce serpyllifolia	thymeleaf sandmat			
Chondrilla juncea	skeletonweed			B
Chrysothamnus viscidiflorus	green rabbitbrush			
Cirsium arvense	creeping thistle			C
Clematis ligusticifolia	western clematis			
Convolvulus arvensis	bind weed			C
Conyza canadensis	Canadian horseweed			
Coreopsis tinctoria	Columbia coreopsis			
Descurainia pinnata	western tnasymustard			
Descurainia sophia	flixweed			
Dieteria canescens	hoary-aster			
Eleocharis palustris	common spike-rush			
Elymus lanceolatus	thickspike wheatgrass			
Equisetum sp.	horsetail			
Ericameria nauseosa	rubber rabbitbrush			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Eriogonum niveum	snow buckwheat			
Eriogonum sp.	buckwheat			
Euphorbia glyptosperma	ribseed sandmat			
Gaillardia aristata	blanket-flower			
Galium sp.	bedstraw			
Hesperostipa comata	needle-and-thread			
Holosteum umbellatum	jagged chickweed			
Hypericum perforatum	common St. John's-wort			C
Iris missouriensis	Rocky Mountain iris			
Lactuca serriola	prickly lettuce			
Ladeania lanceolata	lance-leaf scurf-pea			
Lepidium densiflorum	common pepperweed			
Lepidium draba	heart-podded hoarycress			C
Lepidium perfoliatum	clasping pepperweed			
Leymus cinereus	Great Basin wildrye			
Logfia gallica	daggerleaf cottonrose			
Acmispon americanus	Spanish-clover			
Lupinus sericeus	silky lupine			
Medicago sativa	alfalfa			
Melilotus officinalis	common yellow sweet-clover			
Mentha piperita	peppermint			
Morus alba	white mulberry			
Oenothera pallida	pale evening primrose			
Parthenocissus vitacea	Virginia creeper			
Phalaris arundinacea	reed canarygrass			C
Plantago lanceolata	English plantain			
Plantago patigonica	Indian-wheat			
Poa bulbosa	bulbous bluegrass			
Poa compressa	Canada bluegrass			
Poa secunda	Sandberg's bluegrass			
Prunus virginiana	chokecherry			
Purshia tridentata	Antelope-brush			
Rhaponticum repens	hardheads (Russian knapweed)			B
Rhus glabra	smooth sumac			
Ribes aureum	golden currant			
Robinia pseudoacacia	black locust			
Rosa woodsii	rose			
Rubus bifrons	Himalayan blackberry			C
Rumex crispus	curly dock			
Rumex patienta	patience dock			
Rumex salicifolius	willow dock			
Rumex venosus	veiny dock			
Salix exigua	coyote willow			
Salsola tragus	Russian thistle			
Sisymbrium altissimum	tall tumblemustard			
Solidago lepida	western Canada goldenrod			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Solanum dulcamara	climbing nightshade			
Sphaeralcea munroana	Munro's globemallow			
Sporobolus cryptandrus	sand dropseed			
Stephanomeria paniculata	stiff-branched wirelettuce			
Taraxacum officinale	common dandelion			
Tragopogon dubius	yellow salsify			
Ulmus americana	American elm			
Verbascum thapsus	common mullein			
Vicia cracca	bird vetch			
Xanthium strumarium	common cocklbur			

(a) Nomenclature according to Hitchcock, CL and A Cronquist. 2018. *Flora of the Pacific Northwest: An Illustrated Manual, 2nd Edition*. Edited by DE Giblin, BS Legler, PF Zika, and RG Olmstead. University of Washington Press, Seattle, Washington. 936pp.

(b) Noxious Weed Class B = Prevent spread and contain or reduce existing populations; Noxious Weed Class C = Weeds widespread, control methods available but not normally required.

Table A.5. Bird Species Observed in the Riparian Area of the PNNL Richland Campus in 2015 and 2017–2018

Species Name	Common Name	State Status	Federal Status
Actitis macularius	spotted sandpiper		
Agelaius phoeniceus	red-winged blackbird		
Anas platyrhynchos	mallard		
Ardea herodias	great blue heron		
Branta canadensis	Canada goose		
Bubo virginianus	great-horned owl		
Calidris bairdii	Baird's sandpiper		
Calidris mauri	western sandpiper		
Callipepla californica	California quail		
Ardea alba	great egret		
Columba livia	rock pigeon		
Corvus corax	common raven		
Icterus bullockii	Bullock's oriole		
Larus californicus	California gull		
Megaceryle alcyon	belted kingfisher		
Melospiza lincolnii	Lincoln's sparrow		
Melospiza melodia	song sparrow		
Mergus merganser	common merganser		
Nycticorax nycticorax	black-crowned night heron		
Pandion halaetus	osprey		
Pelecanus erythrorhynchos	American white pelican	Threatened	
Phalacrocorax auritus	double-crested cormorant		
Pica pica	black-billed magpie		
Riparia riparia	bank swallow		
Sturnus vulgaris	European starling		
Tyrannus tyrannus	eastern kingbird		
Tyrannus verticalis	western kingbird		
Turdus migratorius	American robin		
Zenaida macroura	mourning dove		

