PNNL-25738

Pacific Northwest NATIONAL LABORATORY

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Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2015

September 2016

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U.S. DEPARTMENT OF ENERGY

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

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PACIFIC NORTHWEST NATIONAL LABORATORY ANNUAL SITE ENVIRONMENTAL REPORT FOR CY 2015 (PNNL-25738), SEPTEMBER 2016

The Pacific Northwest National Laboratory (PNNL) Annual Site Environmental Report (ASER) is prepared and published annually by the U.S. Department of Energy (DOE) Pacific Northwest Site Office (PNSO) for distribution to local, state, and federal government agencies, Congress, non-governmental organizations, the public, news media, and PNNL employees. This report includes information for calendar year 2015, but may also include late 2014 and early 2016 data. The purpose of this report is to provide the reader with the most recent information available concerning: 1) the status of PNNL's compliance with federal, state, and local government environmental laws and regulations; and 2) regional environmental monitoring efforts.

The report addresses facility operations and environmental surveillance occurring on the PNNL Campus in Richland, Washington, and the PNNL Marine Sciences Laboratory (MSL) near Sequim, Washington. Environmental activities at other locations are also included if they are under PNNL's responsibility. To the extent possible, information was captured from existing summary reports prepared as required by the contracting entity, consistent with DOE guidance for the preparation of the ASER.

This report was prepared for DOE by PNNL staff. If you have any questions or comments about this report, please contact Mr. Tom McDermott of my staff at (509) 372-4675, or via email at either of these addresses; tom.mcdermott@science.doe.gov, pnsomanager@science.doe.gov.

Sincerely,

Roger Snyder
Manager

PNNL-25738

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Pacific Northwest National Laboratory
Richland, Washington 99352

Pacific Northwest National Laboratory
Annual Site Environmental Report for 2015
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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 (PNSO) is responsible for oversight of PNNL.

This report provides a synopsis of ongoing environmental management performance and compliance activities conducted during 2015, meeting the requirements DOE Order 231.1B, Admin Chg 1, *Environmental, Safety and Health Reporting*, and DOE Order 458.1, *Radiation Protection of the Public and the Environment*. The report addresses the operations occurring on the PNNL Campus in Richland, Washington, and at the PNNL Marine Sciences Laboratory (MSL) near Sequim, Washington. It describes the location 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 2015

PNNL is committed to complying with all applicable federal, state, and local laws and regulations and site-specific permits. See Table S.1 and Section 2.0 for the 2015 status of federal and Washington State statutes at PNNL.

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. PNNL is dedicated to responsible planning for and management of resources that could be affected by facility operations. See Section 3.0 for environmental performance objectives and details.

Environmental Monitoring and Dose Assessment

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, and to determine compliance with state and federal regulatory requirements. There were no unplanned releases of regulated substances or substances of concern from PNNL facilities in 2015 (Sections 2.4, 4.2, and 5.2).

Liquid Effluent Monitoring: Liquid effluent discharges from PNNL operations are monitored under permits issued by the Washington State Department of Ecology and the City of Richland. In 2015, 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 2015 (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 2015 were well below dose rate limits for aquatic, terrestrial, and riparian animals and plants for both the PNNL Campus and MSL (Section 4.4).

Environmental Radiological Monitoring: No radiological releases to the environment exceeded permitted limits in 2015.

Radioactive particulates in ambient air are monitored using a particulate air-sampling network located at the perimeter of the PNNL Campus. In 2015, 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 2.6×10^{-4} mrem (2.6×10^{-6} mSv) effective dose equivalent (EDE).

In 2015, within the 80 km (50 mi) radius, the collective dose from radionuclide air emissions that originated from the PNNL Campus was 2.7 × 10^{-4} person-rem (2.7 × 10^{-6} person-Sv). The PNNL Campus MEI location was 0.15 km (0.09 mi) south of the Research Technology Laboratory Complex (Section 4.2.1).

The MSL MEI location was 0.19 km (0.12 mi) west of MSL-5. The dose to the MEI from site emissions was 1.1 × 10^{-4} mrem (1.1 × 10^{-6} mSv) (Section 4.2.2). The 80 km (50 mi) collective dose for MSL emissions was 1.2 × 10^{-4} person-rem (1.2 × 10^{-6} person-Sv).

The total dose to either the PNNL 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 requiring stack monitoring; compliance is achieved by conforming to permit conditions (Section 5.0).

Groundwater Protection

Groundwater under the PNNL 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).

Table S.1. Status of Federal and Washington State Statutes at PNNL, 2015

Regulation	What It Encompasses	2015 Actions and Standing
Federal Statutes		
American Indian Religious Freedom Act; *Antiquities Act of 1906*; *Archaeological and Historic Preservation Act of 1974*; *Archaeological Resources Protection Act of 1979*; *National Historic Preservation Act of 1966*; and *Native American Graves Protection and Repatriation Act of 1990*	Cultural resources.	Five *National Historic Preservation Act* Section 106 cultural resource reviews were conducted for Pacific Northwest National Laboratory (PNNL) projects during fiscal year 2015. No cultural/historical resource compliance issues were identified. In addition, 12 projects were reviewed by cultural resource staff to assure that they were covered by previously conducted Section 106 cultural resource reviews.
Atomic Energy Act of 1954	Management of radioactive materials.	PNNL complies with the *Atomic Energy Act of 1954* through its Radiation Protection Management and Operation Program.
Bald and Golden Eagle Protection Act	Protection of bald and golden eagles.	Biological resource reviews provide assurance that proposed actions will not adversely affect bald or golden eagles.
Clean Air Act	Air quality including emissions from facilities and unmonitored sources.	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 air emissions of regulated substances or substances of concern. Radioactive air emissions in calendar year (CY) 2015 were more than 10,000 times lower than the regulatory standard of 10 mrem/yr (0.1 mSv/yr) at both the PNNL Campus and the Marine Sciences Laboratory (MSL).
Clean Water Act	Includes 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 permit issued by the Washington State Department of Ecology; there were no permit violations at MSL in 2015. Two nationwide permits were acquired by PNNL in 2015. Two instances of a liquid effluent discharge with a pH slightly lower than the permit limit of 5.0 occurred at the Physical Sciences Facility in 2015; the operation contributing to this condition has been modified to prevent a recurrence.

Regulation	What It Encompasses	2015 Actions and Standing
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 in 2015.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)	Sites already contaminated by hazardous materials.	PNNL is not part of any Hanford CERCLA operable unit and had no continuous releases in 2015.
Emergency Planning and Community Right-to-Know Act of 1986	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. PNNL was not required to submit a Toxic Release Inventory Report for 2015.
Endangered Species Act of 1973	Rare plant and animal species.	No Endangered or Threatened species were observed during the annual biological field survey of the PNNL Campus or on lands encompassing MSL. PNNL issued five no-effect determinations in 2015. One Determination of Take authorization was acquired by PNNL in 2015.
Energy Independence and Security Act of 2007 (EISA)	Shifting the United States to greater energy independence and security and promoting energy efficiency, conservation, and savings.	PNNL evaluated 10 buildings under EISA energy and water evaluation requirements. A total of 36 percent of PNNL buildings met DOE criteria as high-performance and sustainable buildings. PNNL also implemented stormwater management practices to promote water drainage and reduce runoff.
Federal Facility Compliance Act of 1992	Amends the *Resource Conservation and Recovery Act of 1976* (RCRA) and CERCLA and requires new mixed waste reporting requirements.	PNNL provides information as part of the Hanford Site Mixed Waste Land Disposal Restrictions Summary Reports pursuant to Tri-Party Agreement Milestone M-26.
Federal Insecticide, Fungicide, and Rodenticide Act	Storage and use of pesticides.	Licensed PNNL staff or certified commercial applicators are used to purchase, store, and apply pesticides on the PNNL Campus and at MSL.

Regulation	What It Encompasses	2015 Actions and Standing
Magnuson–Stevens Fishery Conservation and Management Act	Essential fish habitat.	This Act provides for protection of essential fish habitat (waters and substrate for spawning, breeding, feeding, and growing to maturity). PNNL biological reviews and permits assure the policies of the Act are met. No essential fish habitat consultations were completed by PNNL in 2015.
Marine Mammal Protection Act of 1972	All marine mammals.	The biological resource review and permitting process is the primary means by which PNNL determines whether marine mammal species may be affected by a proposed action. One marine mammal incidental take authorization was obtained by PNNL in 2015. PNNL issued three no-effect determinations in 2015.
Migratory Bird Treaty Act	Migratory birds or their feathers, nests, or eggs.	A number of migratory birds were observed during the biological field survey of the PNNL Campus and the lands encompassing MSL. PNNL biologists resolved over 23 reports concerning migratory birds on the PNNL Campus and at MSL.
National Environmental Policy Act of 1969 (NEPA)	Environmental impact statements, environmental assessments, and categorical exclusions for federal projects that have the potential to affect the quality of the human environment.	PNNL environmental compliance representatives and NEPA staff conducted 1,049 NEPA reviews during CY 2015 for research and support activities. The U.S. Department of Energy (DOE)-Richland Operations Office approved seven generic categorical exclusions in 2015; the Pacific Northwest Site Office (PNSO) approved three generic categorical exclusions. PNSO also approved one project-specific categorical exclusion.
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 is implemented by PNNL.
Resource Conservation and Recovery Act of 1976 (RCRA)	Tracking hazardous waste from generator to treatment, storage, or disposal (referred to as cradle-to-grave management).	PNNL is responsible for one RCRA-permitted storage and treatment unit. Washington State Department of Ecology personnel inspected six PNNL facilities in 2015; administrative issues were identified during three inspections and were corrected, two inspections were in full compliance, and U.S. Environmental Protection Agency (EPA) has not reported results of the sixth. There are no RCRA permits applicable to MSL.

Regulation	What It Encompasses	2015 Actions and Standing
Rivers and Harbors Appropriation Act of 1899	Prohibits obstruction or alteration of navigable waters.	PNNL evaluates the need for *Rivers and Harbors Appropriation Act* Section 10 permits as part of the biological resource review for each project. Two nationwide permits were acquired under Section 10 by PNNL in 2015.
Safe Drinking Water Act of 1974	Drinking water systems.	The PNNL Campus receives all drinking water for uses in laboratory and non-laboratory spaces from the City of Richland drinking water supply. The City is responsible for meeting water-quality standards under the *Safe Drinking Water Act of 1974*. PNNL Campus has registered a stormwater injection well and a heating/cooling facility injection well as required by the Act. At MSL, water is provided exclusively from onsite wells and PNNL is considered the water purveyor.
Superfund Amendments and Reauthorization Act of 1986	Amends and reauthorizes CERCLA.	PNNL Campus areas near the Hanford Site have been evaluated and require no further action. Groundwater near the PNNL Campus is monitored for Hanford Site contaminant migration. No contamination has been identified at MSL that would require response under CERCLA or the Superfund Amendments and Reauthorization Act.
Toxic Substances Control Act	Hazardous chemical regulation and tracking; primarily polychlorinated biphenyls (PCBs).	During 2015, PNNL contributed to the 2014 PCB annual document log report for the Hanford Site and 2014 PCB annual report; both were submitted to the EPA as required.
Washington State Statutes		
Hazardous Waste Management Act of 1976	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.
Shoreline Management Act of 1971	Shoreline use, environmental protection, and public access.	The PNNL biological resource review and permitting process assures the policies of the *Shoreline Management Act of 1971* are met. Three Shoreline Substantial Development Permit Exemptions were acquired by PNNL in 2015.

Regulation	What It Encompasses	2015 Actions and Standing
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, and complete SEPA checklists as required.
Washington Clean Air Act	Implements and supplements the *Clean Air Act*, overseeing air quality.	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 (ORCAA). No events were reported for air emissions of regulated substances or substances of concern. One Nonradiological Air Approval Order was obtained from ORCAA by PNNL in 2015.
Washington Pesticide Application Act	Control of pesticide application and use to protect public health and welfare.	Licensed PNNL staff or certified commercial applicators apply pesticides.
Washington Pesticide Control Act	Proper use and control of pesticides.	Licensed PNNL staff or certified commercial applicators purchase, store, and apply pesticides.

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 included the following:

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AL Miracle	Peer Review

ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
µg/L	microgram(s) per liter
µS/cm	microsiemen(s) per centimeter
ac	acre(s)
A.D.	Anno Domini
ALARA	as low as reasonably achievable
ASO	Analytical Support Operations (laboratory)
Battelle	Battelle Memorial Institute
BCAA	Benton Clean Air Agency
B.P.	Before Present
Bq	bequerel(s)
BSF	Biological Sciences Facility
Btu	British thermal unit(s)
C&D	construction and demolition
ca.	circa (approximately)
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
CY	calendar year
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
EDE	effective dose equivalent
EDL	Engineering Development Laboratory
EISA	*Energy Independence and Security Act of 2007*
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*
ESPC	Energy Savings Performance Contract

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
GGE	gallon gas equivalent
GHG	greenhouse gas
gpd	gallon(s) per day
gpm	gallon(s) per minute
GRI	Global Reporting Initiative
GSF	gross square foot (feet)
Gy	gray(s)
ha	hectare(s)
HPSB	High-Performance Sustainable Building
hr	hour(s)
ILA	industrial, landscaping, and agricultural
in.	inch(es)
ISO	International Organization for Standardization
k	thousand
kg	kilogram(s)
KiBe	Kiona-Benton
km	kilometer(s)
km^2	square kilometer(s)
kW	kilowatt(s)
L	liter(s)
L/min	liter(s) per minute
LEED	Leadership in Engineering and Environmental Design
lb	pound(s)
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
MEI	maximum exposed individual
meq	milliequivalent(s)
mg	milligram(s)
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
mGy/d	milligray(s) per day
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mho	reciprocal of ohm (conductivity measurement)
mmhos/cm	millimhos per centimeter
mph	mile(s) per hour
mrem	millirem
mrem/yr	millirem per year
MSL	Marine Sciences Laboratory
mSv	millisievert(s)
mSv/yr	millisievert(s) per year
$MTCO_2e$	metric tons of carbon dioxide equivalent
NA	not applicable
ND	nondetectable
NEPA	*National Environmental Policy Act of 1969*
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit(s)

ORCAA	Olympic Region Clean Air Agency
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*
RCW	Revised Code of Washington
REC	renewable energy certificate
RTL	Research Technology Laboratory
s	second(s)
SEPA	*State Environmental Policy Act*
SSPP	Strategic Sustainability Performance Plan
Sv	sievert(s)
T&D	transmission and distribution
TRIDEC	Tri-City Development Council
U.S.C.	U.S. Code
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington Department of Health
yr	year(s)

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

This report was prepared to meet the requirements of U.S. Department of Energy (DOE) Order 231.1B, Admin Chg 1 (2012), *Environment, Safety and Health Reporting*, and DOE Order 458.1, Admin Chg 3 (2011) *Radiation Protection of the Public and the Environment*, by providing a synopsis of calendar year (CY) 2015 information related to environmental management performance and compliance efforts at the Pacific Northwest National Laboratory (PNNL).

PNNL, one of 10 DOE Office of Science (DOE-SC) national laboratories, provides innovative science and technology solutions in energy and 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. 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 the primary document for reporting PNNL annual site environmental and operating performance, this report provides environmental and monitoring information to Native American tribes, public officials, regulatory agencies, other interested groups, and the public. It summarizes site compliance with federal, state, and local environmental laws, regulations, policies, directives, permits, and Orders, and provides environmental management performance benchmarks.

After the context-setting background information provided in this Introduction, ensuing chapters present a summary of PNNL's 2015 record of operational activities related to the site environment with regard to compliance, environmental management, monitoring and radiological dose assessment, the nonradiological and groundwater protection programs, and quality assurance.

Appendix A lists information to assist the reader, including scientific notation, units of measure, unit conversions, and radionuclide and chemical information. Appendix B is a glossary of terms. Appendices C and D, respectively, contain lists of plant and animal species found on the PNNL Campus and at PNNL's Marine Sciences Laboratory (MSL) property near Sequim, Washington.

1.1 Location

JP Duncan

PNNL includes facilities at the PNNL Campus in Richland, Washington, and at 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 at various other locations, including Seattle, Washington, and Portland and Corvallis, Oregon.

1.1.1 PNNL Campus

The PNNL Campus 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 Tri-City Development Council (TRIDEC) in 2015 for economic development (DOE-RL 2015a). The PNNL Campus covers approximately 247 ha (610 ac), encompassing the DOE-owned PNNL Site, adjacent land and facilities owned by Battelle that are under an exclusive-use agreement with DOE, and leased facilities located on private land and on the campus of Washington State University–Tri-Cities (Figure 1.2). The area immediately south of the PNNL Campus includes public and privately owned land, currently envisioned to be developed with office, laboratory, residential, and retail space as part of the Tri-Cities Research District.

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

1.1.2 PNNL Marine Sciences Laboratory

MSL is located 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. The developed areas include MSL facilities, an innovative seawater treatment system, research docks, and outdoor experimental tanks and ponds (Figure 1.3). Research scientists and engineers at MSL perform research and development in marine sciences, intelligence, national security, and homeland security operations. DOE has exclusive use of MSL facilities and operations are consolidated under PNSO oversight.

1.2 Background and Mission

1.2.1 PNNL 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

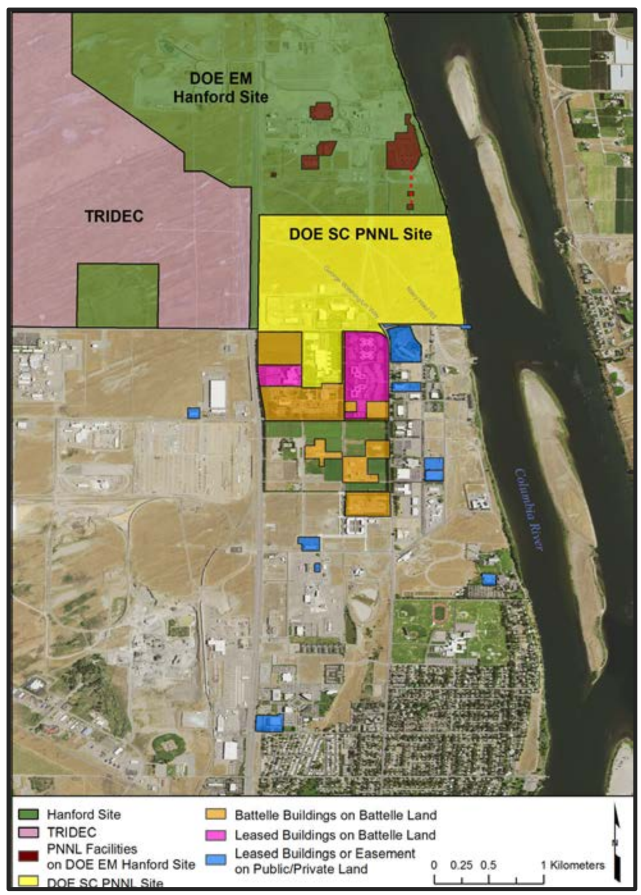


Figure 1.2. Pacific Northwest National Laboratory Campus and Surrounding Area

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. Throughout 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 facilities on the PNNL Campus include the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), the Engineering Development Laboratory, Physical Sciences Laboratory (PSL), Life Sciences Laboratory 2 (LSL2), Biological Sciences Facility/Computational Sciences Facility (BSF/CSF), and the Physical Sciences Facility (PSF) complex. The PSF complex includes the newly constructed 3820 Systems Engineering Building for energy research, which was completed in June 2015; the Materials and Science Technology Laboratory for the development and analysis of high-performance materials for energy, construction, and transportation technologies and systems; and the Radiation Detection Laboratory and Ultra-Trace Laboratory for the development of radiation detection methodologies. The Radiation Portal Monitoring Test Track and Large Detector Laboratory, also part of the PSF complex, are designed to develop and test radiation detection technologies for border entry points and national and homeland security research projects. Research in the Engineering Development Laboratory is focused on national security, with particular emphasis on electromagnetics/radiography, optics/infrared spectroscopy, and acoustics/ultrasonics. PSL and LSL2 are general purpose research facilities. BSF is occupied by the Biological Sciences Division, which performs systems biology research and develops technologies focused on how cells, cell communities, and organisms sense and respond to their environment; and the Earth Systems Science Division, which develops comprehensive monitoring programs and performs environmental and biotechnology research. CSF investigations include the development of visual analytics technologies, cyber analytics, and critical infrastructure assessment and protection.

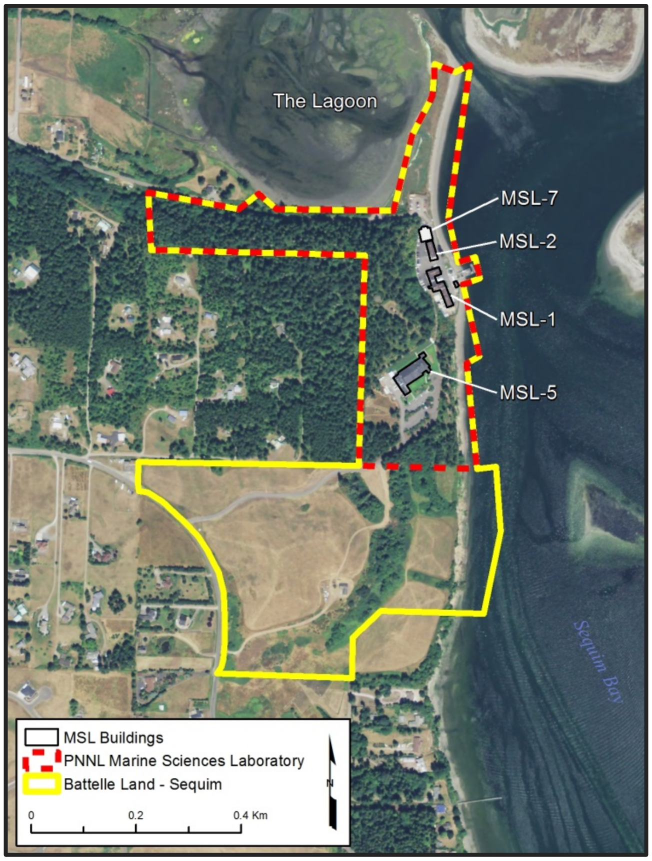


Figure 1.3. Battelle Land–Sequim Encompassing the PNNL Marine Sciences Laboratory Facilities and Surrounding Environment

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 2002, PNNL established the Coastal Security Institute as a component of MSL. The Institute's mission is to support intelligence, national security, and homeland security operations by developing technology to accurately and rapidly detect, identify, and characterize coastal occurrences and events. 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 environmental chemistry, water and ecosystem modeling, remote sensing, remediation technology research, environmental sensors, ecotoxicology, biotechnology, and national and homeland security. Research efforts include the development of sustainable renewable energy from the nearshore and ocean environments and understanding and mitigating the long-term impacts of human activities (including climate change) on marine resources.

1.3 Demographics

JP Duncan

The PNNL 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. In 2015, two land parcels in the southwestern portion of the Hanford Site were transferred to TRIDEC for economic development, pursuant to the *Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015* (Public Law 113-291, Section 3013). Residents north and east of the Hanford Site generally live on farms or in farming communities. Residents south, southwest, and east of the PNNL Campus live in the urban communities of Richland, Kennewick, Pasco, and West Richland.

In 2015, an estimated 190,300 people lived in Benton County and 88,800 people lived in adjacent Franklin County, increases of 8.6 percent and 13.6 percent, respectively, over 2010 figures (USCB 2016a,b). During 2015, Benton and Franklin Counties accounted for 3.9 percent of Washington's population. Based on U.S. Census population data, the population within an 80 km (50 mi) radius of the PNNL Campus is estimated to be about 432,000. This population estimate is used to calculate the radiation dose (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 73,500 people lived in Clallam County in 2015, an increase of approximately 3 percent over 2010 figures and equivalent to approximately 1 percent of Washington's population (USCB 2016c). Sequim, the nearest population center to MSL, had a population of 6,826 people in 2015 (USCB 2016d). An estimated 2,349,100 people live within an 80 km (50 mi) radius of MSL; 1,986,300 in the United States (85 percent) and 362,800 in Canada (15 percent) (Zuljevic et al. 2016).

1.4 Environmental Setting – PNNL Campus

BG Fritz

The PNNL Campus occupies land that has had varying degrees of previous disturbance, the severity and duration of which are indicated somewhat by the current vegetation. 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. Certain uplands have undergone complete habitat conversion and support facilities with landscaping. The riparian zone of the Columbia River is largely undisturbed and supports both native and non-native vegetation.

1.4.1 Geology and Soils

The PNNL 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 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 BSF/CSF on the PNNL Campus (Freedman et al. 2010).