Table A.6. Mammal Species Observed in the Riparian Area of the PNNL Richland Campus in 2015 and 2017–2018

Species Name	Common Name	State Status	Federal Status
Canis latrans	coyote		
Castor canadensis	American beaver		
Erithizon dorsatum	porcupine		
Odocoileus hemionus	mule deer		
Sciurus niger	eastern fox squirrel		

APPENDIX B

PLANT AND ANIMAL SPECIES OBSERVED DURING ANNUAL SURVEYS ON AND IN THE VICINITY OF THE PNNL MARINE SCIENCES LABORATORY LANDS

APPENDIX B

PLANT AND ANIMAL SPECIES OBSERVED DURING ANNUAL SURVEYS ON AND IN THE VICINITY OF THE PNNL MARINE SCIENCES LABORATORY LANDS

Table B.1. Plant Species Observed on PNNL Marine Sciences Laboratory Lands, 2013–2015

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Abies grandis	grand fir			
Abronia latifolia	yellow sand verbena			
Acer circinatum	vine maple			
Acer glabrum	Rocky Mountain maple			
Acer macrophyllum	bigleaf maple			
Achillea millefolium	common yarrow			
Alnus rubra	red alder			
Ambrosia chamissonis	silver bursage			
Amelanchier alnifolia	Saskatoon serviceberry			
Arbutus menziesii	madrone			
Arctostaphylos uva-ursi	kinnikinnick			
Artemisia suksdorfii	Suksdorf's sagebrush			
Avena sp.	oat			
Bellis perennis	daisy			
Struthiopteris spicant	hard fern			
Brassica rapa	field mustard			
Cakile edentula	American searocket			
Carex sp.	sedge			
Castilleja hispida	harsh Indian-paintbrush			
Centaurea cyanus	bachelor's button			M
Cerastium spp.	mouse-ear chickweed			
Chamaenerion angustifolium	fireweed			
Chenopodium album	white goosefoot			
Cirsium arvense	creeping thistle			C
Claytonia perfoliata	miner's lettuce			
Conium maculatum	Poison-hemlock			B
Cornus occidentalis	creek dogwood			
Corylus cornuta var. *californica*	beaked hazelnut			
Crataegus monogyna	1-seed hawthorn			C
Cytisus scoparius	Scot's broom			B
Dactylis glomerata	Orchard-grass			
Dipsacus sylvestris	teasel			C
Distichlis spicata	saltgrass			
Draba verna	Whitlow-grass			
Elymus glaucus	blue wildrye			
Equisetum hyemale	common scouring-rush			
Erodium cicutarium	redstem stork's bill			
Eschscholzia californica	poppy			
Fragaria virginiana	mountain strawberry			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Fritillaria affinis	checker lily			
Galium aparine	stickywilly			
Gaultheria shallon	salal			
Geranium molle	dovefoot geranium			
Grindelia integrifolia	Puget Sound gumweed			
Heracleum maximum	common cow-parsnip			
Holodiscus discolor	oceanspray			
Hypochaeris radicata	hairy cat's ear			C
Ilex aquifolium	holly			M
Juncus sp.	rush			
Lathyrus japonicus	sea peavine			
Lathyrus polyphyllus	leafy peavine			
Leucanthemum vulgare	Oxeye-daisy			C
Lomatium nudicaule	barestemmed biscuitroot			
Lonicera ciliosa	orange honeysuckle			
Lysichiton americanus	skunk cabbage			
Berberis aquifolium	shining Oregon-grape			
Berberis nervosa	dull Oregon-grape			
Maianthemum dilatatum	false lily-of-the-valley			
Maianthemum racemosum ssp. *amplexicaule*	large false Solomon's seal			
Medicago lupulina	black medick			
Erythranthe guttata	seep monkeyflower			
Mycelis muralis	mycelis			
Myosotis sp.	forget-me-not			
Oemleria cerasiformis	Indian plum			
Osmorhiza berteroi	sweet-cicely			
Petasites frigidus	sweet coltsfoot			
Physocarpus capitatus	Pacific ninebark			
Plantago lanceolata	English plantain			
Plantago major	common plantain			
Plantago maritima	sea tongue			
Plectritis congesta	sea blush			
Polystichum munitum	western swordfern			
Populus trichocarpa	black cottonwood			
Potentilla anserina	cinquefoil			
Pseudotsuga menziesii	Douglas fir			
Pteridium aquilinum	bracken fern			
Ranunculus repens	creeping buttercup			
Ranunculus uncinatus	little buttercup			
Ribes sanguineum	redflower currant			
Rosa gymnocarpa	little wild rose			
Rosa nutkana	Nootka rose			
Rubus bifrons	Himalayan blackberry			C
Rubus leucodermis	blackcap			
Rubus nutkanus	thimbleberry			
Rubus ursinus	Pacific blackberry			
Rumex acetosella	sheep sorrel			
Rumex crispus	curly dock			
Rumex occidentalis	western dock			
Salicornia depressa	low glasswort			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Salix spp.	willow			
Sambucus racemosa	red elderberry			
Senecio sylvaticus	wood groundsel			
Spiraea douglasii	spirea			
Symphoricarpos albus	common snowberry			
Taraxacum officinale	common dandelion			
Tellima grandiflora	fringecup			
Thuja plicata	western red cedar			
Tolmiea menziesii	Youth-on-age			
Trifolium latifolium	twin clover			
Trifolium pratense	red clover			
Trifolium repens	white clover			
Triglochin maritima	seaside arrow-grass			
Tsuga heterophylla	western hemlock			
Urtica dioica	stinging nettle			
Vicia americana	American vetch			
Vicia nigricans	giant vetch			
Vicia sativa	common vetch			

(a) Nomenclature according to Hitchcock, CL and A Cronquist. 2018. *Flora of the Pacific Northwest: An Illustrated Manual, 2nd Edition*. Edited by DE Giblin, BS Legler, PF Zika, and RG Olmstead. University of Washington Press, Seattle, Washington. 936pp.

(b) Noxious Weed Class: B = Prevent spread and contain or reduce existing populations; C = Weeds widespread, control methods available but not normally required; M = Monitor list.

Table B.2. Bird Species Observed on and in the Vicinity of the PNNL Marine Sciences Laboratory Lands, 2013–2017

Species Name	Common Name	State Status	Federal Status
Accipiter cooperii	Cooper's hawk		
Agelaius phoeniceus	red-winged blackbird		
Anas platyrhynchos	mallard		
Anthus rubescens	American pipit		
Ardea herodias	great blue heron		
Branta canadensis	Canada goose		
Bubo virginianus	great-horned owl		
Bucephala albeola	bufflehead		
Bucephala clangula	common goldeneye		
Buteo jamaicensis	red-tailed hawk		
Callipepla californica	California quail		
Calypte anna	Anna's hummingbird		
Cardellina pusilla	Wilson's warbler		
Carduelis tristis	American goldfinch		
Carpodacus mexicanus	house finch		
Cathartes aura	turkey vulture		
Catharus ustulatus	Swainson's thrush		
Charadrius vociferus	killdeer		
Cepphus columba	pigeon guillemot		
Cerorhinca monocerata	rhinoceros auklet		
Certhia americana	brown creeper		
Chamaea fasciata	wrentit		

Species Name	Common Name	State Status	Federal Status
Circus cyaneus	northern harrier		
Cistothorus palustris	marsh wren		
Coccothraustes vespertinus	evening grosbeak		
Colaptes auratus	northern flicker		
Columba livia	rock dove (pigeon)		
Corvus brachyrhynchos	American crow		
Corvus corax	common raven		
Cyanocitta stelleri	Steller's jay		
Dendroica townsendii	Townsend's warbler		
Empidonax alnorum	willow flycatcher		
Empidonax difficilis	Pacific-slope flycatcher		
Empidonax hammondii	Hammond's flycatcher		
Euphagus cyanocephalus	Brewer's blackbird		
Falco peregrinus	peregrine falcon		Species of Concern
Haliaeetus leucocephalus	bald eagle		Species of Concern
Hirundo rustica	barn swallow		
Histrionicus histrionicus	harlequin duck		
Junco hyemalis	dark-eyed junco		
Larus glaucescens	glaucus-winged gull		
Larus glaucescens x L. occidentalis	Olympic gull		
Larus occidentalis	western gull		
Larus spp.	gull		
Megaceryle alcyon	belted kingfisher		
Melanitta perspicillata	surf scoter		
Melospiza melodia	song sparrow		
Mergus serrator	red-breasted merganser		
Molothrus ater	brown-headed cowbird		
Oreothlypis celata	orange-crowned warbler		
Parus atricapillus	black-capped chickadee		
Parus gambeli	mountain chickadee		
Parus rufescens	chestnut-backed chickadee		
Passerculus sandwichensis	savannah sparrow		
Passerella iliaca	fox sparrow		
Patagioenas fasciata	band-tailed pigeon		
Petrochelidon pyrrhonota	cliff swallow		
Phalacrocorax auritus	double-crested cormorant		
Phalacrocorax pelagicus	pelagic cormorant		
Phalacrocorax penicillatus	Brant's cormorant		
Pheucticus melanocephalus	black-headed grosbeak		
Picoides pubescens	downy woodpecker		
Picoides villosus	hairy woodpecker		
Pipilo maculatus	spotted towhee		
Piranga ludoviciana	western tanager		
Podilymbus podiceps	pied-billed grebe		
Poecile atricapillus	black-capped chickadee		
Poecile rufescens	chestnut-backed chickadee		
Psaltriparus minimus	bushtit		
Regulus calendula	ruby-crowned kinglet		
Regulus satrapa	golden-crowned kinglet		
Selasphorus rufus	rufous hummingbird		