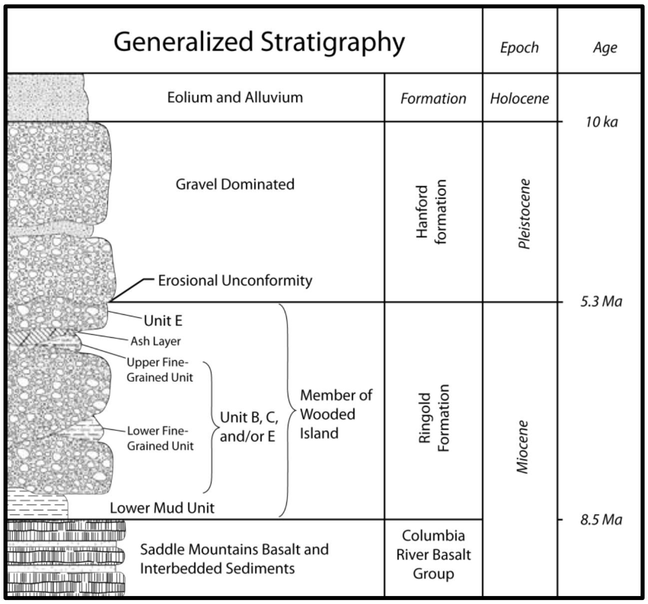


Figure 1.4. Generalized Stratigraphic Column Depicting the Stratigraphy Underlying the PNNL Campus (modified from Reidel et al. 1992; Thorne et al. 1993; Lindsey 1995; Williams et al. 2000; DOE-RL 2002; and Williams et al. 2007)

Additional stratigraphic information was obtained from previously existing geologic logs for nearby irrigation wells, water-supply wells, monitoring wells, and characterization boreholes associated with environmental remediation activities. The uppermost geologic unit in the study area is the Hanford formation—a highly permeable mixture of sand and gravel that was deposited by the Ice Age floods during the late Pleistocene period. These poorly sorted and unconsolidated sediments generally cover a wide range of sizes, from boulder-sized gravel to sand, silt, and clay. Late Miocene- to Pliocene-aged sediments of the Ringold Formation underlie the Hanford formation. The Ringold Formation is texturally and structurally distinct from the overlying Hanford formation and displays lower hydraulic conductivity. The Ringold Formation contains 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.

1.4.2 Hydrology

The general direction of groundwater flow under the PNNL Campus is toward the east-northeast from the Yakima River to the Columbia River (Figure 1.5). The northeasterly flow direction is likely influenced by the City of Richland recharge ponds, upgradient irrigation, and the Yakima River. In addition, the 300 Area of the Hanford Site has been shown to be a convergence zone for groundwater flow (Peterson et al. 2005), which may also contribute to the local gradient of the PNNL Campus.

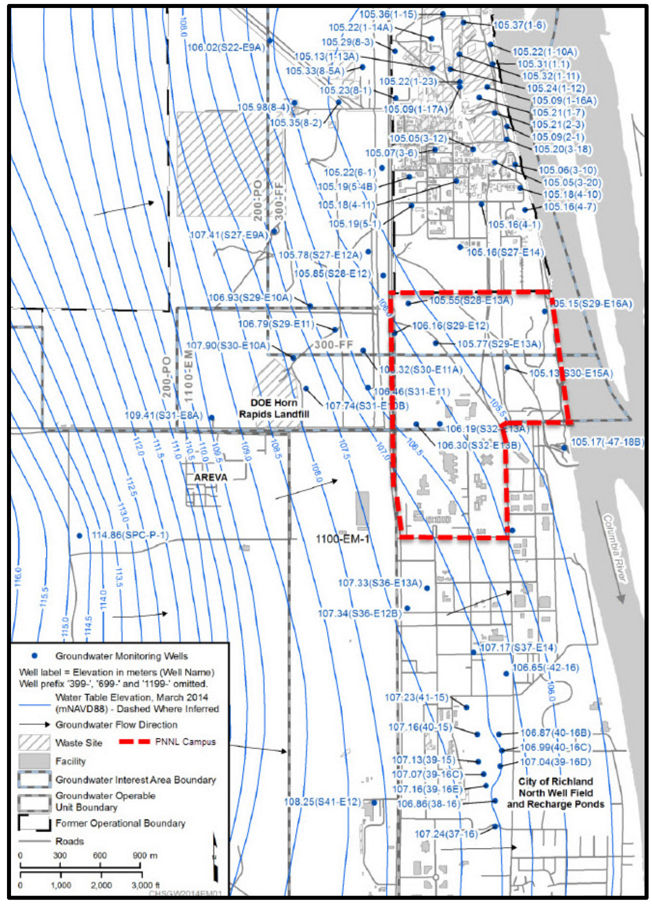


Figure 1.5. Water Table Elevations (m) in 2014 (modified from DOE-RL 2015b). Groundwater flow direction is normal to the water table contour lines. The approximate PNNL Campus is bordered in red. Data for 2015 are not provided; the conditions shown are typical of recent years.

Field data collected on and around the PNNL 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 consists of unsaturated sediments between the ground surface and the water table. This zone occurs predominantly within sandy gravel, gravelly sand, and silty, sandy gravel of the Hanford formation (Newcomer 2007). In some areas, the Ringold Formation extends above the water table into the lower part of the vadose zone. The local thickness of the vadose zone is about 15 m (49 ft) below the PNNL Campus. In general, the thickness of the vadose zone decreases with proximity to the Columbia River, as the ground surface slopes toward the river.

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 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 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 Site would be somewhat larger. The Federal Emergency Management Agency (FEMA) floodplain maps extend only to the southern boundary of the PNNL Site (FEMA 1984). However, FEMA maps suggest that the PNNL Site, 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

Temperature, precipitation, and wind across the Columbia River Basin are affected by mountain barriers. The Cascade Range, west of Yakima, greatly influences the climate at the PNNL Campus because of its rain-shadow effect. 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. One tower (300 Area, Station 11) is located in the vicinity of the PNNL Campus. The Hanford Meteorological Station conducts 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-RL 2015b). The maximum high temperature in 2015 was 44°C (111°F); the minimum was –11.7°C (11°F) (DOE 2016). The Hanford Meteorological Station reported that 2015 temperatures at the Hanford Site were 2.0°C (35.6°F) above the normal of 12.2°C (54.0°F), making it the warmest year since record-keeping began in 1945. The normal annual relative humidity at the Hanford Meteorology Station is 55 percent. Humidity is highest during winter, when it averages approximately 77 percent, and lowest during summer, when it averages approximately 36 percent (DOE-RL 2015b). Normal annual precipitation at the Hanford Meteorological Station is 18.0 cm (7.09 in.). Most precipitation occurs during late autumn and winter, and more than half of the annual amount occurs from November through February. Precipitation for 2015 totaled 16.5 cm (6.5 in.), which is 86 percent of normal (DOE 2016).

Winds from the northwestern quadrant are the most common during winter and summer. During spring and fall, the frequency of southwesterly winds increases, with corresponding decreases in the northwesterly flow (Poston et al. 2011). 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). Wind speeds well above average are usually associated with southwesterly winds. However, summertime drainage winds are generally northwesterly and frequently exceed 13 m/s (30 mph) (Poston et al. 2011).

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 percent of the time at the Hanford Site during summer (Poston et al. 2011). Less favorable conditions may occur when wind speed is light and the mixing layer is shallow. These conditions are most common during winter, when moderate to extremely stable stratification exists (approximately 66 percent of the time). Occasionally (primarily during winter), poor dispersion conditions, associated with stagnant air in stationary high-pressure systems, occur for extended periods. 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 (1945–2015).

1.4.5 Ecology

JM Becker

The PNNL Campus is located in the lowest and most arid portion of the Columbia Plateau Ecoregion (LandScope Washington 2016)—the largest ecoregion in Washington, which is bordered by the Cascade Range to the west and the Blue and Rocky Mountains to the east (WWHCWG 2016). The semi-arid climate of the Columbia Plateau supports native shrub-steppe vegetation, more than half of which has been converted to agriculture. The remaining shrub-steppe habitat is mostly fragmented (WWHCWG 2016); a significant exception is the Hanford Site, which is adjacent to and just north of the PNNL Campus and has been protected from agricultural use and development for more than 65 years. The PNNL Campus south of Horn Rapids Road is entirely maintained landscapes, agricultural fields, and previously disturbed, early successional habitats. The undeveloped areas of the PNNL Campus north of Horn Rapids Road (Figure 1.6) retain much of their native biodiversity and community structure.

A baseline biological survey of undeveloped sections of the PNNL Campus north of Horn Rapids Road was conducted by PNNL ecologists in May and June 2015. The survey included the riparian zone, but was limited by high water. The most recent complete survey of the riparian corridor was completed in 2010 (Chamness et al. 2010). Lists of plant and animal species identified on the PNNL Site between 2009 and 2015 and their status are provided in Appendix C.

Soils on the PNNL Campus north of Horn Rapids Road are primarily sandy and support mostly native shrub-steppe vegetation. Plant communities (Figure 1.6) are classified based on the dominant overstory (shrubs) and understory (grasses and forbs) species. Shrub-steppe plant communities are dominated primarily by big sagebrush (*Artemisia tridentata*) and native perennial bunchgrasses. Antelope bitterbrush (*Purshia tridentata*) and gray and green rabbitbrush (*Ericameria nauseosa* and *Chrysothamnus viscidiflorus,* respectively) are common shrubs co-occurring with big sagebrush. The most common perennial bunchgrass in the area is Sandberg's bluegrass (*Poa secunda*), but several stands of needle-and-thread grass (*Hesperostipa comata*) dominate sandy swales within the area, and Indian ricegrass (*Achnathrum hymenoides)* also is represented in several sandy areas containing antelope bitterbrush. Non-native cheatgrass (*Bromus tectorum*) occurs in all plant communities on the PNNL Campus north of Horn Rapids Road.

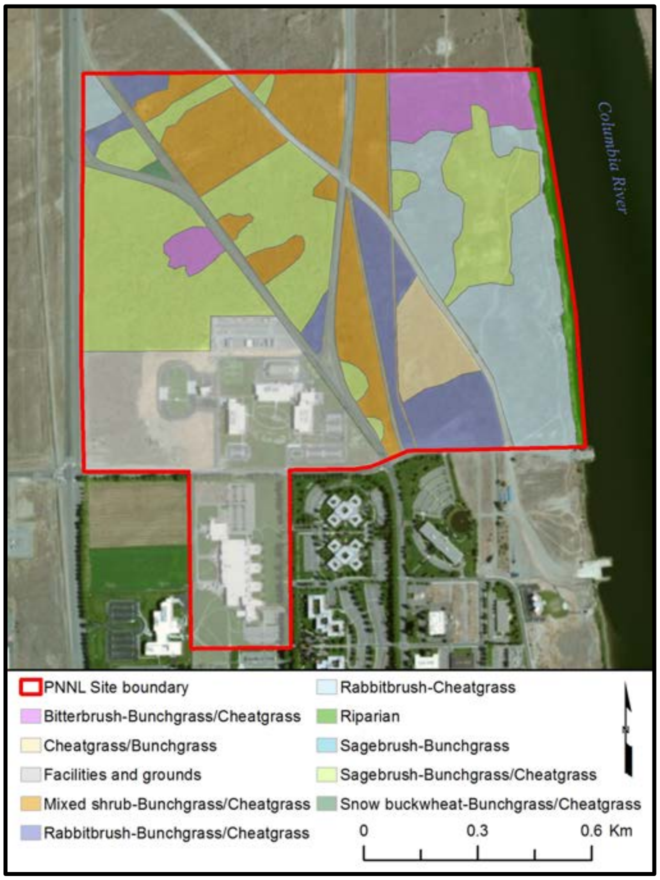


Figure 1.6. Plant Communities Found on the Undeveloped Portions of the PNNL Campus

Common native forb species include Carey's balsamroot (*Balsamorhiza careyana*), long-leaved phlox (*Phlox longifolia*), yarrow (*Achillea millefolium*), pale evening primrose (*Oenothera pallida*), lemon scurfpea (*Psoralidium lanceolatum*), turpentine spring parsley (*Cymopterus terebinthinus*), and daisy fleabane (*Erigeron* spp.). Common non-native forbs include tumble mustard (*Sisymbrium altissimum*), Russian thistle (*Salsola tragus*), and several species listed as Class B and Class C noxious weeds. Common Class B noxious weeds include diffuse knapweed (*Centaurea diffusa*), rush skeletonweed (*Chondrilla juncea*), Russian knapweed (*Acroptilon repens*), burningbush (*Bassia scoparia*), puncturevine (*Tribulus terrestris*), and yellow starthistle (*Centaurea solstitialis*). Common Class C noxious weeds include field bindweed (*Convolvulus arvensis*) and Russian olive (*Elaeagnus angustifolia*). The Class B and Class C noxious weeds listed above are all classified as such by the state of Washington (WAC 16-750-011 and WAC 16-750-015, respectively).

Sagebrush-steppe communities support a variety of wildlife, including coyote (*Canis latrans*), mule deer (*Odocoileus hemionus*), northern pocket gopher (*Thomomys talpoides*), and black-tailed jackrabbit (*Lepus californicus*). Migratory bird species that have been observed and likely nest on the PNNL Campus north of Horn Rapids Road include, but are not limited to, mourning doves (*Zenaida macroura*), lark sparrows (*Chondestes grammacus*), horned larks (*Eremophila alpestris*), western meadowlarks (*Sturnella neglecta*), and sage sparrows (*Amphispiza belli*). California quail (*Callipepla californica*) have also been observed. Several Washington State candidate animal species are known to occur or potentially occur on the PNNL Campus north of Horn Rapids Road (Table 1.1).

In addition to shrub-steppe upland communities, a narrow riparian community exists along the Columbia River shoreline on the eastern part of the PNNL Campus north of Horn Rapids Road (Figure 1.1). Riparian vegetation is limited in extent; narrow bands near the water consist of a number of forbs, grasses, sedges, reeds, rushes, cattails, and scattered groups of deciduous trees and shrubs. Common tree species along the shoreline include Siberian elm (*Ulmus pumila*), white mulberry (*Morus alba*), poplars (*Populus* spp.), and tree-of-heaven (*Ailanthus altissima*), a Class C noxious weed. Shrub willows (*Salix exigua*) and wild rose (*Rosa woodsii*) are common shrub species in the riparian zone downstream of the Hanford Site 300 Area. Common herbaceous species along the shoreline include common St. Johnswort (*Hypericum perforatum*), Himalayan blackberry (*Rubus armeniacus*), and reed canarygrass (*Phalaris arundinacea*), all Class C noxious weeds (WAC 16-750-015), and Columbia tickseed (*Coreopsis atkinsonia*), cocklebur (*Xanthium strumarium*), and chicory (*Cichorium intybus*). Several Washington State threatened or endangered plant species potentially occur along the shoreline of the PNNL Campus (Table 1.1).

Table 1.1. Wildlife, Fish, and Plant Species of Conservation Concern Known to Occur or That Potentially Occur near the PNNL Campus North of Horn Rapids Road or the Riparian Zone of the Columbia River

Common Name[a]	Genus and Species	Federal Status[b]	State Status[c]
Wildlife			
Bald eagle	*Haliaeetus leucocephalus*	Species of Concern	Sensitive
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
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
Large St. Johnswort	*Hypericum majus*		Sensitive
Grand redstem	*Ammania robusta*		Threatened
Lowland toothcup	*Rotala ramosior*		Threatened
Columbian yellowcress	*Rorippa columbiae*	Species of Concern	Threatened

Sources: WDFW (2016a) and WDNR (2015)

(a) The black-tailed jackrabbit has been observed on the Pacific Northwest National Laboratory (PNNL) Campus north of Horn Rapids Road during annual surveys (Appendix C, Table C.3). The burrowing owl and sage sparrow were observed at times outside of the survey period, and so are not included in Appendix C, Table C.2. Other wildlife species potentially occur there based on the availability of suitable habitat. Plant species potentially occur in the riparian zone of the Columbia River located adjacent to the PNNL Campus north of Horn Rapids Road (Salstrom et al. 2012; WDNR 2015; Sackschewsky et al. 2014).

(b) Federal Species of Concern are those that may be in need of conservation actions, ranging from monitoring of populations and habitat to listing 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 2015).

(c) 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 2016a). Threatened plant species are those that are likely to become Endangered within the near future in Washington if the factors contributing to 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 vulnerable or declining and could become Endangered or Threatened in the state without active management or removal of threats (WDNR 2015).

Riparian habitats along the Columbia River in the Columbia Plateau Ecoregion support a diverse assemblage of wildlife. The area managed by PNSO, extending from a point south of the Hanford Site 300 Area along the river shore, consists of multilayered trees, shrubs, and herbaceous species. However, the shoreline below the ordinary high water line is not under the jurisdiction of PNSO. The area is used for daytime perching by wintering bald eagles (*Haliaeetus leucocephalus*) and by foraging osprey (*Pandion haliaetus*). A large number of migratory bird species, including eastern kingbird (*Tyrannus tyrannus*), red-winged blackbird (*Agelaius phoeniceus*), and Bullock's oriole (*Icterus bullockii*), use riparian trees and shrubs as nesting habitat. The area is also frequented by wading birds such as the black-crowned night-heron (*Nycticorax nycticorax*) and great egret (*Casmerodius albus*), and shorebirds such as the spotted sandpiper (*Actitis macularia*). Many migratory bird species use the riparian habitats for resting and feeding during spring and fall migration.

Priority habitats are those habitat types or elements with unique or significant value to a diverse assemblage of species. Both 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 2016b).

The Hanford Reach of Columbia River supports a diverse fish and invertebrate community. It is used as a spawning and migration corridor by anadromous salmonids, including fall Chinook salmon (*Oncorhynchus tshawytscha*), *Endangered Species Act*-listed Upper Columbia River spring Chinook salmon (70 FR 37160) and Upper Columbia River steelhead (*Oncorhynchus mykiss*) (74 FR 42605), and summer Chinook, coho (*Oncorhynchus kisutch*), and sockeye (*Oncorhynchus nerka*) salmon. The Columbia River constitutes critical habitat for Upper Columbia River spring Chinook salmon and Upper Columbia River steelhead (70 FR 52630), and essential fish habitat for Upper Columbia River spring Chinook salmon and fall Chinook salmon. Functions of this habitat for steelhead include juvenile rearing areas, juvenile migration corridors, areas for growth and development to adulthood, adult migration corridors, and spawning areas. Functions of this habitat for Chinook salmon include juvenile rearing and juvenile and adult migration (DOE-RL 2015c). The primary invertebrate fauna include caddisfly (Trichoptera) and chironomid larvae, crayfish (*Pacifasticus leniusculus towbridgii*), and western floater (*Anodonta kennerlyi*) (Mueller et al. 2011).

1.5 Environmental Setting – PNNL Marine Sciences Laboratory Vicinity

BG Fritz

Battelle Land–Sequim 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 the 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 MSL, and it moves in a northeasterly direction toward Sequim Bay.

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. The area experiences cool, wet winters and warm, dry summers with average monthly temperatures ranging from –0.6°C to 21°C (31°F to 70°F). Weather in this region is affected by both marine and high mountain influences. The National Data Buoy Center records daily meteorological data just offshore from MSL. Typically the annual average temperature is around 9°C (48°F). Regional winds are primarily from the northwest, averaging 4.5 m/s (10 mph); however, the local topography of Battelle Land–Sequim may result in localized wind patterns.

1.5.1 Ecology

JM Becker

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 flanks the coastline of Puget Sound, and features many islands, peninsulas, and bays (LandScope Washington 2016; EPA 2016). Timber harvesting and cultivation have fragmented the original vegetation of the Puget Lowland that once consisted of coniferous forest and expanses of prairie-oak woodland (WWF 2016). Today, second-growth coniferous forest and agricultural fields occupy much of the ecoregion's glacial moraines, outwash plains, floodplains, and terraces (EPA 2016; LandScope Washington 2016). These patterns of disturbance have influenced the development of the current vegetation and cover types at MSL (Figure 1.7) and surrounding areas that consist largely of upland second-growth mixed coniferous and deciduous forest and agricultural fields, with adjacent areas of beach, feeder bluff (i.e., eroding bluffs), and spit habitat along Sequim Bay (Clallam County 2013).

MSL uplands consist of the following general cover types: mixed conifer forest and field/meadow, bluff, spit, and developed (facilities) (Figure 1.7). The third biological survey of MSL was conducted in May 2015; species observed during this survey and surveys from the previous 2 years are listed in Appendix D.

Mixed coniferous forest at MSL begins above the ordinary high-water mark of Sequim Bay and extends west of the facilities and along Washington Harbor Road (Figure 1.7). Dominant tree species include Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). Other common tree species include Pacific madrone (*Arbutus menziesii*), bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), and grand fir (*Abies grandis*). Subcanopy tree species include Indian plum (*Oemleria cerasiformis*) and non-native English holly (*Ilex aquifolium*). Common shrub species include salal (*Gaultheria shallon*), hollyleaved barberry (*Mahonia aquifolium*), Cascade barberry (*M. nervosa*), baldhip rose (*Rosa gymnocarpa*), trailing blackberry (*Rubus ursinus*), Himalayan blackberry (*R. discolor*), oceanspray (*Holodiscus discolor*), red flowering currant (*Ribes sanguineum*), vine maple (*Acer circinatum*), snowberry (*Symphoricarpos albus*), and Scotch broom (*Cytisus scoparius*), a Washington State Class B noxious weed (WNWCB 2010). Common fern species include sword fern (*Polystichum munitum*) and western bracken fern (*Pteridium aquilinum*).

Spit habitat is located in the northeastern portion of the MSL site. It includes the area situated just to the west (along the east margin of the lagoon) and just to the east (tidal zone) of the Sequim Bay ordinary high-water mark (Figure 1.7). The west side of the spit includes estuarine and marine wetland. The portion of the spit located west of the ordinary high-water mark was surveyed in May 2015. Dense mats of pickleweed (*Salicornia virginica*) and salt grass (*Distichlis spicata*) occur closest to the lagoon, while dense stands of Puget Sound gum weed (*Grindelia integrifolia*) and common yarrow (*Achillea millefolium*) occur just upgradient of the lagoon.

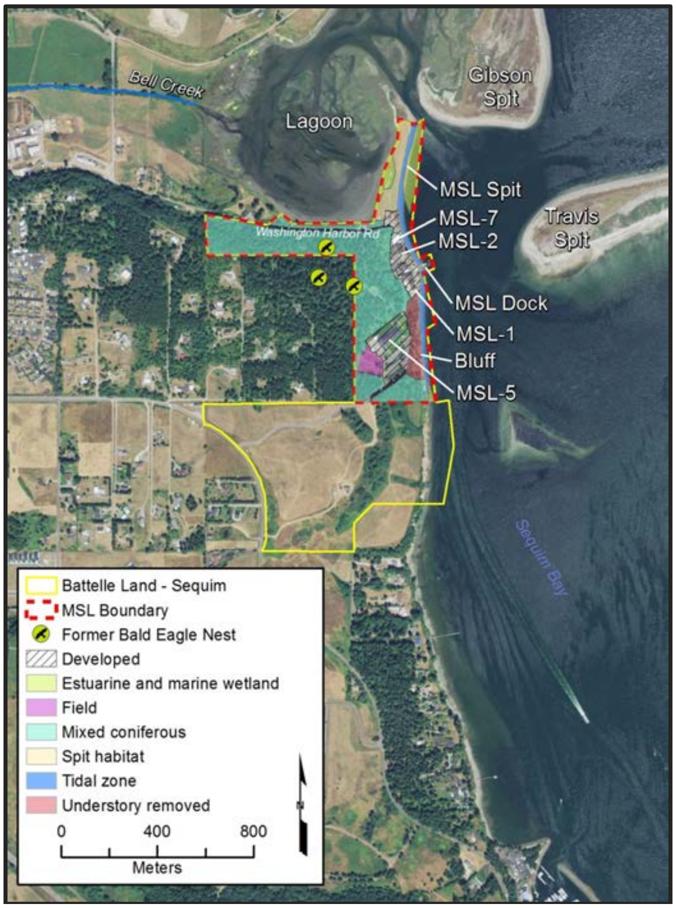


Figure 1.7. Plant Communities and Locations of Former Bald Eagle Nests at MSL

About 6.6 ha (16.3 ac) of estuarine/marine wetland and a total of 1.2 ha (3.0 ac) of freshwater emergent wetland occur within and adjacent to MSL property. The combined acreage of these wetland types is 7.8 ha (19.3 ac). The relatively undisturbed nearshore areas of Puget Sound and the open coast are listed by the WDFW as a priority habitat for the state (WDFW 2016b), and are therefore considered to be a priority for management and conservation (Clallam County 2013). The shore habitat (marine riparian zone) of such areas extends inland from the ordinary high-water mark to the portion of the terrestrial landscape that influences it or that directly influences the aquatic ecosystem. The shore includes feeder bluffs, such as those that front on MSL, which are an important source of sediments that form and sustain beaches (WDFW 2016b).

The nearshore and open-water environment of Sequim Bay provides potential habitat to various aquatic and terrestrial species, most notably federally listed threatened species such as the bull trout (*Salvelinus confluentus*) (64 FR 58910), Puget Sound Chinook salmon (70 FR 37160), Hood Canal summer-run chum salmon (*Oncorhynchus keta*) (70 FR 37160), and Puget Sound steelhead (*Oncorhynchus mykiss*) (72 FR 26722). Sequim Bay is designated critical habitat for bull trout (75 FR 63898), Puget Sound Chinook salmon, and Hood Canal summer-run chum salmon (70 FR 52630). Sequim Bay also provides potential habitat for the federally threatened North American green sturgeon (*Acipenser medirostris*) (71 FR 17757), Pacific eulachon (Columbia River smelt; *Thaleichthys pacificus*) (75 FR 13012), yelloweye rockfish (*Sebastes ruberrimus*) (75 FR 22276), Puget Sound canary rockfish (*Sebastes pinniger*) (75 FR 22276), and marbled murrelet (*Brachyramphus marmoratus*) (75 FR 3424), as well as federally endangered Puget Sound bocaccio (*Sebastes paucispinis*) (75 FR 22276). The northern half of Sequim Bay contains designated nearshore and deepwater critical habitat for yelloweye rockfish, Puget Sound canary rockfish, and bocaccio (78 FR 47635). Critical habitat for the marbled murrelet occurs at the southwest end of Sequim Bay about 6 km (3.7 mi) south of MSL (61 FR 26256). The nearshore environment of Sequim Bay is also spawning habitat for forage fish species such as Pacific sand lance (*Ammodytes hexapterus*) and surf smelt (*Hypomesus pretiosus*) (Ecology 2015; WDFW 2016c).

Common mammal species in the Puget Lowland ecoregion include raccoon (*Procyon lotor*), mink (*Mustela vison*), coyote, and black-tailed deer (*Odocoileus hemionus*) (WWF 2016). These species likely are also common in the MSL vicinity. Klapot Point on the southwest tip of Travis Spit, located in Sequim Bay about 0.4 km (0.25 mi) from MSL, provides a haulout area for harbor seals (*Phoca vitulina*) (WDFW 2016b).

Avian species found at the site are representative of the rich bird diversity of the northern Olympic Peninsula (Olympic Peninsula Audubon Society 2015). The groups represented and some of their most common species include waterfowl such as the bufflehead (*Bucephala albeola*); birds of prey such as the bald eagle; seabirds such as the Olympic gull (*Larus glaucescens x occidentalis*); upland game birds such as the mourning dove; colonial nesting waterbirds such as the great blue heron (*Ardea herodias*); woodpeckers such as the downy woodpecker (*Picoides pubescens*); and a variety of perching birds. Approximately 80 avian species have been observed at MSL (Appendix D).

Six salamander and five frog and toad species are known to occur in the MSL vicinity, the most common being the rough-skinned newt (*Taricha granulosa*) and Pacific tree frog (*Pseudacris regilla*) (Dungeness River Audubon Center 2015). Three snake and one lizard species also occur in the MSL vicinity, the most common of which are the common garter snake (*Thamnophis sirtalis*) and northwestern garter snake (*Thamnophis ordinoides*) (Dungeness River Audubon Center 2015). Five animal species of conservation concern are known to occur or potentially occur at or near MSL facilities (Table 1.2).

1.6 Cultural Setting – PNNL Campus

JL Mendez

The archaeological record of the Mid-Columbia Basin bears evidence of more than 8,000 years of human occupation. Regional development of hydroelectric dams, highways, commercial and residential real estate, and agriculture have obscured or destroyed much of the archaeological record. Despite continual development in the region, places within the Columbia Basin still remain largely undisturbed, including portions of the PNNL Campus. Because the arid climate provides favorable environmental conditions for preservation of materials that might otherwise decay more quickly, evidence of past human behavior may be present within these undisturbed areas. The history of the Mid-Columbia Basin includes three distinct periods of human occupation: the Pre-Contact period, the Euro-American period, and the Manhattan Project period.

1.6.1 Pre-Contact Period

Archaeological investigations conducted on the Columbia Plateau enabled the creation of a cultural chronology dating back to the end of the Pleistocene (about 11,000 years Before Present [B.P.]). Table 1.3 summarizes the pre-contact cultural sequence for the PNNL Campus area.

1.6.2 Ethnographic Period

Ethnographically, the Sahaptin-speaking Cayuse, Walla Walla, Palouse, Nez Perce, Umatilla, Wanapum, and Yakama used the area. During this period, local

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

Common Name[a]	Genus and Species	Federal Status[b]	State Status[c]
Bald eagle	*Haliaeetus leucocephalus*	Species of Concern	Sensitive
Peregrine falcon	*Falco peregrinus*	Species of Concern	Sensitive
Sand-verbena moth	*Copablepharon fuscum*		Candidate
Taylor's checkerspot butterfly	*Euphydryas editha taylori*	Endangered[d]	Endangered
Western toad	*Anaxyrus boreas*		Candidate

Source: WDFW (2016a)

(a) The bald eagle, peregrine falcon, and western toad are known to occur on the PNNL Marine Sciences Laboratory (MSL) property (Appendix D). Taylor's checkerspot butterfly and sand-verbena moth potentially occur in the vicinity of the Marine Sciences Laboratory, based on availability of suitable habitat.

(b) Species of Concern are those that may be in need of conservation actions that could range from monitoring of populations and habitat to listing 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 2015).

(c) Sensitive species are those that are native to the state of Washington, vulnerable or declining and likely to become endangered or threatened in a significant portion of their range within the state without cooperative management or removal of threats. 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.

(d) Listed as Federally Endangered in 2013 (78 FR 61451). Designated critical habitat occurs approximately 5 km (3 mi) north of MSL (78 FR 61506).

Table 1.3. Pre-Contact Cultural Sequence for the PNNL Campus Region

Cultural Period	Years Before Present	Site Types	Architecture	Subsistence
General Columbia Plateau				
Windust Phase	11,000–8,000	Rock shelters, caves, game processing sites, lithic reduction sites; isolated lithic tools. Examples include Marmes Rockshelter, Bernard Creek, Lind Coulee, Kirkwood Bar, Deep Gully, Granite Point, Fivemile Rapids, and Bobs Point.	Rock shelters and caves; open habitation sites. No evidence of constructed dwellings or storage features.	Large mammals supplemented with small mammals and fish. Toolset: Windust, Clovis, Folsom, and Scottsbluff points; contracting stemmed points and/or lanceolate points; cobble tools.
Mid Columbia Region Vantage Area				
Cascade/ Vantage Phase	8,000–4,500	Lithic scatters, quarry sites, resource processing sites, temporary camps.	Rock shelters and caves; open habitation sites.	Mobile, opportunistic foragers subsisting on fish, mussels, seeds, and mammals. Basalt leaf-shaped Cascade and stemmed projectile points, ovate knives, edge-ground cobble tools, microblades, hammerstones, core tools, and scrapers.
Frenchman Springs Period	4,500–2,500	Habitation sites along major rivers, confluences, tributaries, canyons, and rapids. Lithic scatters, quarry sites, resource processing sites, seasonal rounds of upland to lowland travel for resource procurement; seasonal camps.	House dwellings, including semi-subterranean.	As earlier, but with increased use of upland resources, seeds, and roots. Groundstone and cobble tools, mortars, pestles, contracting stemmed, corner-notched, and stemmed projectile points, hopper mortar bases and pestles, knives, scrapers, and gravers. Wider tool material variety.
Cayuse Phase I	2,500–1,200	Habitation sites at major rivers, confluences, tributaries, canyons, and rapids. Lithic scatters, quarry sites, resource processing sites, seasonal round camps. Ideological and spiritual sites.	Pithouses with wall benches.	Reliance on riverine resources, fish, and botanicals; basal-notched and corner-notched projectile points (most corner-notched); variety of tools including groundstone, scrapers, lanceolate, and pentagonal knives, net weights, cobble tools, drills, etc.
Cayuse Phase II	1,200–900	Same as Cayuse Phase I.	Pithouses without wall benches.	Same as Cayuse Phase I.
Cayuse Phase III	900–250	Increased mobility and hunting ability due to horse introduction. Large village habitation sites along rivers, seasonal round camps. Same site types as Cayuse Phases I & II.	Pit longhouse village sites.	Decrease in corner-notched points, increase in stemmed and side-notched projectile points, fine pressure flaked tools. Increase in trade goods.

Sources: Swanson (1962); Nelson (1969); Green (1975); Rice (1980); Galm et al. (1981); Thoms et al. (1983); Benson et al. (1989); Walker (1998); Morgan et al. (2001); Sharpe and Marceau (2001).

residents relied on a pattern of seasonal rounds that included semi-permanent residences in villages along major waterways during the winter months. With the arrival of spring, small groups living in temporary camps would travel into the canyons and river valleys to gather roots. Seasonal camps were used in the inland areas during the spring and early summer months. By late summer or early fall, seasonal rounds focused on ripening berries in the mountains. It was this time of the year when the acquisition of food came to an end and families returned to the winter villages (Chatters 1980; Galm et al. 1981; Bard and McClintock 1996; Dickson 1999).

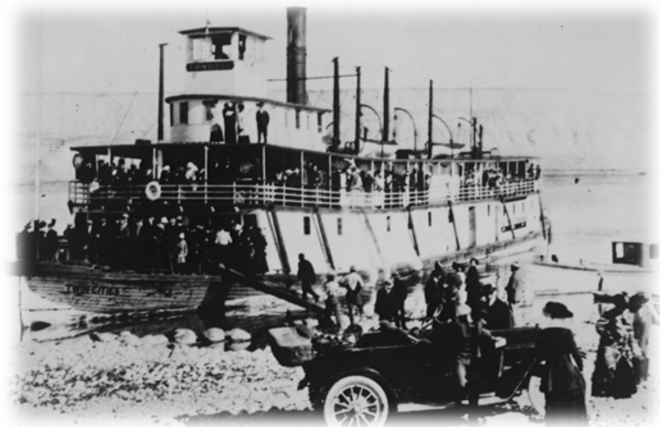
1.6.3 Euro-American Period

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. Numerous features created by Euro-American and Chinese that remain along the shoreline of the Hanford Reach are believed to be related to gold mining (Sharpe 2000). The mining industry created a demand for beef, and the Columbia Basin was ideal for livestock production.

An increase in Euro-American settlement began in eastern Washington in the late 1800s. The initial permanent settlement of non-Indians in the area began slowly with livestock producers who discovered that the area was very suitable for the production of cattle. Pasture was abundant and free for the taking. Ranchers relied on the abundant bunchgrass and open rangeland to graze thousands of cattle and later sheep and horses. The open range lasted from the 1880s to ca. 1910 when homesteaders settled the area and plowed the rangeland to plant crops. However, livestock remained an important economic commodity for the area's agricultural producers. Cattle became confined by fences, while sheep pastured on the remaining open range of Rattlesnake Mountain and Horse Heaven Hills (Fridlund 1985). Agricultural producers gradually replaced the open-range livestock operations that had dominated the area in the latter part of the 1800s and early 1900s.

Homesteaders removed unwanted sagebrush and bunchgrass and plowed the land. The *Homestead Act of 1862* (12 Stat. 392, ch. 75) enabled individuals 21 years of age or older to legally own land if they were willing to live on and develop the land (DOE-RL 1997). Circa 1900, homesteaders moved west, traveling by railroad to the Columbia Basin area.

Local transportation systems were very limited at that time; many of the Hanford area settlers arrived by river transportation. Steamboats and ferries were the primary transportation systems on the Columbia River during the homesteading era (Sharpe 2001). Residents of the new agricultural towns of Hanford and White Bluffs, as well as small communities of Allard-Vernita, Wahluke, and Fruitvale, relied almost exclusively on river transportation during the early development of the area.



The southern Columbia Basin area was unique because it produced ripe agricultural crops and orchard fruit 2 to 3 weeks ahead of surrounding areas, resulting in higher profits to local farmers. In the early 1900s, dryland wheat and livestock were the primary agricultural commodities in Benton County. 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 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 were the primary activities during the Manhattan Project, as well as the subsequent Cold War Era. The industrial components of the Manhattan Project and Cold War Era are still located in discrete areas throughout the site. Reactors in the 100 Areas were used to irradiate uranium fuel to produce plutonium. Plutonium was extracted from irradiated fuel at the chemical separation facilities in the 200 Areas. The uranium fuel was manufactured in the 300 Area, prior to being delivered to the reactors in the 100 Areas for advanced power plants. The 600 Area is a broad expanse between the production areas that contained the infrastructure such as roads and rail systems that served the entire site. The 700 Area was the administration area in Richland (Marceau et al. 2003).

1.7 Cultural Setting – PNNL Marine Sciences Laboratory Vicinity

JL Mendez

Evidence of the earliest settlement of the northwest coast is sparse in the archaeological record. Early sites from the northern northwest coast suggest the presence of coastal populations as early as 10,000 B.P. (Ackerman et al. 1985). These early sites contain lithic assemblages made up of bifaces, scrapers, and microblades similar to those known from Alaskan tool traditions. Sites dating to the earliest occupation of the region often contain assemblages of sea mammal bones. Early components of the Namu site on the central British Columbia coast provide evidence of heavy reliance on salmon, herring, and shellfish. The richness of these resources may have supported semi-sedentary winter occupation of the site as early as 7,000 B.P. (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 B.P., it seems that exploitation 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 is what allowed for the development of the classic complex hunter/fisher/gatherer societies that persisted into the 18th century (Fagan 2001).

Starting in the middle prehistoric period, the diverse groups of the northwest coast began to participate in a more homogeneous regional social system. This spread of ideas and cultural traits is thought to have been facilitated by widespread regional trade networks (Croes 1989). During this middle period (between 3,800 B.P. and A.D. 500), complex cultural mechanisms developed among societies of the northwest coast. Chief among these developments was the accumulation of resource surpluses and the emergence of social ranking. A rich material culture developed during this period that included elaborate ceremonial goods and new artistic traditions (Ames and Maschner 1999).

During the late pre-contact period of the northwest coast (A.D. 500 until the ethnographic period), the classic complex hunter-fisher-gatherer societies of the region grew and flourished. This trend toward more complex societies included hallmarks such as increasing population density, heavy reliance on stored food and other resources, and architectural styles that included plank houses and fortified villages (Fagan 2001). Social mechanisms such as social stratification, redistribution of resources, and political networks were part of the culture that emerged in the region.

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. This area includes parts of present-day British Columbia and Washington State. Five traditional languages were spoken throughout the area: Squamish, Halkomelem, Nooksack, Northern Straits, and Klallam (Suttles 1991). Speakers of the Klallam language are native to the northern Olympic Peninsula, between the Hoko River and Port Discovery Bay. According to early ethnographic data, there were 13 Klallam winter villages in this region—all but 1 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. Anadromous species native to the region include five species of salmon (Chinook, coho, sockeye [*Oncorhynchus nerka*], chum, and pink [*O. gorbuscha*]), steelhead and cutthroat trout, and Dolly Varden (*Salvelinus malma*; Schalk 1988). In marine settings, a reef net consisting of a rectangular net suspended between canoes was used to catch salmon. In freshwater settings, fishing gear included harpoons, leisters, gaff hooks, four-pronged spears, dip nets, basket traps, weirs, and trawl lines (Suttles 1991). In addition to salmon, saltwater fish such as halibut, herring, lingcod, and flounder were exploited. The relatively calm sandy beaches and highly productive estuarine conditions of the eastern portion of the Strait of Juan de Fuca supported large populations of invertebrates such as the little neck clam, butter clam, horse clam, and the basket cockle (Schalk 1988).

The Klallam-speaking people were one of the few groups in the region to practice whaling; however, whales were only hunted opportunistically, when spotted from shore (Schalk 1988). Klallam whalers used harpoons to hunt whales from canoes (Suttles 1991). On land, Salish hunters trapped, drove, and stalked deer as a main source of terrestrial game. Other game species included elk, black bear, mountain goats, and beavers, as well as many species of waterfowl. Ethnographic data suggest that hunting among the Klallam was limited to a small number of specialized hunters who hunted in the mountains, and that terrestrial game played a relatively small role in the overall subsistence pattern (Schalk 1988). Women gathered at least 40 different edible plants including sprouts, stems, bulbs, roots, berries, fruits, and nuts. Other gathered resources include marine mollusks such as mussels, clams, and cockles, as well as sea urchins, crabs, and barnacles (Suttles 1991).

Woodworking was an important aspect of Salish technology, and wooden materials hold an important place in the material culture in this area. A variety of tools, including both chipped and ground stone, were produced for this purpose. Some wooden products in Salish material traditions include house posts, beams, planks, canoes, various boxes, dugout dishes, tools, and weapons, as well as ceremonial paraphernalia (Suttles 1991). Cordage was made using a range of plant and animal fibers including cedar bark, willow bark, sinew, kelp, and hide. These materials were used to manufacture a wide range of products including nets, towels, cradle mattresses, skirts, mats, and different types of containers and baskets. A unique weaving tradition was practiced by groups in the Central Coast Salish Culture Area that used wool produced from mountain goat wool, waterfowl down, fireweed cotton, and the fur of a now extinct breed of dog (Suttles 1991).

Most travel in the region was by canoe. Central Coast Salish groups manufactured different styles of dugout canoes for various purposes including saltwater fishing, freshwater fishing, transportation, and war (Suttles 1991). Winter village sites were located on the water in areas where canoes could be beached. Villages often consisted of one or more rows of plank houses paralleling the shore. Houses were constructed on a framework of posts and beams with plank walls and shed roofs (Suttles 1991).

One important aspect of Central Coast Salish society was the practice of ritual feasts and gift-giving events known as potlatches. The potlatch was a practice that marked an important event or a change in an individual's status (Suttles 1991; Fagan 2001). A typical potlatch included several or all of 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 to establish and reinforce status or fame. Direct reciprocity was not expected, but elaborate gift-giving rituals were seen as an investment in securing relationships and support networks between villages and neighbors (Suttles 1991).

1.7.2 Historic Period

The earliest Euro-American settlement in Clallam County and the Sequim area (in the 1850s) was known as Whiskey Flat; it was located on the cliffs above the Strait of Juan de Fuca (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).

In 1907, the Bugge Clam Cannery was established. A fire destroyed the plant in 1929, but the facility was rebuilt and operated until 1967. In 1967, Battelle hired John Graham and Company, a prominent architecture firm in Seattle, to design a master plan for a marine research laboratory to be located near Sequim, Washington, on 48.6 ha (120 ac) at the mouth of Sequim Bay on the Strait of Juan de Fuca, which Battelle had acquired the previous year (Battelle-Northwest 1967). The laboratory near Sequim was intended to "provide facilities for research projects which require ocean waters or oceanic environments" (Battelle-Northwest 1967).

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 (EO); and DOE Orders, directives, policies, and guidance. PNNL endeavors to conduct operations in a sustainable manner that is protective of the environment. This chapter summarizes PNNL's compliance status for 2015.

2.1 Sustainability and Environmental Management System

JP Duncan

The DOE-Battelle Prime Contract for the management and operation of PNNL (DOE-PNSO 2016) incorporates applicable requirements from DOE Order 436.1, *Departmental Sustainability*, including associated performance goals, objectives, and systems. The 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 (SSPP) pursuant to applicable laws, regulations and Executive Orders (EO), related performance scorecards, and sustainability initiatives…."

PNNL has incorporated these requirements through contract modifications, which include the development of a Site Sustainability Plan (e.g., PNNL 2015a), 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) 14001:2004(E) standards.

The PNNL Site Sustainability Plan, which identifies the status and accomplishments of sustainability projects related to DOE's sustainability goals, is prepared and submitted to DOE annually in accordance with DOE's guidance. The PNNL Site Sustainability Plan includes Pollution Prevention Program activities, accomplishments, and continuous improvement opportunities. Section 3.0 provides additional information concerning PNNL's EMS and the status of sustainability goals.

2.1.2 Executive Order 13693, "Planning for Federal Sustainability in the Next Decade"

Executive Order 13693 of March 19, 2015 (80 FR 15871), strengthens policies for federal agencies to increase energy efficiency and environmental performance. The Order revokes Executive Order 13423 of January 24, 2007, "Strengthening Federal Environmental, Energy, and Transportation Management" (72 FR 3919), and Executive Order 13514 of October 5, 2009, "Federal Leadership in Environmental, Energy, and Economic Performance" (74 FR 52117), which require increased federal sustainability and GHG emission reductions beyond those established by the earlier authorities.

Executive Order 13693 establishes new goals and requirements for GHG emissions reductions and reporting; increased renewable energy generation and use of renewable energy sources; green building performance for new buildings and increased performance compliance in existing buildings; reduction in potable and nonpotable water use; installation of green infrastructure for stormwater and wastewater management; increased fleet performance and sustainable work-related travel practices including electric vehicles, telecommuting and teleconferencing, and carpooling and public transportation; electronics stewardship; and pollution prevention and waste diversion. In addition, Executive Order 13693 requires the development and implementation of an annual Strategic Sustainability Performance Plan. PNNL has developed detailed plans and milestones for achieving site-specific energy efficiency objectives and goals as directed by Executive Order 13693 (80 FR 15871); details are available in Section 3.0.

2.2 Energy Independence and Security Act of 2007

JP Duncan

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 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) 2015, PNNL completed the third year of a 4-year cycle for 10 buildings subject to EISA Section 432 energy and water evaluation requirements. To date, 36 percent of PNNL buildings have met the criteria for DOE Federal Energy Management Program Guiding Principles for high-performance and sustainable buildings (PNNL 2015a). In addition, PNNL began construction on a new laboratory facility in 2015, which is designed as a high-performance and sustainable building using the DOE Guiding Principles.

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. Also, a 125 kW photovoltaic array continued operation in 2015, contributing to onsite energy generation, and together with a solar water heater, additional small photovoltaic arrays on monitoring stations, and renewable energy certificate (REC) purchases, provided over 50 percent of the PNNL electricity consumption from renewables (PNNL 2015a).

2.3 National Environmental Policy Act of 1969

MR Sackschewsky

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) (RCW 43.21C, as amended). Program activities include preparing sitewide project- 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 1,049 NEPA reviews during CY 2015 for research and support activities (635 Electronic Prep and Risk System reviews, 384 EMSL user proposals, and 30 facility-modification permits). NEPA staff reviewed the 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.

PNSO published no environmental impact statements or environmental assessments during 2015, but two environmental assessments were initiated during 2015: one for access to and use of Bio-Safety Level 3 laboratory facilities and one for the future site development of the PNNL Site.

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 possess 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 two new PNSO-approved generic categorical exclusions in 2015, one covering R&D related to terrestrial renewable energy and one for R&D related to aquatic renewable energy. A total of 13 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 sitewide categorical exclusion is not applicable, a project- or activity-specific categorical exclusion is prepared. DOE-PNSO approved one project-specific categorical exclusion in 2015 for the installation of wind profiling radar installations in Oregon and Washington. A list of all PNSO-approved categorical exclusions is available at http://science.energy.gov/pnso/nepa-documents/categorical-exclusion-determinations/.

A total of seven PNNL-related generic categorical exclusions were approved by DOE-RL in 2015, covering areas such as routine maintenance, small-scale R&D, site characterization, constructing 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.

NEPA staff also reviewed a randomly generated statistical subset of 437 maintenance actions to confirm that maintenance activities 1) did not involve significant environmental impacts; 2) were limited in scope, cost, and duration; 3) were adequately addressed under existing NEPA reviews; and 4) showed no trends that might indicate the need for a more intensive and directed review.

2.4 Air Quality

JM Barnett

Federal regulations that apply to air quality at the PNNL Campus and MSL 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, WAC 173-480, and WAC 173-491. The Benton Clean Air Agency (BCAA) implements and enforces most federal and state requirements on the PNNL Campus through BCAA Regulation 1 (BCAA 2014). The Olympic Region Clean Air Agency (ORCAA) implements and enforces most federal and state requirements at MSL. One Nonradiological Air Approval Order was obtained by PNNL from ORCAA in 2015.

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) to govern emissions of radionuclides from DOE facilities. These regulations address the measurement of point-source emissions, but are inclusive of fugitive emissions with regard to complying with established regulations for radioactive air emissions, including standards, monitoring provisions, and annual reporting requirements. The NESHAP 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 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 the reside/abide criterion is met or not (WAC 173-480).

On the PNNL Campus, PSF, the Research Technology Laboratory (RTL), and LSL2 have the potential to emit radionuclides. Radioactive emission point sources at the PNNL 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 Campus sitewide radioactive air permits, commonly called Potential Impact Category 5 (PIC-5) permits, 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 included emissions for instrument and operational checks; for nondispersible radioactive materials; for volumetrically released radioactive materials; and for certain facilities restoration activities.

Details regarding ambient air, stack emissions monitoring, and PIC-5 permit programs for the PNNL Campus and at MSL are reported annually. Data for 2015 are available in the *Pacific Northwest National Laboratory Campus Radionuclide Air Emissions Report for Calendar Year 2015* (Snyder et al. 2016). MSL has two nonpoint minor emission units that have 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 2015* (Snyder and Barnett 2016). During CY 2015, the PNNL 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.

2.4.4 Air Permits

PNNL has several permits that control airborne emissions from facilities within the PNNL Campus boundary. These include the radioactive air emission license (RAEL) issued by the Washington State Department of Health (WDOH; RAEL–005). The RAEL–005 Renewal 1 was issued by WDOH on June 17, 2015; WDOH RAELs are renewed every 5 years. The nonradiological approval orders issued by the BCAA are listed below:

- Environmental Molecular Sciences Laboratory (Order of Approval No. RO 2012-0009)
- Life Sciences Laboratory 2 (Order of Approval No. 2007-0006, Rev. 1)
- Physical Sciences Facility (Order of Approval No. 2007-0013, Rev. 1)
- 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: the RAEL issued by the WDOH (RAEL–014) and the nonradiological regulatory order issued by the Olympic Region Clean Air Agency (Notice of Intent 13NOI968).

2.5 Water Quality and Protection

TW Moon

Federal regulations that apply to water quality at the PNNL 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*, but the Act was significantly reorganized and expanded in 1972. The “Clean Water Act” became the Act’s common name with amendments in 1972. 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 NPDES permit program to the Washington State Department of Ecology.

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 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 Campus and leased facilities and requires monitoring at two discharge points, Outfall CS-001 and Outfall CS-003. Permit CR-IU005 regulates discharges from EMSL to Outfall 001. The process wastewater from EMSL is collected in four retention tanks. The content of each retention tank is monitored prior to its release to verify permit compliance. 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 discharge.