Species Name	Common Name	State Status	Federal Status
Setophaga coronata	yellow-rumped warbler		
Sitta canadensis	red-breasted nuthatch		
Sphyrapicus ruber	red-breasted sapsucker		
Spinus tristis	American goldfinch		
Stelgidopteryx serripennis	northern rough-winged swallow		
Sterna caspia	Caspian tern		
Strix varia	barred owl		
Sturnus vulgaris	European starling		
Tachycineta bicolor	tree swallow		
Tachycineta thalassina	violet-green swallow		
Thryomanes bewickii	Bewick's wren		
Troglodytes pacificus	Pacific wren		
Turdus migratorius	American robin		
Zenaida macroura	mourning dove		
Zonotrichia leucophrys	white-crowned sparrow		

Table B.3. Other Vertebrate Species Observed on PNNL Marine Sciences Laboratory Lands, 2013–2015

Species Name	Common Name	State Status	Federal Status
Anaxyrus boreas	western toad		
Canis latrans	coyote		
Odocoileus hemionus	black-tailed deer		
Rana aurora	northern red-legged frog		
Sorex sp.	shrew		
Tamiasciurus douglasii	Douglas squirrel		
Taricha granulosa	rough-skinned newt		

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APPENDIX C

HELPFUL INFORMATION

APPENDIX C

HELPFUL INFORMATION

The following information is provided to assist readers in understanding this report. Included here is information about scientific notation, units of measurement, radioactivity units, radiological dose units, chemical and elemental nomenclature, and greater than or less than symbols. Definitions of technical terms can be found in Appendix D.

C.1 Scientific Notation

Scientific notation is used to express very large or very small numbers. For example, the number 1 billion can be written as 1,000,000,000 or, by using scientific or E notation, written as 1×10^9 or 1.0E+09. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from its current location. If the value given is 2.0×10^3 (or 2.0E+03), the decimal point should be moved three places to the right, so that the number would then read 2,000. If the value given is 2.0×10^{-5} (or 2.0E-05), the decimal point should be moved five places to the left, so that the result would be 0.00002.

C.2 Units of Measurement

The primary units of measurement used in this report follow the International System of Units and are metric, but U.S. standard measurements are also provided. Table C.1 summarizes and defines the terms and corresponding symbols (metric and non-metric). A conversion table is provided in Table C.2.

C.3 Radioactivity Units

Much of this report deals with levels of radioactivity in various environmental media. Radioactivity in this report is usually discussed in units of curies (Ci), with conversions to becquerels (Bq), the International System of Units measure (Table C.3). The curie is the basic unit used to describe the amount of activity present, and activities are generally expressed in terms of curies per mass or volume (e.g., picocuries per liter). One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. One becquerel is equivalent to one disintegration per second. Nuclear disintegrations produce spontaneous emissions of alpha or beta particles, gamma radiation, or combinations of these. Figure C.1 includes selected conversions from curies to becquerels.

Table C.1. Names and Symbols for Units of Measure

Symbol	Name	Symbol	Name
Temperature		**Concentration**	
°C	degree Celsius	ppb	parts per billion
°F	degree Fahrenheit	ppm	parts per million
Time		ppmv	parts per million by volume
d	day	**Length**	
hr	hour	cm	centimeter (1×10^{-2} m)
min	minute	ft	foot
sec	second	in.	inch
yr	year	km	kilometer (1×10^{3} m)
Rate		m	meter
cfs (or ft^3/sec)	cubic feet per second	mi	mile
cpm	counts per minute	mm	millimeter (1×10^{-3} m)
gpm	gallon per minute	µm	micrometer (1×10^{-6} m)
mph	mile per hour	**Area**	
mR/hr	milliroentgen per hour	ha	hectare (1×10^{4} m^2)
mrem/yr	millirem per year	km^2	square kilometer
Volume		mi^2	square mile
cm^3	cubic centimeter	ft^2	square foot
ft^3	cubic foot	**Mass**	
gal	gallon	g	gram
L	liter	kg	kilogram (1×10^{3} g)
m^3	cubic meter	mg	milligram (1×10^{-3} g)
mL	milliliter (1×10^{-3} L)	µg	microgram (1×10^{-6} g)
yd^3	cubic yard	lb	pound