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 discharge.

2.5.2 Stormwater Management

Stormwater on the PNNL Campus is 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, promptly notifying and cleaning up spills, 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, two drain boxes in the boat storage yard and in the wastewater treatment system area contain multimedia filtration (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 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 (PNNL 2015a).

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 Americans' drinking water. 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 in 1974 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 above-ground 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.[1] Under the Safe Drinking Water

[1] Secondary standards are established to give 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.

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 Campus receives all drinking water for uses in laboratory and non-laboratory spaces from the City of Richland drinking water supply, and is not subject to the *Safe Drinking Water Act of 1974*. However, the registration of underground injection wells for stormwater (Section 2.5.2) and injection of ground-source heat pump return flow water (Section 6.0) have been completed as required by the Act.

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.

2.6 Environmental Restoration and Waste Management

HT Tilden

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.cfm/TriParty/TheAgreement. Printed copies of Revision 8 of the Tri-Party Agreement, which is current as of July 25, 2012, 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 (Ecology et al. 1989), Hanford waste sites were grouped into "operable units" based on geographic proximity or similarity of waste-disposal history. The PNNL 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. 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 Tri-Party Agreement Milestone M-26. Some wells located on the PNNL Campus are monitored by Hanford Site contractors as part of the regional groundwater monitoring network. Sampling data are available in the *Hanford Site Groundwater Monitoring Report for 2014* (DOE-RL 2015d).

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 in November 3, 1989, are located near the PNNL Campus.

A portion of the PNNL Campus 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 Campus areas north of Horn Rapids Road require no further remedial action under CERCLA.

Groundwater under the northern portion of the PNNL Campus is routinely monitored for contaminants migrating from Hanford Site contamination plumes and nitrates from offsite. See Section 6.0 for further information concerning groundwater monitoring on the PNNL 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 2015, no spills or non-permitted discharges that posed a threat to human health or the environment occurred at the PNNL Campus or MSL. Minor spills were cleaned up immediately and disposed of in accordance with applicable requirements. One spill, though minor, merited notification pursuant to the regulations (a small oil leak from the lower unit of an outboard motor causing a temporary sheen on the water at an MSL project on Hood Canal).

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 is located in the Radiochemical Processing Laboratory in the Hanford 300 Area, and is permitted as part of the Hanford Facility RCRA Permit. The Washington

State Department of Ecology approved an expansion of the unit group in 2015 to allow PNNL to treat waste in large boxes for disposal at Hanford. 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). The Hanford RCRA Permit may be viewed at http://www.ecy.wa.gov/programs/nwp/permitting/hdwp/rev/8c/index.html

With the exception of the 325 Hazardous Waste Treatment Units, PNNL facilities in Richland and near Sequim operate under the generator requirements of WAC 173-303. During CY 2015, 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 uses a 500-gallon underground storage tank for the storage of diesel fuel for a backup generator on the PNNL Campus in Richland. The tank is routinely monitored and no problems were observed in CY 2015.

The Washington State Department of Ecology and EPA personnel inspected six PNNL facilities for RCRA compliance in 2015. Three inspection reports (for three different locations accessed on the same day) identified administrative issues related to individual container labels, all of which were corrected during the inspection; two inspections found no noncompliances; and as of May 1, 2016, EPA has not issued the final report for the sixth inspection (conducted in July 2015). In addition, Ecology conducted an underground tank inspection and did not cite any noncompliance.

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 pursuant to Tri-Party Agreement Milestone M-26 (DOE-RL 2015e).

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 *2014 Hanford Site Polychlorinated Biphenyl Annual Document Log* (DOE-RL 2015f) and the *2014 Hanford Site Polychlorinated Biphenyl Annual Report* (DOE-RL 2015g) were produced in 2015 and describe the PCB waste management and disposal activities occurring on the Hanford Site, including PNNL Campus activities related to PCBs. The Annual Report is provided to EPA annually as required by 40 CFR 761.180. MSL did not generate enough PCB waste to require reporting under 40 CFR 761.180 in 2015.

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 2015, commercial pesticides were 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 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 2.1).

PNNL EPCRA reporting combines the quantities of chemicals in the Hanford 300 Area facilities that PNNL occupies and those present in PNNL 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 19, 2016.[2] The report provides updated inventories of diesel fuel and lead-acid batteries (which contain sulfuric acid, an extremely hazardous substance)—the only two chemicals exceeding the combined reporting threshold at the PNNL Campus during CY 2015. 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 19, 2016[3] for stored diesel fuel 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 Campus nor MSL was required to submit a Toxic Release Inventory Report for 2015, because no releases of Toxic Release Inventory chemicals occurred in excess of reporting thresholds.

Table 2.2 provides an overview of PNNL reporting under EPCRA for CY 2015.

2.7 Natural and Cultural Resources

JM Becker

The *Pacific Northwest Site Office Cultural and Biological Resources Management Plan* (CBRMP; DOE-PNSO 2015) provides direction and guidance relative to protecting and managing biological and cultural resources on the PNNL Site. 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.

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[2] Tilden HT. February 19, 2016. "EPCRA Tier Two Inventory Report: PNNL Site." [Email to J Beck, Benton County Emergency Services, Richland, Washington, and M Wroolie, Richland Fire Department, Richland, Washington]. Submitted to the Washington State Department of Ecology 2/19/16 via Secure Access Washington website.

[3] Tilden HT. February 19, 2016. "EPCRA Tier Two Inventory Submittal." [Email to JI Wisecup, Clallam County Emergency Services, Port Angeles, Washington, and P Williams, Clallam County Fire District 3, Sequim, Washington]. Submitted to the Washington State Department of Ecology 2/19/16 via Secure Access Washington website.

Table 2.1. 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 quantity equal to or greater than 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, process, 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), 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 2.2. *Emergency Planning and Community Right-to-Know Act of 1986* Compliance Reporting, 2015

Section	Description of Reporting	Reporting Status	Notes
302	Emergency planning notifications	Not required	No changes to 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	Not required	No changes to previously reported hazardous substances in use.
312	Chemical inventory	Yes	The CY 2015 Tier Two reports for the PNNL Campus and MSL were submitted to the Washington State Department of Ecology, the LEPC, and the local fire department on February 24, 2015.
313	Toxic release inventory	Not required	No releases greater than the reporting threshold requirement.

CY = Calendar Year.
LEPC = Local Emergency Planning Committee.
MSL = PNNL Marine Sciences Laboratory.
PNNL = Pacific Northwest National Laboratory.

2.7.1 Biological Resources

JM Becker and MA Chamness

A number of federal laws, Executive Orders, and related Memoranda contain requirements for protecting biological resources. This section summarizes the requirements and catalogs PNNL's compliance activities related to biological resources in 2015.

The *Endangered Species Act of 1973* (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 the habitats upon which they depend. Under Section 7 of the Act, federal agencies are required to evaluate actions that they perform, fund, or permit to determine if any species listed as endangered or threatened may be affected by the proposed action. Consultation with the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service is required if the action may affect listed species. The biological resource review process is the primary means by which PNNL determines if any listed species may be affected by a proposed action. Biological resource reviews in 2015 demonstrated PNNL compliance. PNNL issued five no-effect determinations in 2015. One Determination of Take authorization was acquired by PNNL in 2015.

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. PNNL projects with a potential to affect avian species listed under the Act comply with the requirements of this Act by using the PNNL biological resource review process as described in the CBRMP (DOE-PNSO 2015). PNNL biologists resolved over 23 reports concerning migratory birds on the PNNL Campus and at MSL.

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 ecological review process provides assurance that a proposed action will not adversely affect bald or golden eagles. Mitigation includes performing work outside of the winter season, staying out of established buffer areas, or entering buffer areas at mid-day, thereby minimizing impacts by avoiding eagle roosting periods.

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 the 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 National Marine Fisheries Service on any action that might adversely affect essential fish habitat. The PNNL biological resource review process supports the protection of essential fish habitat. No essential fish habitat consultations were completed by PNNL in 2015.

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 level. Consultation with the National Marine Fisheries Service is required if an action may affect any marine mammal species.

The biological resource review process is the primary means by which PNNL determines if marine mammal species may be affected by a proposed action. One incidental take authorization was obtained by PNNL in 2015. PNNL issued three no-effect determinations in 2015.

The *Rivers and Harbors Appropriation Act of 1899* (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 is delegated to the U.S. Army Corps of Engineers. PNNL evaluates the need for Section 10 permits as part of the biological resource review for each project. Two nationwide permits were acquired by PNNL under Section 10 in 2015.

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 control mechanisms for nuisance species on aquatic equipment used in infested waters, to prevent accidental introduction of nuisance species into uninfested waters.

Executive Order 11990 of May 24, 1977, "Protection of Wetlands" (42 FR 26961), requires federal agencies to minimize the loss or degradation of wetlands on federal lands, and to preserve and enhance the natural and beneficial values of those lands. Compliance with this Order, as well as the wetland provisions of the *Clean Water Act*, is achieved through the biological resource review process at PNNL. Two nationwide permits were acquired by PNNL under Section 404 of the Clean Water Act in 2015.

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 consequences of flood hazards need to be considered when developing water- and land-use plans, as well as alternatives to floodplain use. The biological resource review process at PNNL identifies any impacts on floodplains within a proposed project area.

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 prevent introduction and control of invasive species.

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 between DOE and the U.S. Fish and Wildlife Service (DOE and USFWS 2013) 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.

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/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, as well as the need for compatible economic development, and encourages 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/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. No federal consistency determinations were acquired by PNNL in 2015.

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 m^3/s (21 ft^3/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 preferred 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 2016) implement the policies of the *Shoreline Management Act of 1971* at the local level and establish a shoreline-specific combined comprehensive plan, zoning ordinance, and development permit system. The PNNL biological resource review process assures the policies of the Act are met. Three Shoreline Substantial Development Permit Exemptions were acquired by PNNL in 2015.

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," and guidance in DOE Order 450.1A, *Environmental Protection Program*, relative 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.

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 implementing any activities that may disturb such resources. Twenty-four biological resource reviews were conducted for PNNL projects in CY 2015, 12 on the Richland Campus, seven at MSL or for MSL-related projects, and five at other locations.

Potential project impacts were evaluated for plant or animal species protected under the *Endangered Species Act of 1973* and species proposed or candidates for such protection, or 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 law, regulation, or conservation priority guidance.

Staff ecologists perform annual pedestrian and visual reconnaissance of biological resources found on undeveloped portions of the PNNL Campus north of Horn Rapids Road and at MSL. The primary objective of the field surveys is to determine the occurrence of the plant and animal species and habitats of interest noted above for project-specific biological resource reviews. A list of plant and animal species identified on the PNNL Campus north of Horn Rapids Road from 2009 to 2015, and MSL from 2013 to 2015 and their status are provided in Appendix C and Appendix D, respectively.

2.7.1.1 Noxious Weed Control

Several species listed as Class B and Class C noxious weeds have been identified on the PNNL Site (Larson and Downs 2009; Duncan et al. 2014, 2015). Class B noxious weeds are species designated for control where they are not yet widespread to prevent new infestations (NWCB 2015). Class C noxious weeds are already widespread and each county determines what level of control is required. On the PNNL Site, Class B species include diffuse knapweed, rush skeletonweed, Russian knapweed, burning bush, puncturevine, and yellow starthistle, while Class C species include field bindweed, Russian olive, and tree-of-heaven. The Class B and Class C noxious weeds listed above are all classified as such by the state of Washington (WAC 16-750-011 and 16-750-015, respectively).

Starting in 2010, licensed PNNL staff, in coordination with staff ecologists, used hand-spraying methods to control populations of these specific weeds while minimizing impacts on other vegetation (Figure 2.1). The herbicide Milestone™ (along with a water conditioner, drift control and sticking agents, and blue dye for visibility) was spread using backpack sprayers. Most areas require spraying over 2 or more years to eradicate perennial weeds that are not completely killed or that germinate from seeds in the soil. Approved biocontrol agents, such as insects that parasitize only the targeted plant species, are reviewed annually for new releases that could replace or supplement the use of herbicides in controlling these plant species on the PNNL Site.

Figure 2.1. Hand-Spraying Herbicides on Individual Noxious Weeds

Diffuse knapweed has not been targeted since 2012 when seed-eating weevils (*Larinus minutus*) were observed parasitizing numerous plants within the PNNL Site (Duncan et al. 2013). The weevils were not purposely introduced by PNNL. The seed-eating weevils do not kill all the plants, but are keeping the plants from spreading by eating the seeds. If the weevils become ineffective, diffuse knapweed will be targeted once again for herbicide treatment.

Russian knapweed can form dense stands where water is adequate. There are no approved biocontrol agents, but application of Milestone™ when the plant is blooming and beginning to create seeds was shown to be effective on plants growing on the PNNL Site (Duncan et al. 2013). Russian knapweed was not targeted in 2015 because of a combination of limited staff availability and dry weather conditions that reduced its growth in 2015. Limited staff availability also prevented hand-spraying of burning bush on and near well access roads. The only practical way to treat the long linear strips of dense burning bush in road margins is by hand-spraying herbicide carried in a tank mounted on a small service vehicle. The early fire hazard restrictions in 2015 precluded access by vehicle to the infested areas.

The primary target species in 2015 were rush skeletonweed and yellow starthistle. Rush skeletonweed spreads by seed and by root, forming dense stands if left unchecked. After 5 years of herbicide treatments, most of the dense populations of rush skeletonweed have been destroyed, leaving scattered individuals and small clusters. Hand-spraying began on June 3 and ended for the season on June 18, 2015, during which approximately 12 ha (30 ac) were treated. Rush skeletonweed was sprayed wherever it was encountered; no yellow starthistle plants were observed. Figure 2.2 shows areas of the PNNL Campus traversed on foot and treated with herbicide.

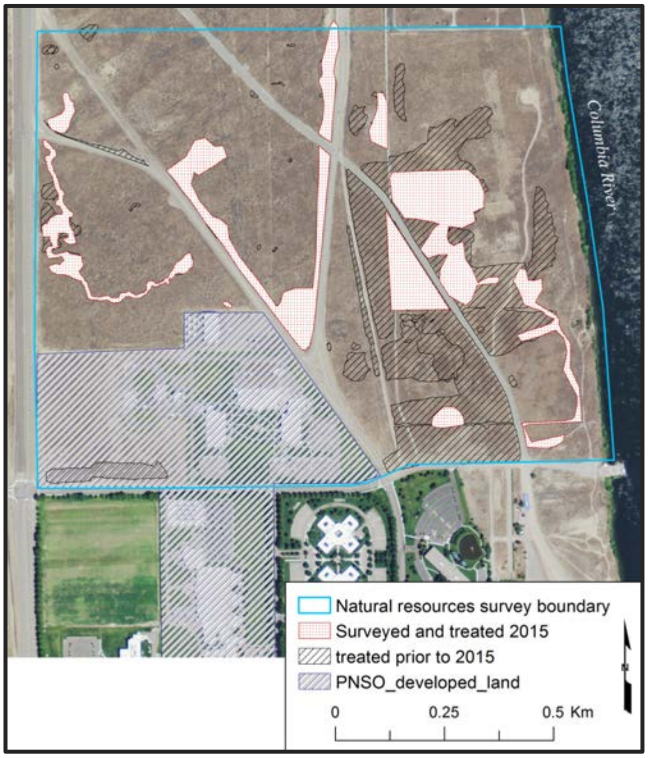


Figure 2.2. Areas Treated for Noxious Weeds on the PNNL Site in 2015

2.7.2 Cultural Resources

JL Mendez

A number of federal Acts and Orders provide the framework for protection of cultural resources on the PNNL Campus and at MSL. This section summarizes the requirements and catalogs PNNL's compliance activities in 2015.

The *National Historic Preservation Act of 1966* (54 U.S.C. § 300101 et seq.) and its amendments establish historical 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 expands the National Register of Historic Places listing to include resources of state and local significance, and it establishes 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* was repealed from 16 U.S.C. § 470 et seq., and reenacted in 54 U.S.C. § 300101 et seq., *Historic Preservation Programs*. At PNNL, compliance with the *National Historic Preservation Act of 1966* is achieved through the cultural resource review process.

The *Antiquities Act of 1906* (54 U.S.C. § 320301–320303 and 18 U.S.C. § 1866(b)) provided for the protection of historical 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 offense, 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 54 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 cultural resource review process supports 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 the 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 *Archaeological 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*.

The 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 are preserved, restored, and maintained.

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 to assure 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 141.1, "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 transmit DOE's *American Indian and Alaska Native Tribal Government Policy* (DOE 2009), 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 141.1, "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 (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.

In accordance with *National Historic Preservation Act of 1966* (54 U.S.C. § 300101 et seq.) Section 106 requirements, 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 *National Historic Preservation Act of 1966* Section 106. Two PNNL projects in 2015 were reviewed and determined to have No Potential to Cause Effect on historic properties as defined by 36 CFR 800.3(1): one at MSL and one project in multiple vicinities including Oregon Raceway Park, Rufus, and Hood River, Oregon. 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, or 3) an Adverse Effect. Five Section 106 cultural resource reviews were conducted for PNNL projects in 2015: one on the PNNL Campus, one on the Hanford Site, and three offsite reviews including Wahkiakum County and Forks, Washington, and one project with components in both Astoria and Coos Bay, Oregon. Four of these reviews resulted in findings of No Historic Properties Affected, while one (on the Hanford Site) resulted in a No Adverse Effect finding. In addition to these Section 106 reviews, 12 projects were reviewed by cultural resources staff to assure that the project activities were covered by previously conducted Section 106 cultural resource reviews. Two emergency cultural resources post-reviews were completed in 2015; one on the PNNL Campus and one at MSL. Consistent with 36 CFR 800.12, emergency situations in which there is an immediate risk to employee or environmental safety do not require a cultural resources review until the emergency is over. Once the emergency is resolved and/or stabilized, a cultural resources review is completed by following the regular 36 CFR Part 800 steps and time frames. Cultural resources staff determined that both emergency reviews included actions and activities covered by previously conducted Section 106 cultural resource reviews. In addition, one *National Historic Preservation Act of 1966* Section 110 review was completed for PNNL in 2015. This review included an archaeological resources inventory of undeveloped lands on the PNNL Campus. The inventory was conducted in an effort to identify archaeological resources within the survey area and the associated report is intended to be used as a guide for future subsurface investigations prior to any proposed project-associated ground-disturbing activities.

To assure that important cultural resources are protected on the PNNL Campus, the CBRMP (DOE-PNSO 2015) requires annual monitoring of three National Register eligible properties to identify potential threats and recommend appropriate actions, if necessary. As stipulated in the CBRMP, trip results are analyzed and reported to local Native American tribes and the Washington State Historic Preservation Office. The annual cultural resources monitoring trip was conducted on October 28, 2015. Monitoring was conducted by the PNNL cultural resources contractor CH2M HILL, with the participation of PNSO, PNNL, 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.

As noted during previous PNNL Campus monitoring, portions of landscape fabric were visible in areas at one site, where windborne sediments have been removed by aeolian processes. An old excavation and associated push pile near the revegetated portions of the site, which was noted in the previous year's monitoring trip, continued to be retaken by native vegetation. Evidence of continued erosional impacts, first identified during a 2013 monitoring trip at a site near the Columbia River, appeared to be less in 2015 compared to prior years, possibly due to unusually low water levels in 2015; however, some erosion on the terrace edge at one of the sites appears to be increasing. Erosional activity appears to be mostly animal related (trails and burrowing) and is continued by wind, water, and gravity. No previously unrecorded impacts on any of the sites were identified during the 2015 monitoring trip and these areas will continue to be monitored.

2.8 Radiation Protection

GA Stoetzel

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 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 during 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. The public is required to be notified annually of property released from PNNL facilities. Notifications are done yearly through the issuance of this annual site environmental report. No property with detectable residual radioactivity above guideline limits was released in 2015.

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.

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

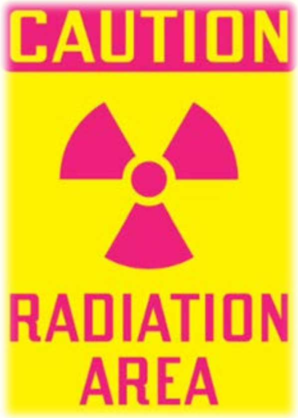
The purpose of DOE Order 435.1 is to establish requirements to assure DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, as well as the environment. The Order takes a cradle-to-grave approach to managing waste, and includes requirements for waste generation, 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

HT Tilden

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 releases to the environment that occurred at PNNL during CY 2015.

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" where reduced reporting requirements apply. There were no continuous releases on the PNNL Campus or at MSL in 2015.

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

DOE Order 232.2, Admin Chg 1, 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 2015. A small release of oil from a faulty engine seal during boat operations was reported to the National Response Center and Washington State Department of Ecology (and DOE). Although the release was very small (less than 0.95 L [1 quart]) it caused a sheen to appear temporarily on the water, which triggered the release reporting requirements.

2.10 Summary of Permits

HT Tilden

Table 2.3 summarizes air, liquid, and hazardous waste permits for the PNNL Campus and MSL during 2015. Project-specific permits are also acquired but are not reflected in the table because they are usually of limited term and scope.

Table 2.3. PNNL Air, Liquid, and Hazardous Waste Permits, 2015

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	12/31/2017
Washington Department of Health	RAEL-005	PNNL Campus	Radioactive air emissions	6/17/2020
Washington Department of Health	RAEL-014	PNNL Marine Sciences Laboratory	Radioactive air emissions	10/1/2017
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	Approval Order[c] 2007-0013, Rev. 2	Physical Science Facility complex (PNNL Campus)	Nonradioactive air emissions	None
Benton Clean Air Agency	Approval Order 2012-0016, Rev. 1	PNNL Campus (PNSO R&D Activities)	Nonradioactive air emissions	None
Benton Clean Air Agency	Approval Order 2012-0017, Rev. 2	PNNL Campus (Battelle building support systems)	Nonradioactive air emissions	None
Benton Clean Air Agency	Approval Order RO 2012-0009	W.R. Wiley Environmental Molecular Sciences Laboratory	Nonradioactive air emissions	None
Benton Clean Air Agency	Approval Order 2007-0006, Rev. 1	Life Sciences Laboratory 2	Nonradioactive air emissions	None
Olympic Region Clean Air Agency	Approval Order for Notice of Construction 05NOC415	PNNL Marine Sciences Laboratory	Nonradioactive air emissions	None
Olympic Region Clean Air Agency	Approval Order for Notice of Construction 08NOC621	PNNL Marine Sciences Laboratory	Nonradioactive air emissions	None
Liquid Effluents[d]				
City of Richland	CR-IU001	PNNL 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	3/30/2017
City of Richland	CR-IU011	Physical Sciences Facility (north of Horn Rapids Road)	Liquid effluent discharges to city sewer	3/3/2018

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[(a)]
City of Richland	CR-IU010(b)	PNNL-occupied locations in Hanford Site 300 Area	Liquid effluent discharges to city sewer	10/20/2016
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-9251	PNNL Campus	Reuse of cooling water for irrigation	6/30/2020
Washington State Department of Ecology	ST-9274	Biological Sciences Facility and Computational Sciences Facility	Reinjection of well water used in ground-source heat pump	6/4/2020
Washington State Department of Ecology	WA0040649	PNNL Marine Sciences Laboratory	Treated liquid effluent discharges to Sequim Bay	11/30/2017
Hazardous Waste				
Washington State Department of Ecology	WA7890008967	325 Hazardous Waste Treatment Units (located in the Hanford Site 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) Permits are issued to DOE-Richland Operations Office (DOE-RL) and/or its contractor(s); PNNL is obligated to comply with these permits through an operating agreement between DOE-RL and PNSO.
(c) Modified to include previous permit amendments on December 22, 2014.
(d) PNNL also conducts activities in leased facilities for which wastewater permits are issued to the owner. These permits are not listed here, but compliance-related impacts from PNNL activities are included in this report.

3.0 ENVIRONMENTAL MANAGEMENT SYSTEM

J Su-Coker

PNNL has a mature, robust EMS that has been certified to meet the requirements of ISO 14001 standards since 2002; registration is maintained through yearly independent third-party verification. 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 if 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. The 2015 EMS third-party audit confirmed that the system remains in conformance with the ISO 14001:2004 Standard (Figure 3.1). Maintaining the ISO 14001-certified EMS is a key component of PNNL's success in achieving sustainability.

In addition, the 2015 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 reevaluated using an established procedure and updated as appropriate (see additional discussion below).
- Measurable environmental goals, objectives, and targets were identified, reviewed, and updated as appropriate (see Section 3.1).
- 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.


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 14001:2004

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 IAF

Certificate Number: 6Z781-EM6
Certificate Issue Date: 10-OCT-2014
Registration Date: 20-OCT-2014
Expiration Date *: 19-OCT-2017

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-14001:2004 Standards

- 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.

PNNL examines its operations to determine which categories of environmental impacts (referred to as "aspects" in the ISO 14001 Standard) 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 analysis 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, including 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, including 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.
- **Physical Interaction with 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.
- **Energy Use**. Using energy judiciously is a prime objective of 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, creates non-regulated 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.
- **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.

- **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 hybrids 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.

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 EMS Core Team as a best practice to drive continuous improvement in its sustainability environmental performance and enable an integrated approach in managing the environmental aspects and impacts. The EMS 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

Signed in 2009, Executive Order 13514 of October 5, 2009, "Federal Leadership in Environmental, Energy, and Economic Performance" (74 FR 52117), establishes sustainability goals for federal agencies and focuses on improving their environmental, energy, and economic performance. Executive Order 13693 of March 19, 2015, "Planning for Federal Sustainability in the Next Decade" (80 FR 15871), was signed, thereby revoking and superseding Executive Order 13514, to establish new numerical targets to achieve sustainability goals for agencies.

PNNL's comprehensive and diverse approach meets the principles of Executive Order 13693 requirements. Details about PNNL's plan to advance DOE's sustainability mission are captured in the PNNL *FY 2016 Site Sustainability Plan* (PNNL 2015a). This plan contains the annual status and strategy for achieving long-term goals and includes practical actions to conserve energy, water, and financial resources; improve the comfort and productivity of PNNL staff; and benefit the environment. Accomplishments from FY 2015 are highlighted below. Each DOE goal and PNNL's performance status, planned actions, and an assessment of the risk of non-attainment are provided in Table 3.1 at the end of this section.

3.1.1 Greenhouse Gas Reduction and Comprehensive Greenhouse Gas Inventory

As shown in Figure 3.2, PNNL's Scope 1 and 2 GHG emissions, generated from operations and activities (Scope 1) or associated with the purchase of energy (Scope 2), have increased from approximately 44,000 metric tons carbon dioxide equivalent ($MTCO_2e$) to over 46,000 $MTCO_2e$ between FY 2008's baseline and FY 2015. This increase was primarily driven by an increase in computer equipment to support the growing computational sciences research area. PNNL executed multiple energy intensity reduction projects, which served to offset much of the additional computer load. PNNL will continue implementing energy conservation measures, including procuring RECs, where cost-effective. In FY 2015, PNNL procured enough RECs to offset 100 percent of its electrical use, thereby exceeding the new FY 2025 goal of 50 percent of annual electrical consumption.

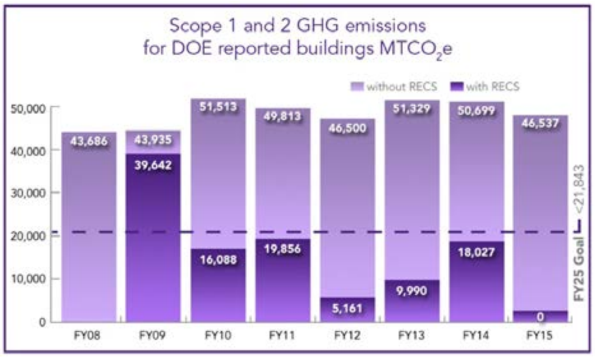


Figure 3.2. Scope 1 and 2 Greenhouse Gas Emissions from DOE Buildings on the PNNL Campus, FY 2008–2015 ($MTCO_2e$ = metric tons of carbon dioxide equivalent)

PNNL's Scope 3 GHG emissions include emissions from business travel (58 percent), employee commuting (30 percent), transmission and distribution (T&D) loss (10 percent), and offsite solid waste disposal and wastewater treatment (2 percent). Scope 3 emissions have decreased by 12 percent compared to the FY 2008 baseline after adjusting for T&D loss-related emissions avoided through REC purchases (Figure 3.3). Reducing Scope 3 emissions continued to be a strategic priority at PNNL in FY 2015. For example, staff members continued to take advantage of the telework option. By the end of FY 2015, approximately 15 percent of employees had signed telework agreements, and 5 percent of staff teleworked an average of at least once per week. This has resulted in an estimated 223 $MTCO_2e$ avoidance. PNNL has also earned the "Bike-Friendly Business" (bronze level) by the League of American Bicyclists in early FY 2015. This prestigious designation, as well as employee support, demonstrates that PNNL has a robust cycling community. PNNL's Scope 3 emissions reduction strategy will continue to emphasize teleworking, alternative commuting, and T&D losses associated with electricity use.

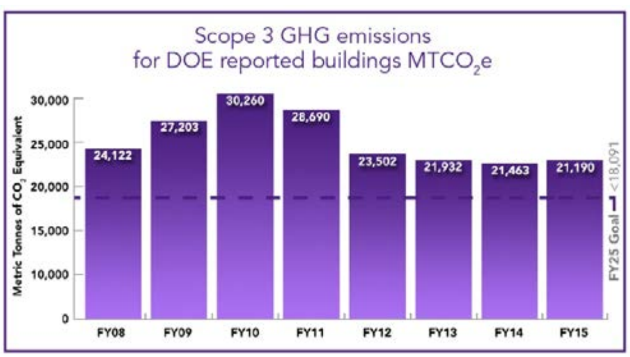


Figure 3.3. Scope 3 Greenhouse Gas Emissions from DOE Buildings on the PNNL Campus, FY 2008–2015 ($MTCO_2e$ = metric tons of carbon dioxide equivalent)

3.1.2 High-Performance Sustainable Buildings

PNNL's greatest environmental challenge lies in reducing building energy intensity. To help achieve building energy intensity reduction, the PNNL Sustainability Program led a successful 3-month campaign in FY 2015 to foster energy conservation behavior and stimulate culture change. Key aspects of the campaign included using 14 building-level sustainability advocates to engage with occupants, emphasizing personal outreach. More than 200 energy-conserving actions were reported in those 14 buildings and they represented an estimated annualized savings of nearly 120,000 kWh. Between FY 2003 and FY 2015, PNNL's energy intensity fell from a baseline of 214 kBtu per GSF to 167 kBtu per GSF—a net reduction of approximately 22 percent (Figure 3.4).

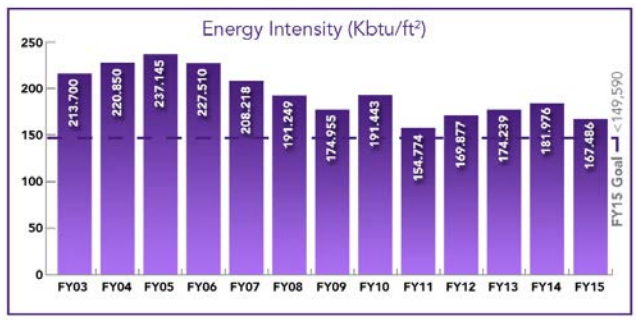


Figure 3.4. PNNL's Energy Intensity Has Decreased Approximately 22 Percent from the FY 2003 Baseline

While we did not achieve the target of a 30 percent reduction by FY 2015, PNNL remains committed to constructing and operating buildings that meet the federal government's Guiding Principles for High-Performance and Sustainable Buildings (HPSBs). Currently, 36 percent of PNNL buildings meet HPSB requirements, including the Systems Engineering Building, which was completed in FY 2015 and received Leadership in Engineering and Environmental Design (LEED) Gold certification.

To improve building operations, PNNL is fully implementing a continuous commissioning process beginning in FY 2016. Continuous commissioning is enabled by investments in advanced building meters, a cloud-based building data management platform, diagnostic tools, and a more robust preventative maintenance program. With real-time monitoring and analysis of building systems data, operations staff will be able to make better and quicker decisions to reduce energy use and maintenance costs, thereby extending facility equipment life.

3.1.3 Fleet Management

PNNL continues to trend in the right direction through expanded use of alternative fuel vehicles, including electric vehicles. Accomplishments related to fleet management in FY 2015 include the following:

- achieved the 20 percent reduction goal and had an overall cumulative reduction of 25 percent from the FY 2005 baseline (Figure 3.5);
- exceeded the alternative fuel use goal (Figure 3.6); and
- 50 percent of the light-duty vehicles acquired in FY 2015 were alternative fuel vehicles. Currently, PNNL has a total of 39 light-duty vehicles, of which 35 (89 percent) are alternative fuel vehicles.

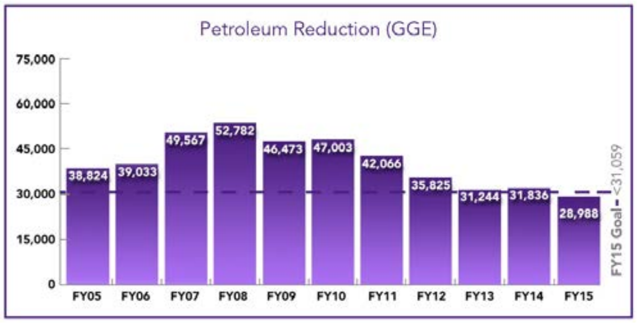


Figure 3.5. Petroleum Fuel Use, FY 2005–2015 (GGE = gallon gas equivalent)

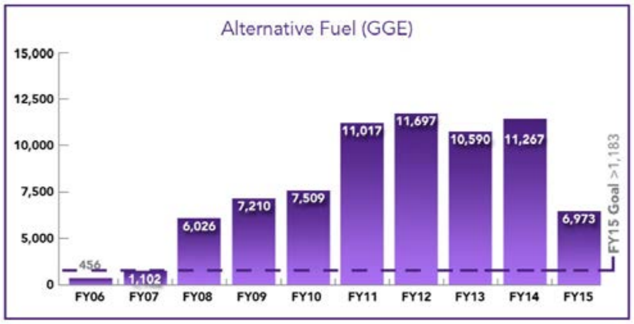


Figure 3.6. Alternative Fuel Use, FY 2006–2015 (GGE = gallon gas equivalent)

3.1.4 Water-Use Efficiency and Management

PNNL has met the FY 2025 potable water reduction goal and, as of FY 2015, has reduced its intensity by 67 percent compared to the FY 2007 baseline (Figure 3.7). In addition to implementation of planned water-saving projects and operational improvements, several opportunities to reduce non-contact cooling water were identified during permit regulatory reviews, thereby further decreasing overall potable water usage.

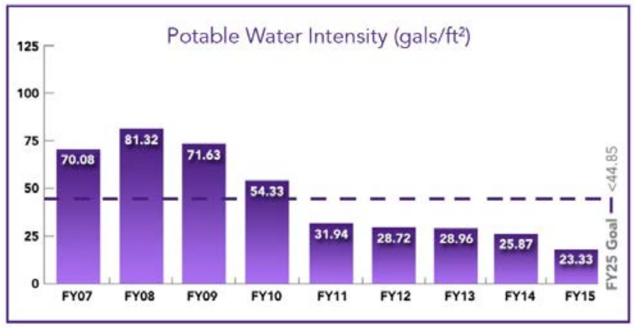


Figure 3.7. Potable Water-Use Intensity, FY 2007–2015

The industrial, landscaping, and agricultural (ILA) water used at PNNL is withdrawn from the Columbia River via PNNL and the City of Richland irrigation systems and is used primarily for landscaping, cooling ponds, and aquatic research. By applying our Landscape Master Plan and implementing ILA water reduction opportunities, PNNL has achieved a reduction of 4.6 percent compared to the FY 2011 baseline (Figure 3.8). Achieving the ILA water reduction goal of 30 percent by FY 2025 from the FY 2011 baseline will be a challenge for PNNL because of the addition of new buildings in areas that are currently semi-arid desert. However, we plan to continue installing metering and moisture monitoring equipment, and to employ our engineering standards and specifications to pursue opportunities for additional ILA reductions.

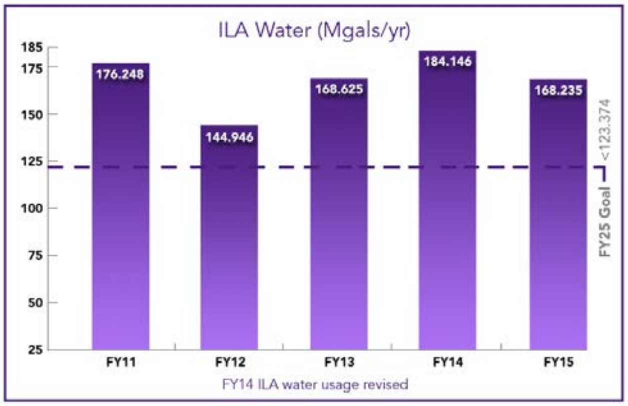


Figure 3.8. Potable Water-Use Intensity, FY 2011–2015 (ILA = industrial, landscaping, and agricultural)

3.1.5 Pollution Prevention and Waste Reduction

During FY 2015, PNNL expanded paper, aluminum, and plastic recycling by placing recycling bins in approximately 40 laboratory spaces. In addition, recognizing that nitrile gloves create one of the largest waste streams from PNNL's research activities, PNNL participated in Kimberly-Clark's "RightCycle," a nitrile glove recycling program. As part of the pilot program, approximately 2,000 nitrile gloves were collected from EMSL and PSL over a 4-month period. PNNL will evaluate expanding nitrile glove recycling in FY 2016.

To improve Pollution Prevention Program performance, PNNL staff conducted an assessment, which consisted of an online survey, staff interviews, and recycling station walk-downs, to identify improvement opportunities that will be used to create a Pollution Prevention Program improvement strategy during FY 2016. In FY 2015, approximately 54 percent of nonhazardous sanitary waste was diverted through recycling and composting (Figure 3.9). Approximately 86 percent of the waste from construction and demolition projects was recycled.

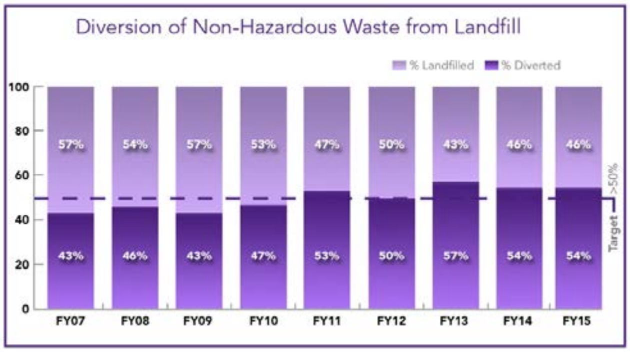


Figure 3.9. Diversion of Nonhazardous Waste from Landfills, FY 2007–2015

3.1.6 Ozone-Depleting Substances

Executive Order 13693 of March 14, 2015, "Planning for Federal Sustainability in the Next Decade" (80 FR 15871), requires DOE sites to purchase sustainable products including Significant New Alternative Policy chemicals or other alternatives to ozone-depleting substances and hydrofluorocarbons that contribute to global warming. PNNL's approach to reducing ozone-depleting substances includes implementing administrative controls using procedures for maintenance, repair, and disposal as well as procurement policy. PNNL's Acquisition Guideline requires the purchase of Class 2 ozone-depleting substance alternatives within the following sectors: refrigeration and air-conditioning, foam-blowing agents, cleaning solvents, fire suppression and explosion protection, aerosols, sterilants, tobacco expansion, adhesives, coatings, and inks. The Acquisition Guideline also requires alternatives to Class 1 ozone-depleting substances, such as chlorofluorocarbons, halons, carbon tetrachloride, methyl chloroform, methyl bromide, and hydrobromofluorocarbons.

3.2 Awards and Recognition

PNNL received three awards for its environmental efforts during CY 2015:

- On April 22, 2015, the League of American Bicyclists awarded PNNL a bronze-level award for being a Bike-Friendly Business."
- On May 12, 2015, the Association of Washington Business awarded PNNL its 2015 annual "Sustainable Communities and Green Building" award for its Sustainable Campus program.
- In January 2016, DOE announced that PNNL was awarded the FY 2015 bronze-level "GreenBuy" award for excellence in sustainable acquisition.

3.3 Climate Change and Sustainability

In addition to our work to curb carbon emissions and conduct other sustainability measures, PNNL is building resilience toward climate impacts that threaten the operation of PNNL. In 2015, PNNL climate impacts scientists and PNNL Facilities and Operations professionals joined forces to put PNNL's research and practical experience with resilience planning to work right at home. The result was the *PNNL Climate Resilience Action Plan* (PNNL 2015b). The highest-priority vulnerabilities identified were the impact of higher temperatures on PNNL's buildings and energy consumption, and the impact of intense precipitation events on PNNL buildings. The Action Plan describes current and planned actions to build PNNL's resilience to future climate exposures. Most current measures are well-established procedures; new measures are being integrated into plans to help manage vulnerabilities.

Table 3.1. DOE Strategic Sustainability Performance Plan (SSPP) Goals and Targets for FY 2015

DOE Goal	Performance Status Through FY14	Planned Actions and Contribution	Risk[a] of Non Attainment
Goal 1: Greenhouse Gas Reduction			
50% Scope 1 & 2 greenhouse gas (GHG) reduction by FY25 from a FY08 baseline (FY15 target: 19%)	FY08 Baseline: 43,686 metric tons of carbon dioxide equivalent ($MTCO_2e$) FY15 Actual: 0 $MTCO_2e$ (46,537 $MTCO_2e$ without renewable energy certificates [RECs]) FY25 Goal: 21,843 $MTCO_2e$ Status: 100% reduction	Continue REC purchases for near-term GHG reduction goal and implement energy conservation measures, where cost-effective.	Low
25% Scope 3 GHG reduction by FY25 from a FY08 baseline (FY15 target: 6%)	FY08 Baseline: 24,122 $MTCO_2e$ FY15 Actual: 21,190 $MTCO_2e$ (24,277 $MTCO_2e$ without RECs) FY25 Goal: 18,091 $MTCO_2e$ Status: 12% reduction	Continue to promote telework and use of video teleconferencing to reduce travel; encourage staff through bus and carpool promotions and incentives.	Low
Goal 2: Sustainable Buildings			
25% energy intensity (British thermal units [Btu] per gross square foot [GSF]) reduction in goal-subject buildings, achieving 2.5% reductions annually, by FY25 from a FY15 baseline.	FY15 Baseline: 167,486 Btu/GSF FY25 Goal: 125,878 Btu/GSF	Continue to implement Consolidated Energy Data Report projects and operational improvements.	High
Energy Independence and Security Act of 2007 (EISA) Section 432 energy and water evaluations.	Completed third year of the 4-year EISA cycle of 10 buildings.	Continue to execute EISA evaluations.	Low
Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.[b]	All individual buildings metered for electricity, natural gas, steam, and water, where cost-effective and appropriate.	Improve building performance through data analysis from the meters.	Low
At least 15% (by building count or GSF) of existing buildings >5,000 GSF to be compliant with the revised Guiding Principles for High-Performance Sustainable Buildings (HPSBs) by FY25, with progress to 100% thereafter.[c]	36% of PNNL buildings >5,000 GSF per Facilities Information Management System are HPSB compliant.	Continue to trend toward 100% of facilities meeting HPSB Guiding Principles.	Low

DOE Goal	Performance Status Through FY14	Planned Actions and Contribution	Risk[a] of Non Attainment
Efforts to increase regional and local planning coordination and involvement.	Collaborated with City of Richland Energy Services on contingency planning associated with electrical service outages and catastrophic events.	Continue to leverage partnerships to obtain Strategic Sustainability Performance goals.	Low
Net Zero Buildings: Percentage of the site's existing buildings >5,000 GSF intended to be energy, waste, or water net zero buildings by FY25.	No net zero buildings currently on campus.	Perform an assessment in FY16 to gain understanding of this requirement and actions required to meet it.	Low
Net Zero Buildings: Percentage of new buildings (>5,000 GSF) entering the planning process designed to achieve energy net zero beginning in FY20.	No net zero buildings currently on campus.	Perform an assessment in FY16 to gain understanding of this requirement and actions required to meet it.	Low
Goal 3: Clean & 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 10% in FY16–17, working toward 25% by FY25.	FY15: 39.4% of annual electric and thermal energy from renewable and alternative energy.	Continue to meet the clean energy goal through onsite generation and RECs.	Low
"Renewable Electric Energy" requires that renewable electric energy account for not less than 10% of a total agency electric consumption in FY16–17, working toward 30% of total agency electric consumption by FY25.	FY15: 53% of annual electric consumption is renewable electric energy.	Continue to meet the renewable energy goal through onsite generation and RECs.	Low
Goal 4: Water Use Efficiency and Management			
36% potable water intensity (gallon [gal] per GSF) reduction by FY25 from a FY07 baseline. (FY15 target: 16%)	FY07 Baseline: 70.08 gal/GSF FY15 Actual: 23.33 gal/GSF FY25 Goal: 44.85 gal/GSF Status: Exceeded goal	Update site water management plan in FY16 to identify opportunities for additional reductions.	Low

DOE Goal	Performance Status Through FY14	Planned Actions and Contribution	Risk[a] of Non Attainment
30% water consumption (gal) reduction of industrial, landscaping, and agricultural water by FY25 from a FY10 baseline. (FY15 target: 10%)	FY11 Baseline: 176,248,000 gal FY15 Actual: 168,235,000 gal FY25 Goal: 123,374 gal Status: 4.6% decrease	Update site water management plan in FY16 to identify opportunities for additional reductions.	Medium
Goal 5: Fleet Management			
20% reduction in annual petroleum consumption by FY15 relative to a FY05 baseline; maintain 20% reduction thereafter. (FY15 target: 20%)	FY05 Baseline: 38,824 gal of gasoline equivalent (GGE) FY15 Actual: 28,988 GGE FY15 Goal: 31,059 GGE Status: 25% reduction	Continue to promote sharing of vehicles, mileage reimbursement plans, and short-term rentals where viable to reduce petroleum consumption.	Low
10% increase in annual alternative fuel consumption by FY15 relative to a FY05 baseline; maintain 10% increase thereafter. (FY15 target: 10%)	FY06 Baseline: 456 GGE (note: FY05 usage not measured) FY15 Actual: 6,973 GGE FY15 Goal: 502 GGE Status: Exceeded goal	PNNL periodically checks the availability in the local area for bio-diesel fuel. As older vehicles are replaced, PNNL works with the General Services Administration (GSA) to determine if an alternative fuel or fully electric vehicle (EV) is an option for replacement.	Low
30% reduction in fleet-wide per-mile GHG reduction by FY25 from a FY14 baseline. (FY15 target: NA; FY17 target: 4%)	FY14 Baseline: 668 gCO_2e/mile FY15 Actual: 709 gCO_2e Status: 6% increase	Continue to educate staff members about the importance of avoiding extra idling time, speed control, combining trips with other staff members when feasible, and proper maintenance to help reduce their GHG impact.	Low
75% of light-duty vehicle (LDV) acquisitions must consist of alternative fuel vehicles (AFVs). (FY15 target: 75%)	In FY15, 50% of the new LDV fleet acquisitions consisted of AFV vehicles. Currently, PNNL has a total of 39 LDVs, 35 of which (89%) are AFVs.	Continue to work with GSA to replace vehicles with AFV types whenever available.	Low

DOE Goal	Performance Status Through FY14	Planned Actions and Contribution	Risk[(a)] of Non Attainment
20% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid EVs by FY20, working toward 50% by FY25. (FY15 target: NA)	In FY15, PNNL evaluated this new goal and is working to determine how best to further integrate zero emission and plug-in hybrid EVs into the existing fleet.	Work closely with GSA to acquire zero emission or plug-in hybrid vehicles for all newly acquired passenger vehicles. Zero emission or plug-in hybrid vehicles will also be considered when ordering other classes of vehicles.	Low
Goal 6: Sustainable Acquisition			
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring biopreferred and biobased provisions and clauses are included in 95% of applicable contracts.	100% of acquisition actions contain a clause regarding sustainable acquisitions considerations, which includes reference to biopreferred and biobased requirements.	Continue to be proactive with sustainable item procurement.	Low
Goal 7: Pollution Prevention and Waste Reduction			
Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris.	FY15: Diverted 54% of nonhazardous solid waste	Continue to assess waste reduction opportunities.	Low
Divert at least 50% of construction and demolition materials and debris.	FY15: Diverted 86% of construction and demolition (C&D) waste.	Continue to monitor C&D recycling performance and raising awareness of waste diversion requirements.	Low
Goal 8: Energy Performance Contracts			
Annual targets for performance contracting to be implemented in FY17 and annually thereafter as part of the planning to meet Section 14 of Executive Order 13693.	Three Energy Savings Performance Contracts (ESPCs) have been implemented at PNNL.	Evaluate potential candidate projects for opportunities to use alternative financing mechanisms.	Low
Goal 9: Electronic Stewardship			
Purchases – 95% of eligible acquisitions each year are Electronic Product Environmental Assessment Tool (EPEAT)-registered products.	In FY15, 99% of eligible acquisitions were EPEAT-registered products.	Continue to purchase EPEAT-registered products when available.	Low

DOE Goal	Performance Status Through FY14	Planned Actions and Contribution	Risk[a] of Non Attainment
Power management – 100% of eligible personal computers, laptops, and monitors have power management enabled.	100% Windows and Mac systems are shipped with power management capabilities enabled.	Continue to implement power management features upon initial setup.	Low
Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled.	The default printer software is configured to use automatic duplex printing.	Continue to use duplex printing as the default configuration.	Low
End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	In FY15, all assets identified as electronics to be disposed of as excess were reused or recycled using environmentally sound disposition options.	Continue to reuse and recycle electronics.	Low
Goal 10: Climate Change Resilience			
Update policies to incentivize planning for and addressing the impacts of climate change.	In FY15, PNNL completed a vulnerability assessment and developed a climate resiliency action plan.	The internal climate resiliency planning stakeholder team established in FY15 will meet annually to determine the need to revise plans and procedures.	Low
Update emergency response procedures and protocols to account for projected climate change, including extreme weather events.	The PNNL Sustainability Program met with members of the Emergency Preparedness office during FY13 and 14 to review the status of both emergency preparedness and business continuity plans.	The Sustainability Program will continue to engage Environmental Planning and Emergency Preparedness as part of the annual climate resiliency review.	Low
Assure that workforce protocols and policies reflect the projected human health and safety impacts of climate change.	The FY15 vulnerability assessment identified six potential regional climate exposures that could influence worker health and safety. Existing plans and procedures were determined to address the risk in most cases.	Continue to work with Worker Safety and Health professionals to mitigate risks due to climate change.	Low

DOE Goal	Performance Status Through FY14	Planned Actions and Contribution	Risk[a] of Non Attainment
Assure site/lab management demonstrates commitment to adaptation efforts through internal communications and policies.	The climate resiliency planning internal stakeholder team established during FY15 was composed of senior managers of programs deemed critical to PNNL's climate resiliency.	The climate resiliency planning internal stakeholder team will meet annually to assure that we have followed through on commitments to improve PNNL's resiliency, review metrics that could indicate changes in our vulnerability, and determine the need to revise plans and procedures.	Low
Assure that PNNL climate adaptation and resilience policies and programs reflect the best available current climate change science, updated as necessary.	PNNL's research on atmospheric processes and the interconnections among energy, climate, and other human and natural systems is helping to inform sustainable solutions to the nation's energy and environmental challenges.	Sustainability Program team members responsible for climate resiliency planning will review updates to national plans as they occur and consult with internal subject matter experts as warranted to discuss evolving climate change scenarios.	Low

(a) Definitions:

- Technical Risks: Technology is/is not available in current facilities and systems to attain goal.
- Management Risks: Management systems and/or policies may require changes for which approval authority is outside DOE or requires an internal policy or procedural change.
- Financial Risks: Funds are/are not identified in current or out-year targets to achieve the goal.