Table C.2. Conversion Table

Multiply	By	To Obtain	Multiply	By	To Obtain
cm	0.394	in.	in.	2.54	cm
m	3.28	ft	ft	0.305	m
km	0.621	mi	mi	1.61	km
kg	2.205	lb	lb	0.454	kg
L	0.2642	gal	gal	3.785	L
m^2	10.76	ft^2	ft^2	0.093	m^2
ha	2.47	acres	acre	0.405	ha
km^2	0.386	mi^2	mi^2	2.59	km^2
m^3	35.31	ft^3	ft^3	0.0283	m^3
m^3	1.308	yd^3	yd^3	0.7646	m^3
pCi	1,000	nCi	nCi	0.001	pCi
µCi/mL	10^9	pCi/L	pCi/L	10^{-9}	µCi/mL
Ci/m^3	10^{12}	pCi/m^3	pCi/m^3	10^{-12}	Ci/m^3
mCi/cm^3	10^{15}	pCi/m^3	pCi/m^3	10^{-15}	mCi/cm^3
nCi/m^2	1.0	mCi/km^2	mCi/km^2	1.0	nCi/m^2
Ci	3.7×10^{10}	Bq	Bq	2.7×10^{-11}	Ci
pCi	0.037	Bq	Bq	27	pCi
rad	0.01	Gy	Gy	100	rad
rem	0.01	Sv	Sv	100	rem
ppm	1,000	ppb	ppb	0.001	ppm
°C	(°C × 9/5) + 32	°F	°F	(°F -32) ÷ 9/5	°C
oz	28.349	g	g	0.035	oz
ton	0.9078	tonne	tonne	1.1	ton

Table C.3. Names and Symbols for Units of Radioactivity

Symbol	Name	Symbol	Name
Ci	curie	Bq	becquerel
mCi	millicurie (1×10^{-3} Ci)	kBq	kilobecquerel (1×10^3 Bq)
µCi	microcurie (1×10^{-6} Ci)	mBq	millibecquerel (1×10^{-3} Bq)
nCi	nanocurie (1×10^{-9} Ci)	MBq	megabecquerel (1×10^6 Bq)
pCi	picocurie (1×10^{-12} Ci)	GBq	gigabecquerel (1×10^9 Bq)
fCi	femtocurie (1×10^{-15} Ci)	TBq	terabecquerel (1×10^{12} Bq)
aCi	attocurie (1×10^{-18} Ci)		

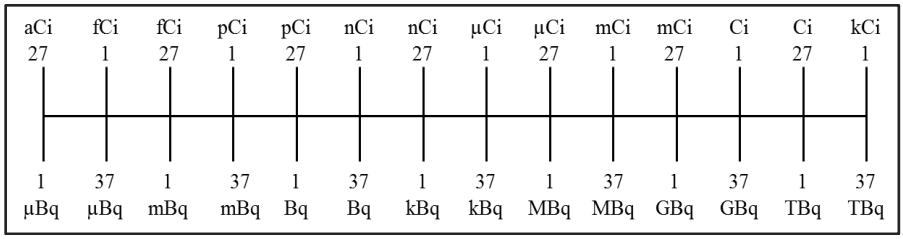

Figure C.1. Conversions for Radioactivity Units

C.4 Radiological Dose Units

Radiological dose in this report is usually written in terms of effective dose equivalent (EDE) and reported numerically in units of millirem (mrem), with the metric units millisievert (mSv) or microsievert (µSv) following in parentheses or footnoted. The EDE and effective dose (ED) units can be considered equivalent for the purposes of this report and reflect the units calculated by the software used.

Millirem (millisievert) is a unit of measurement that relates a given amount of absorbed radiation energy to its biological effectiveness or risk (to humans). For perspective, a dose of 0.01 mrem (1 mSv) would have a biological effect roughly the same as that received from 1 day's exposure to natural background radiation. An acute (short-term) dose to the whole body of 100 rem (1 Sv) would likely cause temporary radiation sickness in some exposed individuals. An acute dose of over 500 rem (5 Sv) would soon result in death in approximately 50% of those exposed. Exposure to lower amounts of radiation (10 mrem [100 µSv] or less) produces no immediate observable effects, but long-term (delayed) effects are possible. The average person in the United States receives an annual dose from exposure to naturally produced radiation of approximately 300 mrem (3 mSv). Medical and dental x-rays and air travel add to this total. Figure C.2 includes selected conversions from rem to sievert.

Also used in this report is the term rad, with the corresponding International System of Units, gray (Gy), in parentheses or footnoted. The rad (gray) is a measure of the energy absorbed by any material, whereas a rem relates to both the amount of radiation energy absorbed by humans and its consequence. The gray can be converted to rad by multiplying by 100. The conversions in Figure C.2 can also be used to convert grays to rads.

The names and symbols for units of radiation dose used in this report are listed in Table C.4.

Additional information about radiation and dose terminology can be found in APPENDIX D. A list of the radionuclides discussed in this report, their symbols, and their half-lives are included in Table C.5.

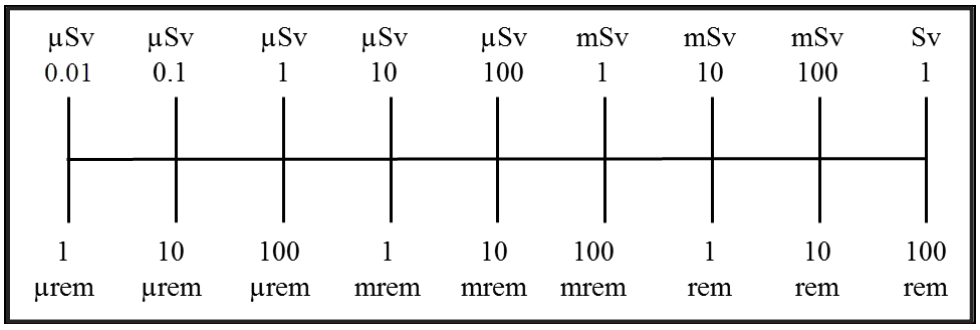

Figure C.2. Conversions for Radiological Dose Units

Table C.4. Names and Symbols for Units of Radiation Dose or Exposure

Symbol	Name
mrad	millirad (1×10^{-3} rad)
mrem	millirem (1×10^{-3} rem)
µrem	microrem (1×10^{-6} rem)
Sv	sievert (100 rem)
mSv	millisievert (1×10^{-3} Sv)
µSv	microsievert (1×10^{-6} Sv)
Gy	gray (100 rad)
mGy	milligray (1×10^{-3} Gy)

Table C.5. Radionuclides and Their Half-Lives[a]

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
^{3}H	tritium	12.35 yr	^{140}Ba	barium-140	12.75 d
^{7}Be	beryllium-7	53.3 d	^{152}Eu	europium-152	13.33 yr
^{14}C	carbon-14	5,730 yr	^{154}Eu	europium-154	8.8 yr
^{24}Na	sodium-24	14.96 h	^{155}Eu	europium-155	4.96 yr
^{40}K	potassium-40	1.28×10^{9} yr	^{177}Lu	lutetium-177	6.65 d
^{37}Ar	argon-37	35.01 d	^{208}Po	polonium-208	2.90 yr
^{39}Ar	argon-39	269 yr	^{210}Pb	lead-210	22.3 yr
^{51}Cr	chromium-51	27.70 d	^{212}Pb	lead-212	10.64 h
^{54}Mn	manganese-54	312.5 d	^{220}Rn	radon-220	55.6 sec
^{55}Fe	iron-55	2.7 yr	^{222}Rn	radon-222	3.82 d
^{59}Fe	iron-59	44.53 d	^{226}Ra	radium-226	1600 yr
^{59}Ni	nickel-59	7.5×10^{4} yr	^{228}Ra	radium-228	5.75 yr
^{57}Co	cobalt-57	272 d	^{228}Th	thorium-228	1.91 yr
^{60}Co	cobalt-60	5.27 yr	^{229}Th	thorium-229	7340 yr
^{63}Ni	nickel-63	96 yr	^{230}Th	thorium-230	7.54×10^{4} yr
^{65}Zn	zinc-65	243.9 d	^{232}Th	thorium-232	1.41×10^{10} yr
^{82}Br	bromine-82	35.3 h	U or uranium	natural uranium	~4.5×10^{9}[b]
^{85}Kr	krypton-85	10.72 yr	^{233}U	uranium-233	1.59×10^{5} yr
^{89}Sr	strontium-89	50.53 d	^{234}U	uranium-234	2.45×10^{5} yr
^{90}Sr	strontium-90	29.12 yr	^{235}U	uranium-235	7.04×10^{8} yr
^{88}Y	yttrium-88	106.7 d	^{238}U	uranium-238	4.47×10^{9} yr
^{90}Y	yttrium-90	64.0 h	^{236}Np	neptunium-236	1.54×10^{5} yr
^{95}Zr	zirconium-95	63.98 d	^{237}Np	neptunium-237	2.14×10^{6} yr
^{99}Tc	technetium-99	2.13×10^{5} yr	^{238}Pu	plutonium-238	87.74 yr
^{103}Ru	ruthenium-103	39.28 d	^{239}Pu	plutonium-239	2.41×10^{4} yr
^{106}Ru	ruthenium-106	368.2 d	^{240}Pu	plutonium-240	6.54×10^{3} yr
^{109}Cd	cadmium-109	462.6 d	^{241}Pu	plutonium-241	14.4 yr
^{113}Sn	tin-113	115.1 d	^{242}Pu	plutonium-242	3.76×10^{5} yr
^{125}Sb	antimony-125	2.77 yr	^{244}Pu	plutonium-244	8.0×10^{7} yr
^{129}I	iodine-129	1.57×10^{7} yr	^{241}Am	americium-241	432.2 yr
^{131}I	iodine-131	8.04 d	^{243}Am	americium-243	7,380 yr
^{132}I	iodine-132	2.30 h	^{243}Cm	curium-243	28.5 yr
^{133}Xe	xenon-133	5.24 d	^{244}Cm	curium-244	18.11 yr
^{134}Cs	cesium-134	2.06 yr	^{245}Cm	curium-245	8,500 yr
^{137}Cs	cesium-137	30.0 yr	^{250}Cf	californium-250	13.08 yr
^{137m}Ba	barium-137m	2.55 min	^{252}Cf	californium-252	2.645 yr

(a) From EPA 402-R-99-001 (EPA 1999) and Table of Nuclides at http://atom.kaeri.re.kr/nuchart/.
(b) Natural uranium is a mixture dominated by uranium-238.