Each risk is assigned a rating of high, medium, or low, defined as follows.

- High Risk: Risk in one of the three categories is so significant that goal non-attainment is likely or expected.
- Medium Risk: Risk in one of the three categories is significant enough that goal non-attainment is moderate.
- Low Risk: Any risks are satisfactorily mitigated such that goal attainment is likely.

(b) In accordance with the *National Energy Conservation Policy Act* (42 U.S.C. § 8201 et seq.), the term "buildings" includes industrial, process, or laboratory facilities.

(c) DOE considers buildings meeting the following criteria as complying with Guiding Principles:

- any building that achieves an LEED-EB (Leadership in Engineering and Environmental Design for Existing Buildings) rating of Silver or higher or LEED-NC (for New Construction) Gold or higher;
- any building that achieves a Green Globes-NC rating of four or a Green Globes Continual Improvement of Existing Buildings rating of three;
- any building that has been occupied for more than 1 year that achieves a Living Status designation by the Living Building Challenge (although included as policy in the 2012 SSPP, these equivalencies are contingent upon Office of Management and Budget and Council on Environmental and Quality approval).

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 Campus and MSL.

4.1 Liquid Radiological Discharges and Doses

TW Moon

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 where 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 concentration of radiological components in the wastewater is below the screening criteria, the wastewater is released to the City of Richland's sanitary sewer system. If the analytical results indicate that the wastewater is 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 4.4.1, 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 prepares and provides 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 wash down 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 wash down is estimated to be 190 L (50 gal). The worst case concentration of radioactivity in each wash down is estimated to be 7.1 E-07 pCi/L.

In 2015, the fume hoods were washed down an estimated total of 24 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 0.0000035 percent of 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

JM Barnett

Radionuclide air emissions are routinely monitored at both the PNNL Campus and MSL. Regulatory compliance reporting as well as monitoring results are reported in an annual air emission report for each location (Snyder et al. 2016; Snyder and Barnett 2016). CY 2015 data are summarized in the following sections.

The federal regulatory standard for a maximum dose to any member of the public is 10 mrem/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 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 also include doses attributable to fugitive emissions, radon, and nonroutine events.

4.2.1 Radiological Discharges and Doses from Air – PNNL Campus

Operations are registered with the state of Washington under RAEL–005. For CY 2015, the PNNL Campus MEI location was 0.15 km (0.10 mi) south of the RTL Complex. Table 4.1 lists the relative contributions of each nuclide to the MEI dose.

There were no nonroutine emissions from the PNNL Campus in CY 2015. Emissions were determined from both monitoring 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 2.6×10^{-4} mrem (2.6×10^{-6} mSv) EDE 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). In addition to the MEI, the maximum modeled air concentration is located at the lot southwest of 3rd Street and George Washington Way; and if a person had occupied that lot with a subsistence farm for the entire year, the dose to that receptor would have been about 25 percent greater than the reported MEI dose.

The estimated regional collective dose from PNNL Campus air emissions in CY 2015 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). The close proximity of the Hanford Site 300 Area and relatively rural region within 80 km (50 mi) of the PNNL Campus permits the Hanford Site 300 Area 80 km (50 mi) population estimate to be applicable. However, an adjustment was made to add 320 residents in the closest south-southwest population sector to account for the 160 apartment units south-southwest of RTL. Pathways evaluated for population exposure include inhalation, air submersion, ground-shine, and consumption of food. The CY 2015 total collective dose from radionuclide air emissions estimated from nuclides that originated from the PNNL Campus was 2.7×10^{-4} person-rem (2.7×10^{-6} person-Sv).

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

Table 4.1. PNNL Emissions and Dose Contributions by Radionuclide, 2015 (Snyder et al. 2016)

Radionuclide	Releases (Ci)	Dose to MEI (mrem EDE)	Percent of Total EDE Percent
Hydrogen-3[a] (tritium)	1.2×10^{-4}	7.5×10^{-9}	<1%
Carbon-14[a]	1.1×10^{-4}	1.8×10^{-5}	7%
Calcium-45[a]	1.0×10^{-6}	7.0×10^{-8}	<1%
Cobalt-60[a]	9.9×10^{-9}	1.2×10^{-8}	<1%
Strontium-85[a]	2.0×10^{-6}	4.4×10^{-7}	<1%
Strontium-90[a]	3.2×10^{-6}	9.6×10^{-5}	37%
Technetium-99[a]	1.2×10^{-5}	6.6×10^{-5}	25%
Iodine-131[a]	2.0×10^{-8}	5.5×10^{-9}	<1%
Xenon-131m[a]	2.3×10^{-7}	6.7×10^{-13}	<1%
Xenon-133[a]	1.0×10^{-6}	3.1×10^{-12}	<1%
Xenon-133m[a]	8.0×10^{-8}	2.2×10^{-13}	<1%
Cesium-137[b]	1.3×10^{-6}	1.3×10^{-5}	5%
Lutetium-177[a]	1.1×10^{-5}	1.1×10^{-8}	<1%
Radium-226[a, c]	1.5×10^{-9}	6.6×10^{-8}	<1%
Thorium-232[a]	1.6×10^{-8}	3.9×10^{-6}	1%
Uranium-233/234[a]	6.6×10^{-7}	1.6×10^{-5}	6%
Uranium-235[a]	4.3×10^{-8}	1.4×10^{-6}	1%
Uranium-238[a]	1.5×10^{-6}	4.4×10^{-5}	17%
Neptunium-237[a]	8.6×10^{-10}	7.5×10^{-9}	<1%
Plutonium-238[a]	1.4×10^{-9}	2.7×10^{-8}	<1%
Plutonium-239/240[d]	1.1×10^{-7}	1.9×10^{-6}	1%
Americium-241[a, e]	3.9×10^{-10}	5.8×10^{-8}	<1%
Americium-243[a]	3.8×10^{-10}	5.8×10^{-9}	<1%
Curium-243/244[a]	9.8×10^{-10}	1.1×10^{-8}	<1%
Californium-252[a]	1.6×10^{-9}	2.5×10^{-7}	<1%
Table 2.3 (all other) nuclides	1.8×10^{-6}	2.6×10^{-7}	<1%
PIC-5 emissions – VRRM	NA	9.4×10^{-7}[f]	<1%
PIC-5 emissions – Facilities Restoration	NA	8.4×10^{-7}[f]	<1%
PIC-5 emissions – LLS	NA	0[f]	0%
PIC-5 emissions – NDRM	NA	6.6×10^{-8}[f]	<1%
Total	**5.2×10^{-4} Ci**	**2.6×10^{-4} mrem EDE**	**100%**

(a) Release based on 40 CFR Part 61, Appendix D, or release records.
(b) Gross beta from PSF building sampling assumed to be cesium-137. Also, calculated cesium-137 release based on 40 CFR Part 61, Appendix D, and Life Sciences Laboratory 2 gross beta.
(c) Dose includes progeny isotope radon-222.
(d) Gross alpha activity from PSF building assumed to be plutonium-239. Also includes plutonium-239 and plutonium-240 calculated based on 40 CFR Part 61, Appendix D.
(e) Gross alpha activity from Life Sciences Laboratory 2 assigned as americium-241.
(f) The Potential Impact Category 5 (PIC-5) emission doses are assigned based on permit value. The LLS permit was not used in CY 2015.

To convert Ci to GBq, multiply Ci by 37.
To convert from mrem to μSv, multiply mrem by 10.
NA = not applicable.
EDE = effective dose equivalent
VRRM = volumetrically released radioactive material
LLS = low level sources
NDRM = nondispersible radioactive material

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

MSL operations for the two nonpoint-source minor emission units associated with MSL-1 and MSL-5 facilities (Figure 1.3) are registered with the state of Washington under RAEL–014. For CY 2015, the MSL MEI location was 0.19 km (0.12 mi) west of MSL-5, which is a hypothetical boundary receptor (and also the location of the maximum modeled air concentration). Radiological operations at MSL facilities emit very low levels of radioactive materials.

Table 4.2 lists the gross beta/gamma and gross alpha activity contributions to the MEI dose. The 40 CFR Part 61, Appendix D method was used to determine the routine emissions from MSL in CY 2015. 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 1.6 (Level 4) was used for estimating dose. The americium-241 unit dose factor was applied to all alpha-emitters. The cesium-137 unit dose factor was applied to all beta/gamma-emitters, as a conservative measure, except for the use of the iodine-129 nuclide-specific dose factor. The dose to the MSL MEI was 1.1×10^{-4} mrem (1.1×10^{-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.

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 2015 MSL curies released dispersed in the 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 1.2×10^{-4} person-rem (1.2×10^{-6} person-Sv). If the release were dispersed only to the maximum Canadian sector (NNW), the maximum estimated Canadian collective dose would be 4.9×10^{-5} person-rem (4.9×10^{-7} 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

GA Stoetzel

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 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.

Table 4.2. Marine Sciences Laboratory Emissions and Dose Contributions, 2015 (Snyder and Barnett 2016)

Radionuclide	Releases (Ci)	Dose to MEI (mrem EDE)	Contribution to Total EDE Percent
Beta/gamma[(a)]	3.23×10^{-8}	1.5×10^{-5}	14
Alpha[(b)]	7.76×10^{-9}	9.1×10^{-5}	86
Total	4.01×10^{-8} Ci	1.1×10^{-4} mrem	

(a) Unit dose factor for cesium-137 was applied to estimate dose for all nuclide emissions except iodine-129.
(b) Unit dose factor for amercium-241 was applied to estimate dose.
To convert Ci to GBq, multiply Ci by 37.
To convert from mrem to μSv, multiply mrem by 10.

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 2015.

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 2015.

In 2013, in accordance with PNNL Prime Contract Section J, Appendix J, paragraph eight (DOE-PNSO 2016), PNNL (Battelle) initiated a survey program with an objective to release five Battelle Memorial Institute-owned buildings by September 30, 2017, for unrestricted use. These facilities include the Engineering Development Laboratory (EDL), PSL, and LSL2 on the PNNL Campus, and the MSL-1 and MSL-5 facilities at MSL near Sequim, Washington. Unrestricted use status is scheduled to be completed for EDL, PSL, and LSL2 prior to September 30, 2017, and MSL-1 and MSL-5 are scheduled to achieve unrestricted use access prior to September 30, 2019. Program activities completed during CY 2015 included initiation of final status surveys in EDL, PSL, and LSL2, and development of detailed radiological release plans for MSL-1 and MSL-5.

4.3.2 Property Potentially Contaminated in Volume

PNNL uses pre-approved volumetric release limits when releasing small-volume research samples and wastewater potentially contaminated in volume (Table 4.4). DOE approved these release limits in response to an authorized limits request submitted by PNNL in 2000 and 2007 (DOE-RL 2001; DOE-PNSO 2007). During CY 2015, PNNL released hundreds of liquid research samples with a total volume on the order of 1,300 L (343 gal) using the pre-approved release limits in Table 4.4. The liquid samples were not released to the public, but were used by staff without radiological controls in PNNL facilities. When disposed of, the samples were treated as radioactive waste.

4.4 Radiation Protection of Biota

JM Barnett

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 to the PNNL Campus and MSL.

Table 4.3. Pre-Approved Surface Activity Guideline Limits

Radionuclides	Allowable Total Residual Surface Contamination Limits (dpm/100 cm^2)		
	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	Not applicable	Not applicable

(a) All transuranic elements except plutonium-241, which is treated as a beta/gamma emitter (1,000 dpm/100 cm^2 removable and 5,000 dpm/100 cm^2 total).
dpm = disintegrations per minute.

Table 4.4. 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 Campus

Environmental media pathways were evaluated during the development of the PNNL Campus data quality objectives (DQOs) in support of radiological emissions monitoring. 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; these results did not change with the addition of the LSL2 and RTL facilities to the PNNL sources in 2012 (Barnett et al. 2012a). 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 Campus is not conducted.

Routine operations were conducted on the PNNL Campus during CY 2015—there were no unplanned radiological emissions. The CY 2015 PNNL-reported total particulate radionuclide emissions are reported by Snyder et al. (2016). The resultant external dose rates were less than 1.1×10^{-3} rad/d (1.1×10^{-2} mGy/d) from contaminated water to aquatic animals and terrestrial plants and less than 1.0×10^{-2} rad/d (1.0×10^{-1} mGy/d) from contaminated soil to riparian and terrestrial animals (Table 4.5). These conservative dose rates are well below dose rate limits. All of the particulate radioactive material is assumed to be 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 DQO 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. 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. 2012b). 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 distant from MSL is not conducted.

Routine operations were conducted at MSL facilities during CY 2015—there were no unplanned radiological emissions. The external dose rates for operations in CY 2015 were less than 2.0×10^{-3} rad/d (2.0×10^{-2} mGy/d) from contaminated water to aquatic animals and terrestrial plants and less than 4.5×10^{-2} rad/d (4.5×10^{-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 2015 (Snyder and Barnett 2016). All of the particulate radioactive material is assumed to be 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.

Table 4.5. Screening-Level Dose Rates for the PNNL Campus, 2015

Nuclide[a]	Particulate Emissions[a] (Bq/yr)	Screening Level for 1 rad/d Dose Rate[b] (Gy/yr per Bq/m³)	Screening Level for 0.1 rad/d Dose Rate[b] (Gy/yr per Bq/kg)	Radionuclide Concentration in 1 m³ Water[c] (Bq/m³)	Radionuclide Concentration in 1 m² Soil[d] (Bq/kg)	Dose Rate for Aquatic Animals and Terrestrial Plants (mGy/d)	Dose Rate for Riparian and Terrestrial Animals (mGy/d)
Gross alpha[e,f]	3.7×10^{3}	6.8×10^{-9}	1.4×10^{-5}	3.7×10^{3}	1.7×10^{1}	6.9×10^{-5}	6.3×10^{-4}
Gross beta[e,g]	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}
Calcium-45[g]	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}
Cobalt-60	3.6×10^{2}	6.6×10^{-9}	1.3×10^{-5}	3.6×10^{2}	1.6×10^{0}	6.6×10^{-6}	5.8×10^{-5}
Strontium-85[g]	7.4×10^{4}	6.6×10^{-9}	1.3×10^{-5}	7.4×10^{4}	3.3×10^{2}	1.3×10^{-3}	1.2×10^{-2}
Strontium-90	1.2×10^{5}	2.8×10^{-9}	5.7×10^{-6}	1.2×10^{5}	5.3×10^{2}	9.1×10^{-4}	8.3×10^{-3}
Technicium-99	4.4×10^{5}	2.1×10^{-10}	4.3×10^{-7}	4.4×10^{5}	2.0×10^{3}	2.6×10^{-4}	2.3×10^{-3}
Iodine-131	7.4×10^{2}	1.4×10^{-9}	2.9×10^{-6}	7.4×10^{2}	3.3×10^{0}	2.8×10^{-6}	2.6×10^{-5}
Cesium-137	1.1×10^{4}	2.0×10^{-9}	4.0×10^{-6}	1.1×10^{4}	5.0×10^{1}	6.1×10^{-5}	5.4×10^{-4}
Lutetium-177[g]	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}
Radium-226	5.6×10^{1}	6.8×10^{-9}	1.4×10^{-5}	5.6×10^{1}	2.5×10^{-1}	1.0×10^{-6}	9.5×10^{-6}
Thorium-232	5.9×10^{2}	3.0×10^{-11}	6.1×10^{-8}	5.9×10^{2}	2.6×10^{0}	4.9×10^{-8}	4.4×10^{-7}
Uranium-233/234	2.4×10^{4}	3.2×10^{-11}	6.5×10^{-8}	2.4×10^{4}	1.1×10^{2}	2.1×10^{-6}	1.9×10^{-5}
Uranium-235	1.6×10^{3}	9.4×10^{-10}	1.8×10^{-6}	1.6×10^{3}	7.1×10^{0}	4.1×10^{-6}	3.5×10^{-5}
Neptunium-237	3.2×10^{1}	1.3×10^{-9}	2.5×10^{-6}	3.2×10^{1}	1.4×10^{-1}	1.1×10^{-7}	9.7×10^{-7}
Plutonium-238	5.2×10^{1}	2.5×10^{-11}	5.0×10^{-8}	5.2×10^{1}	2.3×10^{-1}	3.6×10^{-9}	3.2×10^{-8}
Plutonium-239/240	1.6×10^{2}	2.5×10^{-11}	4.9×10^{-8}	1.6×10^{2}	7.1×10^{-1}	1.1×10^{-8}	9.5×10^{-8}
Americium-241	1.4×10^{1}	1.4×10^{-10}	2.9×10^{-7}	1.4×10^{1}	6.4×10^{-2}	5.5×10^{-9}	5.1×10^{-8}
Americium-243	1.4×10^{1}	1.3×10^{-9}	2.5×10^{-6}	1.4×10^{1}	6.3×10^{-2}	5.0×10^{-8}	4.3×10^{-7}
Curium-243/244	3.6×10^{1}	6.4×10^{-10}	1.3×10^{-6}	3.6×10^{1}	1.6×10^{-1}	6.4×10^{-8}	5.8×10^{-7}
Californium-252[f]	5.9×10^{1}	6.8×10^{-9}	1.4×10^{-5}	5.9×10^{1}	2.6×10^{-1}	1.1×10^{-6}	1.0×10^{-5}
					Total	**1.1×10^{-2}**	**1.0×10^{-1}**

(a) Data from Table 2.4 of Snyder et al. (2016).
(b) Data from DOE (2002).
(c) Conservative dose rate is assumed to be from 1 m³ (35 ft³) of contaminated water.
(d) Conservative dose rate is assumed to be from 1 m² (10.8 ft²) of contaminated soil with a soil density of 224 kg m² (14 lb/ft²) to a depth of 15 cm (6 in.) (Napier 2006).
(e) Maximum of the bi-weekly or semi-annual average measurement (Snyder et al. 2016).
(f) Radium-226 dose rate factor used as a conservative alpha surrogate.
(g) Cobalt-60 dose rate factor used as conservative beta surrogate.
Conversion factors: 1 Ci = 3.7×10^{10} Bq; 1 Gy = 100 rad.

Table 4.6. Screening-Level Dose Rates for the PNNL Marine Sciences Laboratory, 2015

Nuclide[a]	Particulate Emissions[a] (Bq/yr)	Screening Level for 1 rad/d Dose Rate[b] (Gy/yr per Bq/m^3)	Screening Level for 0.1 rad/d Dose Rate[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 and Terrestrial Plants (mGy/d)	Dose Rate for Riparian and Terrestrial Animals (mGy/d)
Gross alpha[e]	2.9×10^{2}	6.8×10^{-9}	1.4×10^{-5}	2.9×10^{2}	1.3×10^{0}	5.3×10^{-6}	4.9×10^{-5}
Gross beta[f]	1.2×10^{3}	6.6×10^{-9}	1.3×10^{-5}	1.2×10^{3}	5.3×10^{0}	2.2×10^{-5}	1.9×10^{-4}
					Total	**2.7×10^{-5}**	**2.4×10^{-4}**

(a) Data from Table 3.3 in Snyder and Barnett (2016).
(b) Data from DOE (2002).
(c) Conservative dose rate is assumed to be from 1 m^3 (35 ft^3) of contaminated water.
(d) 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).
(e) Radium-226 dose rate factor was used as conservative alpha surrogate.
(f) Cobalt-60 dose rate factor was used as conservative beta surrogate.
Conversion factors: 1 Ci = 3.7×10^{10} Bq; 1 Gy = 100 rad.

4.5 Unplanned Radiological Releases

JM Barnett

No radiological releases to the environment exceeded permitted limits at the PNNL Campus or MSL in 2015.

4.6 Environmental Radiological Monitoring

JM Barnett

The DOE Handbook, "Environmental Radiological Effluent Monitoring and Environmental Surveillance," provides information about basic program implementation requirements and activities (DOE 2015a). In addition, the WDOH stipulates in certain licenses that a program is required. The environmental radiological monitoring activities conducted by PNNL for both the PNNL Campus and MSL are included herein.

4.6.1 Environmental Radiological Monitoring – PNNL Campus

A particulate air-sampling (environmental surveillance) network was established in 2010 to monitor radioactive particulates in ambient air near the PNNL Campus. As a result of changes in DOE-permitted operations in 2012, the air-sampling network was reevaluated (Barnett et al. 2012a). The current particulate air-sampling network consists of four samplers—PNL-1, PNL-2, PNL-3, and PNL-4 (Figure 4.1).

During CY 2015, the collection of air samples occurred 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]

The Hanford Site has a single background monitoring station in Yakima, Washington. The Yakima station, which is approximately 97 km (60 mi) in the general upwind direction from both the PNNL Campus and the Hanford Site, is considered to be unaffected by either DOE operation, so it is used as a background (or reference) location for the PNNL Campus monitoring program.

In CY 2015, there was no indication that any PNNL activities resulted in increased ambient air concentrations at the air-sampling locations (Table 4.7). For the required composite isotopic analyses, only uranium-233/234 samples and one americium-241 sample were measured at detectable concentrations. For all nuclides measured at detectable concentrations, the annual average and individual results were well below the 40 CFR Part 61, Appendix E Table 2 concentration levels for environmental compliance. The lack of overall detectable concentrations supports the results of stack effluent monitoring, and demonstrates that emissions from the PNNL Campus are low, and have minimal potential for dose to members of the public.

In addition to the air particulate monitoring discussed above, the PNNL Radiation Protection organization performs semi-annual external dose rate surveys within 6 m (20 ft) of PNNL buildings that contain radiological areas. For CY 2015, 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.

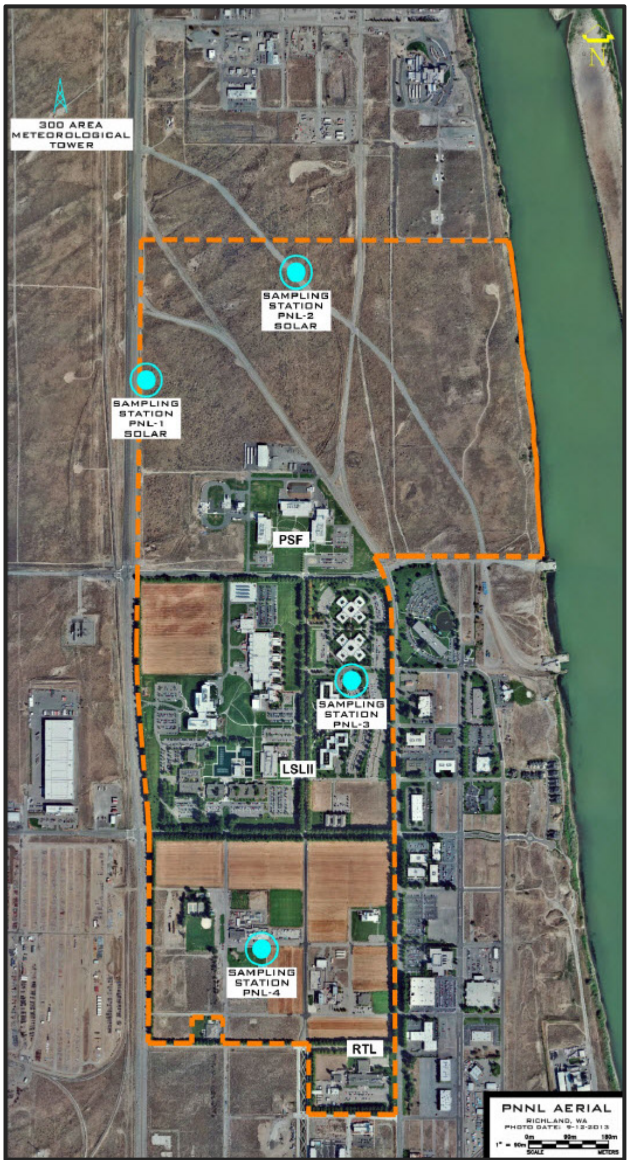


Figure 4.1. Air Surveillance Station Locations on the PNNL Campus (Snyder et al. 2016)

4.6.2 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. 2012b). 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 with low levels of releases (i.e., releases that result in a MEI dose below the minor emissions unit limit of 0.1 mrem/yr [0.001 mSv/yr; Barnett et al. 2012b]). For this reason, a particulate air-sampling network has not been established at MSL.