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APPENDIX D

GLOSSARY

APPENDIX D

GLOSSARY

This glossary contains selected words and phrases used in this report that may not be familiar to readers. Words appearing in *italic* type within a definition are also defined in this glossary.

alpha particle – A positively charged particle composed of two protons and two neutrons ejected spontaneously from the nuclei of some *radionuclides* during radioactive decay. It has a low penetrating power and short range. The most energetic alpha particle will generally fail to penetrate the skin, but is hazardous when introduced into the body.

aquifer – Underground sediment or rock that stores and/or transmits water.

background radiation – *Radiation* in the natural environment, including cosmic rays from space and *radiation* from naturally occurring radioactive elements in the air, in the earth, and in human bodies. It also includes *radiation* from global fallout from historical atmospheric nuclear weapons testing. In the United States, the average person receives approximately 300 *millirem* of background radiation per year.

Battelle Land–Sequim – Battelle privately owned land and supporting infrastructure (pump houses, access roads, parking lots, docks, etc.) located near Sequim, Washington, and associated with the PNNL Marine Sciences Laboratory area.

becquerel (Bq) – Unit of activity or amount of a radioactive substance (also *radioactivity*) equal to one nuclear transformation per second (1 Bq = 1 disintegration per second). Another unit of *radioactivity*, the *curie*, is related to the becquerel: $1\ Ci = 3.7 \times 10^{10}\ Bq$.

beta particle – A negatively charged particle (essentially an electron) released from a nucleus during radioactive *decay*. At high enough intensities, some beta particles may cause skin burns and may be harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal or plastic.

Categorical Exclusion – A class of actions that DOE has determined are not likely to have significant environmental impacts under normal circumstances, and for which an environmental assessment or environmental impact statement is not normally needed. These are listed at 10 CFR Part 1021 Appendix D.

collective dose – Sum of the total *effective dose equivalent* for individuals composing a defined population. Collective dose units are *person-rem* or person-sievert.

composite sample – Sample formed by combining discrete samples taken at different times or from different locations.

confined aquifer – An *aquifer* bounded above and below by less permeable layers. *Groundwater* in the confined aquifer is under a pressure greater than atmospheric pressure.

curie (Ci) – A unit of *radioactivity* equal to 37 billion (3.7×10^{10}) nuclear transformations per second (*becquerels*).

decay – The decrease in the amount of any radioactive material (disintegration) with the passage of time. See *radioactivity*.

decay product – The atomic nucleus or nuclei that are left after radioactive transformation of a radioactive material. Decay products may be radioactive or nonradioactive (stable). They are informally referred to as daughter products or progeny. See *radioactivity*.

dispersion – Process whereby *effluents* or *emissions* are spread or mixed when they are transported by *groundwater*, surface water, or air.

dose rate – The rate at which a dose is delivered over time (e.g., *millirem* per hour [mrem/h]).

effective dose equivalent (EDE) – Dose unit qualifier to indicate wholebody risk from ionizing radiation exposure. Calculated as the sum of critical human-tissue doses weighted for total health risk. Total health risk includes the risk of fatal and non-fatal cancers, severe hereditary effects, and lifespan.

effluent – Liquid material released from a facility.

effluent monitoring – Sampling or measuring specific liquid *effluent* streams for the presence of pollutants.

emission – Gaseous stream released from a facility.

exposure – The interaction of an organism with a physical agent (e.g., *radiation*) or a chemical agent (e.g., arsenic) of interest. Also used as a term for quantifying x- and *gamma-radiation* fields.

fission – The splitting or breaking apart of a nucleus into at least two other nuclei, accompanied by the release of a relatively large amount of energy.

gamma radiation – High-energy electromagnetic *radiation* (photons) originating in the nucleus of decaying *radionuclides*. Gamma radiation is substantially more penetrating than *alpha* or *beta emissions*, but comparatively the energy is not as readily absorbed.

grab sample – A short-duration sample (e.g., air, water, and soil) that is grabbed from the collection site.

gray (Gy) – Unit of absorbed dose in the International System of Units equal to the absorption of 1 joule per kilogram. The common unit of absorbed dose, the *rad*, is equal to 0.01 Gy.

groundwater – Subsurface water that is in the pores of sand and gravel or in the cracks of fractured rock.

high-level waste – Highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid material derived from such liquid waste that contains *fission* products and other *radioisotopes* in sufficient concentrations to require permanent isolation.

isotopes – *Nuclides* of the same chemical element with the same number of protons but a different number of neutrons.