The PNNL Radiation Protection organization performs semi-annual external dose rate surveys at MSL-5 exterior door locations. For CY 2015, survey results were at background levels in areas that could be occupied by the public.

4.7 Future Radiological Monitoring

JM Barnett

An additional PNNL-operated background air-monitoring station for the PNNL Campus is anticipated to become operational in CY 2016. An access agreement with the Kiona-Benton School District to establish a background station at the Kiona-Benton High School was approved in 2015. This site was selected based on the establishment and application of PNNL-developed criteria (Fritz et al. 2014, 2015). The new background air-monitoring station will eliminate the dependence on the Hanford Site background station, guarantee that samples collected from the ambient background air are representative of PNNL Campus background levels, and assure samples are analyzed with methods and for isotopes consistent with samples collected at the other PNNL Campus air-sampling locations (Figure 4.1).

Table 4.7. Summary of 2015 Air-Sampling Results for PNNL (Snyder et al. 2016)

Nuclide	Location[(a)]	No. of Samples Analyzed	No. of Detections	Value ± 2σ (pCi/m³)		
Gross alpha	PNL-1	24	21	7.8×10^{-4}	±	1.9×10^{-3}
	PNL-2	24	17	6.8×10^{-4}	±	1.8×10^{-3}
	PNL-3	25	16	7.7×10^{-4}	±	1.8×10^{-3}
	PNL-4	25	21	7.6×10^{-4}	±	1.8×10^{-3}
	YAKIMA	26	22	9.0×10^{-4}	±	2.0×10^{-3}
Gross beta	PNL-1	24	24	2.0×10^{-2}	±	6.7×10^{-3}
	PNL-2	24	24	1.7×10^{-2}	±	6.0×10^{-3}
	PNL-3	25	25	1.7×10^{-2}	±	6.3×10^{-3}
	PNL-4	25	25	1.8×10^{-2}	±	6.5×10^{-3}
	YAKIMA	26	26	1.7×10^{-2}	±	9.4×10^{-3}
Cobalt-60	PNL-1	2	0	9.4×10^{-5}	±	5.5×10^{-4}
	PNL-2	2	0	-1.4×10^{-4}	±	5.7×10^{-4}
	PNL-3	2	0	3.6×10^{-5}	±	4.4×10^{-4}
	PNL-4	2	0	-1.2×10^{-4}	±	6.3×10^{-4}
	YAKIMA	2	0	1.4×10^{-4}	±	7.2×10^{-4}
Uranium-233/234	PNL-1	2	2	5.8×10^{-5}	±	2.2×10^{-5}
	PNL-2	2	2	5.6×10^{-5}	±	1.6×10^{-5}
	PNL-3	2	2	5.4×10^{-5}	±	1.4×10^{-5}
	PNL-4	2	2	5.8×10^{-5}	±	1.6×10^{-5}
Uranium-234	YAKIMA	2	1	4.1×10^{-5}	±	4.1×10^{-5}
Plutonium-238	PNL-1	2	0	-8.9×10^{-7}	±	4.8×10^{-6}
	PNL-2	2	0	1.9×10^{-6}	±	3.6×10^{-6}
	PNL-3	2	0	1.4×10^{-6}	±	3.6×10^{-6}
	PNL-4	2	0	3.5×10^{-7}	±	3.1×10^{-6}
	YAKIMA	1	0	-2.1×10^{-6}	±	1.8×10^{-5}
Plutonium-239/240	PNL-1	2	0	1.6×10^{-6}	±	5.7×10^{-6}
	PNL-2	2	0	1.7×10^{-6}	±	3.0×10^{-6}
	PNL-3	2	0	1.5×10^{-6}	±	3.9×10^{-6}
	PNL-4	2	0	2.2×10^{-6}	±	3.3×10^{-6}
	YAKIMA	1	0	1.1×10^{-6}	±	3.7×10^{-6}
Americium-241	PNL-1	2	0	9.8×10^{-6}	±	2.2×10^{-5}
	PNL-2	2	0	6.2×10^{-7}	±	1.9×10^{-6}
	PNL-3	2	0	8.0×10^{-7}	±	4.2×10^{-6}
	PNL-4	2	1	3.9×10^{-6}	±	5.9×10^{-6}
	YAKIMA	0	0	Not analyzed[(c)]		
Americium-243	PNL-1	2	0	7.1×10^{-6}	±	9.6×10^{-6}
	PNL-2	2	0	4.5×10^{-6}	±	7.5×10^{-6}
	PNL-3	2	0	6.6×10^{-7}	±	3.6×10^{-6}
	PNL-4	2	0	4.8×10^{-6}	±	1.0×10^{-5}
	YAKIMA	0	0	Not analyzed[(c)]		

Nuclide	Location[a]	No. of Samples Analyzed	No. of Detections	Value ± 2σ (pCi/m³)		
Curium-243/244	PNL-1	2	0	-7.5×10^{-7}	±	1.1×10^{-5}
	PNL-2	2	0	-3.1×10^{-7}	±	2.8×10^{-6}
	PNL-3	2	0	9.1×10^{-7}	±	3.9×10^{-6}
	PNL-4	2	0	1.5×10^{-6}	±	4.8×10^{-6}
	YAKIMA	0	0	Not analyzed[c]		

(a) Refer to Figure 4.1.
(b) Hanford Site Monitoring Data from the Yakima location are reported as uranium-234, not uranium-233/234
(c) Americium-241 values reported for PNNL Campus locations use a more sensitive alpha spectroscopy analytical method, which differs from the method used for Yakima; therefore, Yakima americium-241 measurements are not directly applicable. Americium-243 and curium-243/244 are not analyzed at the Yakima background station.
To convert pCi/m³ to Bq/m³, multiply pCi by 0.037.

5.0 ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

The Effluent Management 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 MSL, verifying compliance with effluent standards and controls, assisting facility operations, and monitoring compliance with air and water permits.

The Effluent Management 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 Effluent Management Group and interactions with other PNNL organizations is provided in the internal *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan* (Ballinger and Beus 2013). The ALARA principle is applied to effluent activities to minimize the potential effects of emissions to the public and the environment.

5.1 Liquid Effluent Monitoring

TW Moon, EA Raney, and MY Ballinger

The PNNL Campus operates under three industrial wastewater discharge permits that regulate the discharge of process wastewater to the City of Richland sanitary sewer system. Permit CR-IU005 regulates the wastewater discharges from EMSL, Permit CR-IU011 regulates wastewater discharges from the PSF, and Permit CR-IU001 regulates wastewater discharged from other PNNL Campus facilities. 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 results are reported as required to the City of Richland. Each of these waste streams discharges to the City of Richland's Publicly Owned Treatment Works and is not discharged directly to a surface water of the state of Washington.

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 2015 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 to meet permit monitoring requirements. There were no regulated discharges from Outfall 007 during this time period. Almost all parameters were measured at concentrations below the Method Reporting Limit.

The Washington State Department of Ecology has issued a permit for non-contact cooling water discharged from the Richland Research Complex cooling ponds (ST-9251) through the irrigation system. The permit requires a grab sample of the water to be analyzed once per season for pH, conductivity, and total dissolved solids. PNNL is in compliance with all applicable sampling and monitoring requirements. Staff collected one grab sample; analysis revealed a pH of 7.8, conductivity of 154 µS/cm, and total dissolved solids of 123 mg/L.

Table 5.1. PNNL Marine Sciences Laboratory 2015 NPDES Monitoring Results for Outfall 008[a]

Parameter	Quantity Found Below Method Reporting Limit	Method[b] Reporting Limit	Maximum Value
Maximum Flow (gpd)	NA	NA	94,500
Chlorine, Total Residual (μg/L)	12	50	<50
Ammonia (μg/L)	2	50	<50
Antimony (μg/L)	2	0.5	<0.5
Arsenic (μg/L)	2	5	<5
Beryllium (μg/L)	1	0.2	<0.2
Cadmium (μg/L)	2	0.2	<0.2
Chromium (μg/L)	2	2	<2
Copper (μg/L)	6	1	5
Lead (μg/L)	10	0.2	0.6
Mercury (μg/L)	2	0.2	<0.2
Nickel (μg/L)	2	2	<2
Selenium (μg/L)	1	10	17
Silver (μg/L)	2	0.2	<0.2
Thallium (μg/L)	2	0.2	<0.2
Zinc (μg/L)	8	5	16
pH[c]	NA	NA	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 NA = not applicable μg/L = micrograms per liter.

5.2 Air Effluent

JM Barnett and CJ Duchsherer

PNNL is not a large source of nonradiological air emissions. Past 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. The 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 assure they comply 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 ozone-depleting substances includes administrative controls implemented through procedures for maintenance, repair, and disposal, as well as minimizing procurement of Class I ozone-depleting substances for new and replacement refrigeration systems. Over the last 10 years, Laboratory usage of Class I ozone-depleting substance has decreased by approximately 30 percent.

Table 5.2. PNNL Campus Nonradiological Atmospheric Emissions for 2015 Reported in Accordance with the Global Reporting Initiative (GRI) Standards

GRI Indicator	Indicator Title	2015 Emissions	Units
EN15	Direct greenhouse gas emissions	10,067	metric tons of carbon dioxide equivalent
EN16	Energy indirect greenhouse gas emissions	36,470	metric tons of carbon dioxide equivalent
EN17	Other relevant indirect greenhouse gas emissions	24,279	metric tons of carbon dioxide equivalent
EN20	Ozone-depleting substance R12	0.000454	metric tons
	Ozone-depleting substance R22	0.002689	metric tons
	Ozone-depleting substance R123	0.00166	metric tons
	Ozone-depleting substance 403B	0	metric tons
	Ozone-depleting substance 414B	0	metric tons
	Emissions of ozone-depleting substances in CFC-11 Equivalent	0.0048	metric tons
EN21	Nitrogen oxides	3,671	kilograms
	Sulfur dioxide	33	kilograms
	Volatile organic compounds	789	kilograms
	Hazardous air pollutants	334	kilograms
	Particulate matter	429	kilograms
	Carbon monoxide	5,369	kilograms

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

5.3 Soil Monitoring

TW Moon, EA Raney, and MY Ballinger

Water from the Richland Research Complex cooling ponds supplements irrigation system water on the PNNL Campus. During the summer months, a blue dye is added to the cooling ponds to prohibit algae growth. The application of water from the cooling ponds to agricultural land on the campus is considered an industrial application. PNNL staff sample and analyze the surrounding soils as required by Washington State Department of Ecology State Waste Discharge Permit ST-9251. In 2015, representative soil samples were collected from four different sites that receive the application of irrigation water, and the samples were analyzed for common soil parameters in accordance with requirements of the permit. All of the data appear to be characteristic of soils from agricultural fields and landscape areas and no anomalies were noted by the analytical laboratory. Table 5.3 provides the results of the soil analyses. PNNL is in compliance with all sampling and monitoring requirements of the discharge permit. No other sampling of soils at either the PNNL Campus or MSL is required for environmental compliance.

Table 5.3. Richland Research Complex Cooling Ponds Soil Sample Results, 2015[(a)]

Parameter	Minimum Value	Maximum Value
Depth (in.)	12	24
Moisture (%)	5.28	14.27
Exchangeable sodium (%)	1.43	3.05
Cation-exchange capacity (meq/100 g)	7.9	9.5
Organic matter (%)	0.80	1.76
Total Kjeldahl nitrogen (mg/kg)	512	980
Nitrate as nitrogen (mg/kg)	0.1	6.3
Ammonia as nitrogen (mg/kg)	5.3	16.0
Total phosphorus (mg/kg)	698	989
Conductivity 1:1 (mmhos/cm)	0.19	0.36
Sodium (meq/100 g)	0.12	0.19
Calcium (meq/100 g)	5.99	7.51
Magnesium (meq/100 g)	1.71	2.12
Potassium (mg/kg)	75	201
Sulfate (mg/kg)	10	12
pH 1:1	6.7	6.8
Redoximorphic features	Absent	Absent

(a) A total of eight samples from four locations were analyzed in 2015.

6.0 GROUNDWATER PROTECTION PROGRAM

TW Moon, EA Raney, and MY Ballinger

Groundwater under the PNNL Campus is monitored routinely through seven groundwater monitoring wells. Monitoring of the groundwater under the PNNL 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. Sampling and monitoring focuses on contaminants, including uranium, tritium, nitrate, and trichloroethylene, found in regional contaminant plumes that might be drawn toward the ground-source heat pump during groundwater withdrawal, and on potential increases in the temperature of groundwater that will reach the Columbia River. 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 Site 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 2015. 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 Campus or MSL is required for environmental compliance.

Table 6.1. Biological Science Facility/Computational Sciences Facility Ground-Source Heat Pump Monitoring Results, 2015

Parameter	Number of Samples Analyzed	Quantity Found Below Method Reporting Limit	Method Reporting Limit	Minimum Reported Value	Maximum Reported Value
Injection Wells					
Flow (gpd)	NA	NA	NA	148	1134
Temperature (°C)	NA	NA	NA	16.3	29.2
pH (pH units)	4	NA	NA	7.1	7.6
Dissolved oxygen (mg/L)	4	NA	NA	6.7	6.8
Conductivity (µS/cm)	4	NA	NA	726	741
Turbidity (NTU)	2	2	0.2	<0.2	<0.2
Total dissolved solids (mg/L)	2	0	10	440	464
Nitrate-nitrite (mg/L)	2	0	0.5	19.4	21.9
Uranium (µg/L)	2	0	0.02	6.01	6.25
Tritium (pCi/L)	2	2	1,000	ND	ND
Trichloroethylene (µg/L)	2	2	5	ND	ND
Monitoring Wells Downgradient of the Injection Wells					
Temperature (°C)	NA	NA	NA	15.9	19.5
pH (pH units)	28	NA	NA	7.1	7.6
Dissolved oxygen (mg/L)	28	NA	NA	3.7	9.0
Conductivity (µS/cm)	28	NA	NA	672	861
Turbidity (NTU)	14	7	0.2	<0.2	0.48
Total dissolved solids (mg/L)	14	0	10	415	544
Nitrate-nitrite (mg/L)	14	0	0.5	15.6	23
Uranium (µg/L)	14	0	0.02	3.88	8.31
Tritium (pCi/L)	14	14	1,000	ND	ND
Trichloroethylene (µg/L)	14	14	5	ND	ND

gpd = gallons per day.
NA = not applicable.
ND = nondetectable.
NTU = nephelometric turbidity unit.

7.0 QUALITY ASSURANCE

MY Ballinger and CP Beus

Environmental sampling and monitoring activities were performed under PNNL's Environmental Management Program. These activities included sampling of water, wastewater, radiological air emissions, and ambient air and were subject to the PNNL quality assurance program, which implements the requirements of DOE Order 414.1D, Admin Chg 1, *Quality Assurance*. Sampling is conducted by the Effluent Management Group or its delegates under quality assurance plans that describe the specific quality assurance elements that apply to each activity. The quality assurance plans address requirements and guidance in DOE Order 414.1D, Admin Chg 1, and EPA QA/G-5 (EPA 2002). The plans were approved by the PNNL quality assurance organization that monitors compliance with the plan. Work performed through contracts or statements of work, such as sample analyses, must meet the same quality assurance requirements. Potential suppliers of calibrated equipment and services were evaluated before service contracts were approved and awarded, or before materials were purchased that could have a significant impact on quality.

Radiological environmental monitoring activities for the PNNL Campus were determined using the DQO process (Barnett et al. 2012a) described in the EPA *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA 2006). The DQO process is a series of logical steps that guide a team to establish performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. The DQO process resulted in a determination and documentation of the environmental sampling and monitoring requirements necessary to comply with applicable regulations. Results of the DQO process were implemented, and quality assurance requirements were integrated into the *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan* (Ballinger and Beus 2013). The quality assurance plan contains and references specific quality assurance requirements for individual activities including environmental sampling and monitoring. MSL uses trace quantities of radioactive material. Potential radioactive air emissions are permitted under a radioactive air emissions license. Compliance is demonstrated through calculated emissions and no environmental sampling and/or monitoring are required.

Water and wastewater sampling and monitoring at the PNNL 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 the NPDES and Group A Drinking Water permits. Quality assurance requirements for these activities have been integrated into the *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan* (Ballinger and Beus 2013), which includes specific requirements such as sampling locations, quality objective criteria, analytical methods, and detection limits included.

7.1 Sample Collection Quality Assurance

Samples were collected by personnel trained to conduct sampling according to approved and documented procedures. Sampling protocols include the use of appropriate sampling methods and equipment, a defined sampling frequency, specified sampling locations, and protocols for sample handling (which may include storage, packaging, and shipping) to maintain sample integrity. Chain-of-custody processes were used to track the transfer of samples from the point of collection to the analytical laboratory. Quality assurance program requirements are integrated into the statement of work for subcontracted analytical laboratories. The requirements include analysis of method blanks to evaluate sources of contamination, analysis of field or laboratory duplicates to evaluate method precision, and analysis of laboratory control samples/blank spike samples to assess accuracy, which may also include matrix spikes and/or surrogates.

Wastewater samples are analyzed using methods approved by EPA or specified by the 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 quality control (QC) requirements and to demonstrate compliance with method requirements.

7.2 Quality Assurance Analytical Results

The following laboratories were used for analyses of environmental samples (i.e., stack air emissions, ambient air, water, and wastewater) from the PNNL Campus and MSL during 2015: 1) radiological air emission samples were analyzed by PNNL's Analytical Support Operations (ASO) laboratory in the Radiochemical Processing Laboratory; 2) ambient air samples were analyzed for radioactivity by General Engineering Laboratories (GEL), LLC, Charleston, South Carolina; and 3) water and wastewater samples were analyzed by ALS Environmental, Kelso, Washington; the Benton-Franklin Health District Laboratory, Kennewick, Washington; an in-house MSL accredited laboratory; and Spectra Laboratories, Poulsbo, Washington. Analyses were performed according to a documented 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 calibrating and performance testing of analytical equipment; implementing a quality assurance program; maintaining analytical and support equipment and facilities; handling, protecting, and analyzing samples; checking data traceability, validity, and quality; recording all analytical data; 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 quality issues were identified that resulted in invalid data (e.g., missed hold times; laboratory blanks, spikes, or duplicates do not meet QC criteria), the issue was documented and resampling was required.

In 2015, the ASO laboratory and GEL analyzed all airborne filter samples for radioactivity according to the criteria in their respective statements of work and contracts. Both laboratories participated in a QC program that included internal QC measurements that provide estimates of precision and accuracy of the data. Both laboratories also participated in the Mixed-Analyte Performance Evaluation Program (MAPEP) intercomparison program, which provides an evaluation of laboratory performance. MAPEP provided standard samples of environmental media, including air filters, containing specific amounts of one or more radionuclides unknown to the participating laboratory. After analysis, the results were compared for accuracy by determining if each result was within a stated acceptance range of a reference value. In 2015, GEL participated in two MAPEP studies (MAPEP 32 and 33 [DOE 2015b,c]), and 100 percent of air filter results for radiological analysis identified in Table **7.1** were within acceptable control limits. In 2015, GEL also participated in Multi-Media Radiochemistry Proficiency Testing studies (MRaD™ 22 and 23) and all results were within the acceptable range for air filter radionuclide analyses. GEL is audited annually by the DOE Consolidated Audit Program, which provides added confidence in the data reported by the laboratory. The ASO laboratory participated in MAPEP 33 and 86 percent of the results were within the acceptable control limits.

QC samples (e.g., blanks, spiked samples, and sample duplicate pairs) were prepared by the contracted analytical laboratory and analyzed as required in the contract and statement of work. The ASO laboratory analyzed a blank and an instrument control sample 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 analyzed for specific isotopes in addition to alpha and beta activity. Similar QC samples were analyzed by GEL. The QC samples from both laboratories (Table 7.1) indicated that the sample batches had no measurable contamination from sample preparation activities, and no issues were identified in the sample preparation process.

ALS Environmental, the Benton-Franklin Health District, Spectra Laboratories, and an in-house laboratory at MSL analyzed all water and wastewater samples from the PNNL Campus and MSL during 2015. All analytical laboratories are accredited by the Washington State Department of Ecology for the analysis of water and wastewater samples. To receive accreditation, a laboratory must implement a quality assurance 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 quality assurance requirements. All analytical laboratories must also pass a quality assurance evaluation before being awarded a contract with PNNL. ALS Laboratories 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). Quality assurance and QC requirements in the contract with PNNL include the measurement or assessment of accuracy, precision, reliability, representativeness, completeness, and comparability. These measurements are reviewed for each analytical data package to verify that the data are valid. Analytical methods, method detection limits, holding times, sample containers, and preservation must meet 40 CFR Part 136 requirements and are verified for each sample collected.

7.3 Data Management and Calculations

Quality assurance is integrated into data management processes and calculations through documents such as the quality assurance plans, a data management plan, and procedures. Software quality assurance processes are used to verify the accuracy of databases used for analytical results. Parameters for dose calculations are documented as a component of the PNNL environmental monitoring plan (Snyder et al. 2011). A procedure identifies 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.

Table 7.1. Summary of Quality Control Results Used for Air Filter Analyses, 2015

Quality Control Sample Type	Analyte(s)	Number of Results Reported	Results within Control Limits
General Engineering Laboratories, LLC Air Filter Analyses			
Laboratory blanks	Gross alpha, gross beta	25	54%[b]
	Be-7, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, K-40, Ru-106, Sb-125, Am-241, Am-243, Cm-243/244, Pu-238, Pu-239/240, U-233/234, U-235, U-238	2	100%
Duplicate sample pairs	Be-7, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, K-40, Ru-106, Sb-125, Am-241, Am-243, Cm-243/244, Pu-238, Pu-239/240, U-233/234, U-235, U-238	2	100%[c]
Matrix spike samples	Am-241, Cm-243/244, Pu-239/240, U-238	2	100%[d]
Laboratory control samples	Co-60, Cs-137, Am-241, Cm-243/244, Pu-239/240, U-238	2	100%[e]
Pacific Northwest National Laboratory Analytical Support Operations Laboratory:			
Laboratory blanks	Gross alpha, gross beta, Am-241, Am-243, Cm-243/244, Np-237, Pu-238, Pu-239/240, U-233	2	100%[b]
Matrix spike samples	Gross alpha, gross beta, Pu-239, Sr-90	2	100%[d]

(a) From nuclide table at http://atom.Kaeri.re.Kr:8080/ton/index.html.

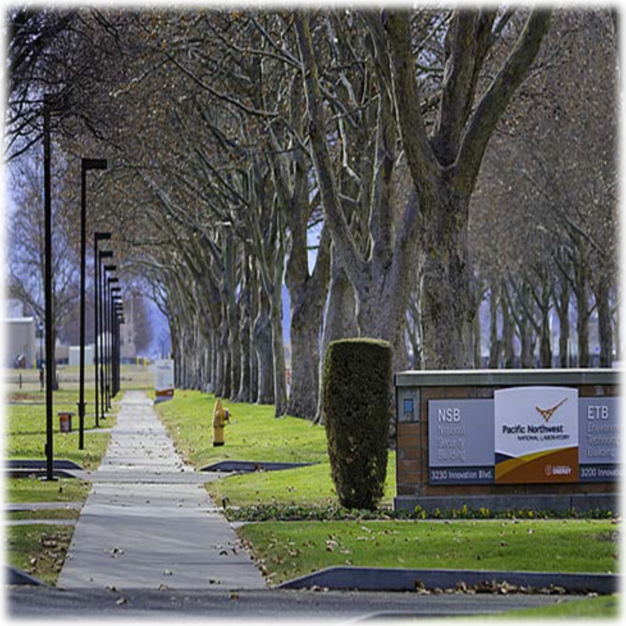
(b) Percentage of results either below minimum detectable activity (MDA) or below reporting limits. Similar filter media were counted for the blanks GEL analyzed. The gross beta blank results often exceeded the MDA; however, the blank MDA was less than the reporting limits.

(c) The relative percent difference between the sample and duplicate result is less than 20%, or the duplicate error ratio is less than 3.

(d) Control limit ±25%.

(e) Percentage of results within control limits for spiked analytes and either below MDA or below reporting limits for unspiked analytes.

8.0 REFERENCES



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Appendix A

Helpful Information

APPENDIX A

HELPFUL INFORMATION

The following information is provided to assist the reader 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 B.

A.1 Scientific Notation

Scientific notation is used to express very large or very small numbers. For example, the number 1 billion could 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.

A.2 Units of Measurement

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

A.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 A.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 A.1 includes selected conversions from curies to becquerels.

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

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

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

Symbol	Name	Symbol	Name
Ci	curie	Bq	becquerel (2.7×10^{-11} Ci)
mCi	millicurie (1×10^{-3} Ci)	kBq	kilobecquerel (1×10^{3} Bq)
µCi	microcurie (1×10^{-6} Ci)	MBq	megabecquerel (1×10^{6} Bq)
nCi	nanocurie (1×10^{-9} Ci)	mBq	millibecquerel (1×10^{-3} 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)		

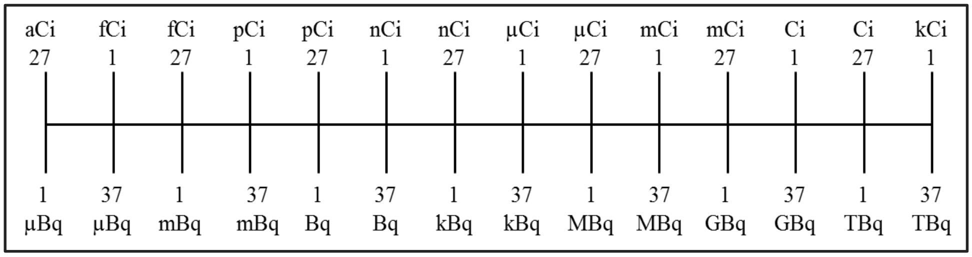

Figure A.1. Conversions for Radioactivity Units

A.4 Radiological Dose Units

Radiological dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of millirem (mrem), with the metric units millisievert (mSv) or microsievert (μSv) following in parentheses or footnoted.

Millirem (millisievert) is a term that relates a given amount of absorbed radiation energy to its biological effectiveness or risk (to humans). For perspective, a dose of 0.01 millirem (1 millisievert) 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 percent 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 A.2 includes selected conversions from rem to sievert.

Also used in this report is the term rad, with the corresponding unit 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 A.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 A.4.

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

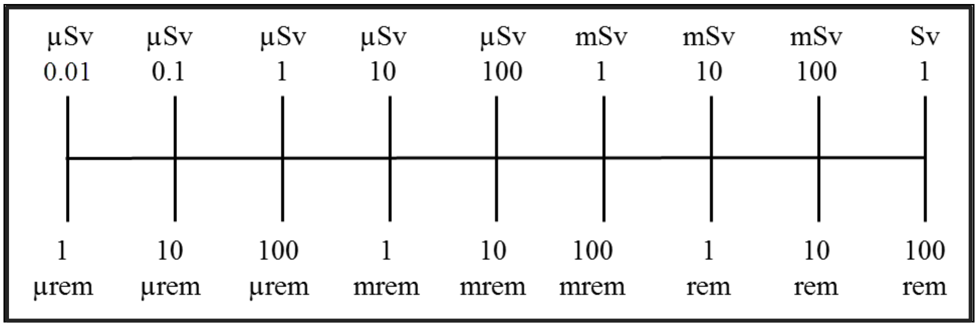

Figure A.2. Conversions for Radiological Dose Units

Table A.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)

Appendix B

Glossary

APPENDIX B

GLOSSARY

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

absorbed dose – Energy of ionizing *radiation* absorbed per unit mass. Measured in *rad* (1 rad = 0.01 *gray* [Gy]).

alpha particle – A positively charged particle composed of two protons and two neutrons ejected spontaneously from the nuclei of some *radionuclides*. It has low penetrating power and short range. The most energetic alpha particle will generally fail to penetrate the skin. Alpha particles are hazardous when an alpha-emitting *isotope* is 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 = 3.7×10^{10} Bq.

beta particle – A negatively charged particle (essentially an electron) emitted from a nucleus during radioactive *decay*. Large amounts of beta particles may cause skin burns and are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal or plastic.

biological half-life – The time required for one-half of the amount of a *radionuclide* to be expelled from the body by natural metabolic processes, excluding radioactive *decay*, following ingestion, inhalation, or absorption.

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

composite sample – Sample formed by mixing 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. See *radioactivity*.

derived concentration guide – Concentrations of *radionuclides* in air and water that an individual could continuously consume, inhale, or be immersed in at average annual rates and not receive an *effective dose equivalent* of greater than 100 *millirem* per year.

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

dose equivalent – Product of the absorbed dose, a quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of *radiation* on a common scale. The unit of dose equivalent is the *rem*.

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

effective dose equivalent – The sum of products of *dose equivalent* to selected tissues of the body and appropriate tissue weighting factors. The tissue weighting factors put doses to various tissues and organs on an equal basis in terms of health *risk*.

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 with a 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 particles*.

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

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

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

half-life – Length of time in which a radioactive substance will lose one-half of its *radioactivity* by *decay*. Half-lives range from a fraction of a second to billions of years, and each *radionuclide* has a unique half-life.

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

irradiation – *exposure* to *radiation*

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

isotopic plutonium – Any of two or more atoms of the chemical element *plutonium* with the same atomic number and position in the periodic table and nearly identical chemical behavior but with different atomic mass numbers and different physical properties. Plutonium-239 is produced by neutron *irradiation* of uranium-238.

isotopic uranium – Any of two or more atoms of the chemical element uranium with the same atomic number and position in the periodic table and nearly identical chemical behavior but with different atomic mass numbers and different physical properties. Uranium exists naturally as a mixture of three *isotopes* of mass 234, 235, and 238 in the proportions of 0.006 percent, 0.71 percent, and 99.27 percent, respectively.

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

maximally exposed individual – A hypothetical member of the public residing near the Hanford Site who, by virtue of location and living habits, would reasonably receive the highest possible *radiation* dose from materials originating from the site.

millirem – A unit of *radiation dose equivalent* 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, 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.

photon – A particle signifying a quantum of radiant energy.

plutonium – A heavy, radioactive, metallic element consisting of several *isotopes*. One important *isotope* is plutonium-239, which is produced by the irradiation of uranium-238. Routine analysis cannot distinguish between the plutonium-239 and plutonium-240 *isotopes*; hence, the term plutonium-239/240 as used in this report is symbolic of the presence of one or both of these *isotopes* in the analytical results.

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

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

PNNL Site – DOE-owned lands on the *PNNL Campus*

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 the features and characteristics of a material, process, product, or service to 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 particles (e.g., *alpha* and *beta particles*) such as that from transforming *radionuclides*. 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.

radioisotope – An unstable *isotope* of an element that *decays* or disintegrates spontaneously, emitting *radiation* (Shleien 1992).

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 – A unit of *dose equivalent* and *effective dose equivalent*.

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 *dose equivalent* and its variants in the International System of Units (SI). The common unit for *dose equivalent* and its variants, the *rem*, is equal to 0.01 Sv.

sitewide categorical exclusion – A category of proposed actions (activities) that are "sitewide" in nature and extent, and for which neither an environmental assessment nor an environmental impact statement is normally required. The spatial application of the proposed actions is detailed within the sitewide categorical exclusion.

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.

total effective dose equivalent – The sum of committed *effective dose equivalent* from the intake of radioactive material and dose equivalent from exposure to external radiation. Unit: rem or sievert.

total uranium – The sum of concentrations of the isotopes uranium-234, uranium-235, and uranium-238.

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 (half-lives greater than 20 years).

tritium – The heaviest radioactive isotope of hydrogen (hydrogen-3) with 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; used in solvents and degreasing compounds as raw materials.

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

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Appendix C

Plant and Animal Species Found on the PNNL Site, 2009–2015

APPENDIX C

PLANT AND ANIMAL SPECIES FOUND ON THE PNNL SITE, 2009–2015

Table C.1. Plant Species Observed on the PNNL Site 2009–2015

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Achillea millefolium	common yarrow			
Achnatherum hymenoides	Indian ricegrass			
Acroptilon repens	Russian knapweed			B
Agoseris heterophylla	annual mountain dandelion			
Agropyron cristatum	crested wheatgrass			
Ailanthus altissima	tree of heaven			C
Allium schoenoprasum	wild chives			
Amaranthus albus	prostrate pigweed			
Ambrosia acanthicarpa	flatspine bur ragweed			
Amsinckia lycopsoides	tarweed fiddleneck			
Amsinckia tessellata	bristly fiddleneck			
Artemisia campestris	field sagewort			
Artemisia dracunculus	tarragon			
Artemisia lindleyana	Columbia river mugwort			
Artemisia tridentata	big sagebrush			
Asclepias speciosa	showy milkweed			
Asparagus officinalis	garden asparagus			
Astragalus caricinus	buckwheat milkvetch			
Balsamorhiza careyana	Carey's balsamroot			
Bassia scoparia	burningbush			B
Bromus tectorum	cheatgrass			
Cardaria draba	whitetop			
Centaurea diffusa	diffuse knapweed			B
Chaenactis douglasii	hoary false yarrow			
Chamaesyce serpyllifolia	thymeleaf sandmat			
Chenopodium leptophyllum	narrowleaf goosefoot			
Chenopodium rubrum	red goosefoot			
Chondrilla juncea	rush skeletonweed			B
Chorispora tenella	blue mustard			
Chrysothamnus viscidiflorus	green rabbitbrush			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Cichorium intybus	chicory			
Cirsium sp.	thistle			
Clematis ligusticifolia	western white clematis			
Comandra umbellata	bastard toadflax			
Convolvulus arvensis	field bind weed			C
Conyza canadensis	Canadian horseweed			
Coreopsis tinctoria var. atkinsoniana	Columbia tickseed			
Crepis atribarba	slender hawksbeard			
Cryptantha circumscissa	matted cryptantha			
Cryptantha flaccida	weak-stemmed cryptantha			
Cryptantha fendleri	Fendler's cryptantha			
Cryptantha pterocarya	winged cryptantha			
Dalea ornata	Blue Mountain prairie clover			
Descurainia pinnata	western tansymustard			
Descurainia sophia	herb sophia			
Delphinium nuttallianum	upland larkspur			
Draba verna	spring whitlowgrass			
Eleocharis sp.	spikerush			
Elymus elymoides	squirreltail			
Elymus lanceolatus	thickspike wheatgrass			
Epilobium brachycarpum	tall willowherb			
Equisetum sp	horsetail			
Ericameria nauseosa	rubber rabbitbrush			
Erigeron filifolius	threadleaf fleabane			
Eriogonum niveum	snow buckwheat			
Eriogonum vimineum	broom buckwheat			
Erodium cicutarium	redstem stork's bill			
Gaillardia aristata	blanketflower			
Gilia sinuata	shy gilia			
Gratiola neglecta	American hedge-hyssop			
Grayia spinosa	spiny hopsage			
Gypsophila paniculata	baby's breath			C
Hesperostipa comata	needle-and-thread grass			
Holosteum umbellatum	jagged chickweed			
Hymenopappus filifolius	fineleaf hymenopappus			
Hypericum perforatum	common St. Johnswort			
Iris missouriensis	Rocky Mountain iris			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Koeleria macrantha	prairie junegrass			
Lactuca serriola	prickly lettuce			
Lagophylla rammosissima	rabbitleaf			
Layia glandulosa	tidytips			
Lepidium densiflorum	common pepperweed			
Lepedium latifolium	broadleaf pepperweed			B
Lepidium perfoliatum	clasping pepperweed			
Leptodactylon pungens	prickly phlox			
Leymus cinereus	basin wildrye			
Logfia arvensis	field fluffweed			
Lomatium macrocarpum	bigseed desertparsley			
Machaeranthera canescens	hoary aster			
Malus pumila	apple			
Medicago sativa	alfalfa			
Melilotus officianalis	sweetclover			
Mentzelia albicaulis	whitestem stickleaf			
Microsteris gracilis	pink microsteris			
Morus alba	white mulberry			
Oenothera pallida	pale evening primrose			
Opuntia polyacantha	plains pricklypear			
Orobanche corymbosa	flat-top broomrape			
Phacelia hastata	silverleaf phacelia			
Phacelia linearis	threadleaf scorpionweed			
Phalaris arundinacea	reed canarygrass			C
Phlox longifolia	longleaf phlox			
Plantago lanceolata	English plantain			
Plantago patigonica	woolly plantain			
Plectritis macrocera	white cupseed			
Poa bulbosa	bulbous bluegrass			
Poa secunda	Sandberg bluegrass			
Polygonum convolvulus	climbing bindweed			
Plantago patigonica	woolly plantain			
Prunus virginiana	chokecherry			
Pseudognaphalium stramineum	cottonbatting plant			
Pseudoroegneria spicata	bluebunch wheatgrass			
Psoralidium lanceolatum	lemon scurfpea			
Pteryxia terebinthina	turpentine wavewing			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Purshia tridentata	antelope bitterbrush			
Robinia pseudoacacia	black locust			
Rosa woodsii	Woods' rose			
Rubus armeniacus	Himalayan blackberry			C
Rumex salicifolius	willow dock			
Rumex venosus	veiny dock			
Salix exigua	narrowleaf willow			
Salsola tragus	prickly Russian thistle			
Senecio vulgaris	common groundsel			
Sisymbrium altissimum	tall tumblemustard			
Solidago canadensis	Canada goldenrod			
Solanum dulcamara	climbing nightshade			
Sphaeralcea munroana	Munro's globemallow			
Sporobolus cryptandrus	sand dropseed			
Stephanomeria paniculata	tufted wirelettuce			
Tragopogon dubius	yellow salsify			
Tribulus terrestris	puncturevine			B
Triteleia grandiflora	Douglas clusterlily			
Ulmus pumila	Siberian elm			
Verbascum thapsus	common mullein			
Vulpia microstachys	small sixweeks			
Vulpia octoflora	slender sixweeks			
Zigadenus venenosus	meadow death camas			

(a) Nomenclature according to USDA (2016), Natural Resource Conservation Service Plants Database. http://plants.usda.gov/java/nameSearch

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

Table C.2. Bird Species Observed on the PNNL Site, 2009–2015

Species Name	Common Name	State Status	Federal Status
Actitis macularia	spotted sandpiper		
Agelaius phoeniceus	red-winged blackbird		
Artemisiospiza nevadensis	sagebrush sparrow		
Anas platyrhynchos	mallard		
Ardea herodias	great blue heron		
Asio flammeus	short-eared owl		
Branta canadensis	Canada goose		
Buteo jamaicensis	red-tailed hawk		

Species Name	Common Name	State Status	Federal Status
Calidris bairdi	Baird's sandpiper		
Calidris mauri	western sandpiper		
Callipepla californica	California quail		
Carpodacus mexicanus	house finch		
Carduelis tristis	American goldfinch		
Casmerodius albus	great egret		
Charadrius vociferus	killdeer		
Chordeiles minor	common nighthawk		
Circus cyaneus	northern harrier		
Columbus livia	rock dove		
Corvus brachyrhynchos	American crow		
Corvus corax	common raven		
Eremophila alpestris	horned lark		
Hirundo pyrrhonota	cliff swallow		
Hirundo rustica	barn swallow		
Icterus galbula	Bullock's oriole		
Larus californicus	California gull		
Melospiza melodia	song sparrow		
Mergus merganser	common merganser		
Numenius americanus	long-billed curlew		
Nycticorax nycticorax	black-crowned night-heron		
Pandion haliaetus	osprey		
Passer domesticus	house sparrow		
Pelecanus erythrorhynchos	American white pelican		
Phasianus colchicus	ring-necked pheasant		
Pica pica	black-billed magpie		
Riparia riparia	bank swallow		
Sturnella neglecta	western meadowlark		
Sturnus vulgaris	European starling		
Turdus migratorius	American robin		
Tyrannus tyrannus	eastern kingbird		
Tyrannus verticalis	western kingbird		
Zenaida macroura	mourning dove		
Zonotrichia leucophrys	white-crowned sparrow		

Table C.3. Mammal Species Observed on the PNNL Campus, 2009–2015

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

SC = Species of Concern

Table C.4. Plant Species Observed in the Riparian Area of the PNNL Campus in 2015

Species Name[(a)]	Common Name[(a)]	State Status	Federal Status	Noxious Weed Class[(b)]
Achillea millefolium	common yarrow			
Achnatherum hymenoides	Indian ricegrass			
Acroptilon repens	Russian knapweed			B
Ailanthus altissima	tree of heaven			C
Allium schoenoprasum	wild chives			
Amsinckia lycopsoides	tarweed fiddleneck			
Artemisia campestris	field sagewort			
Artemisia dracunculus	tarragon			
Artemisia tridentata	big sagebrush			
Asparagus officinalis	garden asparagus			
Bromus tectorum	cheatgrass			
Centaurea diffusa	diffuse knapweed			B
Chondrilla juncea	rush skeletonweed			B
Cirsium sp.	thistle			
Clematis ligusticifolia	western white clematis			
Convolvulus arvensis	field bind weed			C
Descurainia sophia	herb sophia			
Eleocharis sp.	spikerush			
Elymus lanceolatus	thickspike wheatgrass			
Ericameria nauseosa	rubber rabbitbrush			
Ericameria teretifolia	green rabbitbrush			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Eriogonum niveum	snow buckwheat			
Gaillardia aristata	blanketflower			
Hesperostipa comata	needle-and-thread grass			
Hypericum perforatum	common St. Johnswort			
Iris missouriensis	Rocky Mountain iris			
Lepidium densiflorum	common pepperweed			
Lepidium perfoliatum	clasping pepperweed			
Machaeranthera canescens	hoary tansyaster			
Morus alba	white mulberry			
Oenothera pallida	pale evening primrose			
Phalaris arundinacea	reed canarygrass			C
Plantago patigonica	woolly plantain			
Poa bulbosa	bulbous bluegrass			
Poa secunda	Sandberg bluegrass			
Prunus virginiana	chokecherry			
Psoralidium lanceolatum	lemon scurfpea			
Purshia tridentata	antelope bitterbrush			
Rhus glabra	smooth sumac			
Robinia pseudoacacia	black locust			
Rosa woodsii	Woods' rose			
Rubus armeniacus	Himalayan blackberry			C
Rumex salicifolius	willow dock			
Rumex venosus	veiny dock			
Salix exigua	narrowleaf willow			
Sisymbrium altissimum	tall tumblemustard			
Solidago canadensis	Canada goldenrod			
Solanum dulcamara	climbing nightshade			
Sphaeralcea munroana	Munro's globemallow			
Sporobolus cryptandrus	sand dropseed			
Tragopogon dubius	yellow salsify			
Verbascum thapsus	common mullein			

(a) Nomenclature according to the U.S. Department of Agriculture (USDA 2016), Natural Resource Conservation Service Plants Database. http://plants.usda.gov/java/

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

Table C.5. Bird Species Observed in the Riparian Area of the PNNL Campus in 2015

Species Name	Common Name	State Status	Federal Status
Actitis macularia	spotted sandpiper		
Agelaius phoeniceus	red-winged blackbird		
Anas platyrhynchos	mallard		
Callipepla californica	California quail		
Casmerodius albus	great egret		
Icterus galbula	Bullock's oriole		
Nycticorax nycticorax	black-crowned night-heron		
Pica pica	black-billed magpie		
Sturnus vulgaris	European starling		
Turdus migratorius	American robin		

Table C.6. Mammal Species Observed in the Riparian Area of the PNNL Campus in 2015

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 D

Plant and Animal Species Observed during Annual Surveys (2013–2015) in the Vicinity of the PNNL Marine Sciences Laboratory

APPENDIX D

PLANT AND ANIMAL SPECIES OBSERVED DURING ANNUAL SURVEYS (2013–2015) IN THE VICINITY OF THE PNNL MARINE SCIENCES LABORATORY

Table D.1. Plant Species Observed on PNNL Marine Sciences Laboratory Lands

Species Name[(a)]	Common Name[(a)]	State Status	Federal Status	Noxious Weed Class[(b)]
Abies grandis	grand fir			
Abronia latifolia	coastal sand verbena			
Acer circinatum	vine maple			
Acer glabrum	Douglas maple			
Acer macrophyllum	bigleaf maple			
Achillea millefolium	common yarrow			
Alnus rubra	red alder			
Ambrosia chamissonis	silver bur ragweed			
Amelanchier alnifolia	saskatoon serviceberry			
Arbutus menziesii	Pacific madrone			
Arctostaphylos uva-ursi	kinnikinnick			
Artemisia suksdorfii	coastal wormwood			
Avena sp.	oat			
Bellis perennis	lawndaisy			
Blechnum spicant	deer fern			
Brassica rapa	field mustard			
Cakile edentula	American searocket			
Carex sp.	sedge			
Castilleja hispida.	harsh Indian paintbrush			
Centaurea cyanus	garden cornflower			
Cerastium spp.	mouse-ear chickweed			
Chenopodium album	lambsquarters			
Cirsium arvense	Canada thistle			C
Cirsium spp.	thistle			
Claytonia perfoliata	miner's lettuce			
Conium maculatum	poison hemlock			B
Cornus sericea	redosier dogwood			
Corylus cornuta var. californica	California hazelnut			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Crataegus monogyna	oneseed hawthorn			
Cytisus scoparius	Scotch broom			B
Dactylis glomerata	orchardgrass			
Dipsacus fullonum	Fuller's teasel			
Distichlis spicata	saltgrass			
Draba verna	spring draba			
Elymus glaucus	blue wildrye			
Chamerion angustifolium	fireweed			
Equisetum hyemale	scouring-rush horsetail			
Equisetum spp.	horsetail			
Erodium cicutarium	redstem stork's bill			
Eschscholzia californica	California poppy			
Fragaria virginiana	Virginia strawberry			
Frittilaria 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	English holly			M
Juncus sp.	rush			
Lathyrus japonicus	beach pea			
Lathyrus polyphyllus	peavine			
Leucanthemum vulgare	oxeye daisy			C
Lomatium nudicaule	bare-stemmed biscuitroot			
Lonicera ciliosa	orange honeysuckle			
Lysichiton americanus	skunk cabbage			
Mahonia aquifolium	hollyleaved barberry			
Mahonia nervosa	Cascade barberry			
Maianthemum dilatatum	false lily of the valley			
Maianthemum racemosum ssp. *amplexicaule*	feathery false lily of the valley			
Medicago lupulina	black medick			
Mimulus guttatus	seep monkey flower			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Mycelis muralis	wall lettuce			
Myosotis sp.	forget-me-not			
Oemleria cerasiformis	Indian plum			
Osmorhiza berteroi	sweetcicely			
Petasites frigidus	Arctic sweet coltsfoot			
Physocarpus capitatus	Pacific ninebark			
Plantago lanceolata	narrowleaf plantain			
Plantago major	common plantain			
Plantago maritima	goose tongue			
Plectritis congesta	shortspur seablush			
Polystichum munitum	western swordfern			
Populus balsamifera ssp. trichocarpa	black cottonwood			
Potentilla anserina	silverweed cinquefoil			
Pseudotsuga menziesii	Douglas fir			
Pteridium aquilinum	western bracken fern			
Ranunculus repens	creeping buttercup			
Ranunculus uncinatus	woodland buttercup			
Ribes sanguineum	redflower currant			
Rosa gymnocarpa	dwarf rose			
Rosa nutkana	Nootka rose			
Rubus armeniacus	Himalayan blackberry			C
Rubus leucodermis	whitebark raspberry			
Rubus parviflorus	thimbleberry			
Rubus ursinus	California blackberry			
Rumex acetosella	common sheep sorrel			
Rumex crispus	curly dock			
Rumex aquaticus	western dock			
Salicornia depressa	American glasswort			
Salix spp.	willow			
Sambucus racemosa	red elderberry			
Senecio slyvaticus	woodland ragwort			
Spiraea douglasii	rose spirea			
Symphoricarpos albus	common snowberry			
Taraxacum officinale	common dandelion			
Tellima grandiflora	bigflower tellima			
Thuja plicata	western red cedar			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Tolmiea menziesii	youth on age			
Trientalis borealis	broadleaf starflower			
Trifolium latifolium	twin clover			
Trifolium pratense	red clover			
Trifolium repens	white clover			
Triglochin maritima	seaside arrowgrass			
Tsuga heterophylla	western hemlock			
Urtica dioica	stinging nettle			
Vicia americana	American vetch			
Vicia nigricans	giant vetch			
Vicia sativa	garden vetch			
Vicia sp.	vetch			

(a) Nomenclature according to USDA (2016), Natural Resource Conservation Service Plants Database. http://plants.usda.gov/java

(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 D.2. Bird Species Observed in the Vicinity of the PNNL Marine Sciences Laboratory

Species Name	Common Name	State Status	Federal Status
Accipiter cooperii	Cooper's hawk		
Agelaius phoeniceus	red-winged blackbird		
Anas platyrhynchos	mallard		
Ardea herodias	great blue heron	Monitor	
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		
Catharus ustulatus	Swainson's thrush		
Charadrius vociferus	killdeer		

Species Name	Common Name	State Status	Federal Status
Cepphus columba	pigeon guillemot		
Cerorhinca monocerata	rhinoceros auklet		
Certhia americana	brown creeper		
Chamaea fasciata	wrentit		
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	Sensitive	Species of Concern
Haliaeetus leucocephalus	bald eagle	Sensitive	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 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-caped chickadee		
Parus gambeli	mountain chickadee		
Parus rufescens	chestnut-backed chickadee		
Passerculus sandwichensis	savannah sparrow		
Passerella iliaca	fox sparrow		
Petrochelidon pyrrhonota	cliff swallow		
Phalacrocorax auritus	double-crested cormorant		

Species Name	Common Name	State Status	Federal Status
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		
Setophaga coronata	yellow-rumped warbler		
Sitta canadensis	red-breasted nuthatch		
Spinus tristis	American goldfinch		
Stelgidopteryx serripennis	northern rough-winged swallow		
Sterna caspia	Caspian tern	Monitor	
Strix varia	barred owl		
Sturnus vulgaris	European starling		
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 D.3. Other Vertebrate Species Observed on PNNL Marine Sciences Laboratory Lands

Species Name	Common Name	State Status	Federal Status
Anaxyrus boreas	western toad	SC	
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		

SC = Species of Concern

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