low-level waste – Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, *transuranic waste*, byproduct material, or naturally occurring radioactive material.

maximum exposed individual – A hypothetical member of the public residing near the PNNL Richland Campus or MSL who, by virtue of location and living habits, would reasonably receive the highest possible *radiation* dose from radioactive materials originating from the site.

method reporting limit – The lowest amount of analyte in a sample that can be quantitatively determined with the stated acceptable precision and accuracy under controlled laboratory conditions.

millirem – A unit of *radiation dose* that is equal to one one-thousandth (1/1000) of a *rem*.

minimum detectable activity – The smallest amount or concentration of a chemical or radioactive material that can be reliably detected in a sample.

mitigation – Prevention or reduction of expected *risks* to workers, the public, or the environment.

mixed waste – A U.S. Environmental Protection Agency or state-designated dangerous, extremely hazardous, or acutely hazardous waste that contains both a nonradioactive hazardous component and a radioactive component.

monitoring – As defined in DOE Order 458.1, Admin Chg 3, the collection and analysis of samples or measurements of liquid *effluent* and gaseous *emissions* for purposes of characterizing and quantifying contaminants, assessing *radiation exposure* to the public, and demonstrating compliance with regulatory standards.

nuclide – A particular combination of neutrons and protons. A *radionuclide* is a radioactive nuclide.

operable unit – A discrete area for which an incremental step can be taken toward comprehensively addressing site problems. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site.

outfall – End of a drain or pipe that carries wastewater or other *effluent* into a ditch, pond, or river.

person-rem or **person-sievert (person-Sv)** – Unit of *collective dose*. 1 person-Sv = 100 person-rem.

plutonium – A heavy, radioactive, metallic element of several possible *isotopes*. One important *isotope* is plutonium-239, which is produced after a specific neutron reaction with uranium-238. Routine analysis cannot distinguish between the plutonium-239 and plutonium-240 *isotopes*; hence, the term plutonium-239/240 is used in this report to indicate the presence of one or both of these *isotopes* in the analytical results.

PNNL Richland Campus – Includes a mix of federal and private land and facility ownership.

PNNL Marine Sciences Laboratory – Referred to as MSL, it consists of DOE-contracted elements on *Battelle Land–Sequim*.

quality assurance – Actions that provide confidence that an item or process meets or exceeds a user's requirements and expectations.

quality control – All actions necessary to control and verify that the features and characteristics of a material, process, product, or service meet specified requirements. Quality control is an element of *quality assurance*.

rad – The unit of absorbed dose. 1 rad = 0.01 gray (Gy).

radiation – The energy emitted in the form of photons or energetic *alpha* and *beta particles* subsequent to radioactive decay. For this report, radiation refers to ionizing types of radiation; not radiowaves, microwaves, radiant light, or other types of non-ionizing radiation.

radioactivity – Property possessed by *radioisotopes* emitting *radiation* (such as *alpha* or *beta particles*, or high-energy photons) spontaneously in their *decay* process; also, the *radiation* emitted.

radionuclide – An atom that has a particular number of protons (Z), a particular number of neutrons (A), and a particular atomic weight (N = Z + A) that happens to emit *radiation*. Carbon-14 is a radionuclide but carbon-12, which is not radioactive, is referred to simply as a *nuclide*.

rem – The unit of *effective dose equivalent*. 1 rem = 0.01 sievert (Sv).

remediation – Reduction (or cleanup) of known *risks* to the public and environment to an agreed-upon level.

risk – The probability that a detrimental health effect will occur.

shrub-steppe – A drought-resistant shrub and grassland ecosystem.

sievert (Sv) – The unit of *effective dose equivalent* and its variants in the International System of Units.

The common unit for *effective dose equivalent* and its variants, the *rem*, is equal to 0.01 Sv.

surveillance – As defined in DOE Order 458.1, Admin Chg 3, the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media, and the measurement of external radiation for purposes of demonstrating compliance with applicable standards, assessing exposures to the public, and assessing effects, if any, on the local environment.

transuranic element – An element with an atomic number greater than 92 (92 is the atomic number of uranium).

transuranic waste – Waste containing more than 100 nanocuries (10^{-9} *curies*) per gram of alpha-emitting transuranic isotopes that have half-lives longer than 20 years.

tritium – The heaviest radioactive isotope of hydrogen (hydrogen-3); it has a 12.3-year half-life.

unconfined aquifer – An *aquifer* containing groundwater that is not confined above by relatively impermeable rocks. The pressure at the top of the unconfined aquifer is equal to that of the atmosphere. At the Hanford Site, the unconfined aquifer is the uppermost aquifer and is most susceptible to contamination from site operations.

vadose zone – Underground area from the ground surface to the top of the *water table* or *aquifer*.

volatile organic compounds – Lightweight organic compounds that vaporize easily; they are used in solvents and degreasing compounds as raw materials.

water table – The top of the *unconfined aquifer*.

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