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Pacific Northwest National Laboratory
U.S. Department of Energy — Office of Science

Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2014

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PACIFIC NORTHWEST NATIONAL LABORATORY ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 2014 (PNNL-24668), SEPTEMBER 2015

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 2014, but may also include late 2013 and early 2015 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 of 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-24668

Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2014

Final

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September 2015

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

Pacific Northwest National Laboratory
Richland, Washington 99352

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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 at its Campus in Richland, Washington, and at its facilities in Sequim, Seattle, and North Bonneville, Washington, and Corvallis and Portland, Oregon.

This report provides a synopsis of ongoing environmental management performance and compliance activities conducted during 2014, meeting the requirements DOE Order 231.1B, Environmental, Safety and Health Reporting. The report addresses the operations occurring on the PNNL Campus in Richland, Washington, and PNNL's Marine Sciences Laboratory (MSL) in Sequim, Washington. It includes a description of 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 status, presents potential radiation doses to staff and the public in the surrounding areas, and describes DOE-required data quality assurance (QA) methods used for data verification.

Compliance with Federal, State, and Local Laws and Regulations in 2014

PNNL is committed to complying with all applicable federal, state, and local laws and regulations and site-specific permits. In 2014, PNNL was in compliance with applicable requirements (Table S.1). Section 2.0 provides further details regarding compliance issues.

Environmental Sustainability Performance

PNNL is committed to operating safely and sustainably and has established and implemented an Environmental Management System (EMS). PNNL's EMS was recertified in 2014, validating conformance with ISO 14001 standards, the international accepted environmental management standard. Each year PNNL develops a Site Sustainability Plan that identifies the status and accomplishments of sustainability projects related to DOE's sustainability goals (Section 3.0).

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 2014 (Sections 2.4, 4.2, and 5.2).

Liquid Effluent Monitoring: Liquid effluent discharges from PNNL Campus operations are monitored under permits issued by the Washington State Department of Ecology and the City of Richland. Liquid effluent discharges from MSL operations are monitored under a permit issued by the Washington State Department of Ecology. There were no unplanned releases of regulated pollutants or contaminated wastewater from PNNL facilities, nor were releases of regulated pollutants or contaminated wastewater found during monitoring of routine discharges (Sections 2.5.1, 4.1, and 5.1).

PNNL does not have stormwater discharges requiring monitoring under federal or state National Pollutant Discharge Elimination System stormwater regulations (Section 2.5.2).

Table S.1. PNNL Federal and Washington State Statute Compliance, 2014

Regulation	What It Encompasses	2014 Compliance Summary
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.	Six National Historic Preservation Act Section 106 cultural resource reviews were conducted for Pacific Northwest National Laboratory (PNNL) projects in fiscal year (FY) 2014. 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. PNNL was in compliance.
Clean Air Act	Air quality including emissions from facilities and unmonitored sources.	PNNL operated under permits issued by the Washington State Department of Health, Washington State Department of Ecology, Benton Clean Air Agency, and Olympic Region Clean Air Agency. No events were reported for air emissions of regulated substances or substances of concern. Radioactive air emissions in calendar year (CY) 2014 were more than 100,000 times lower than the regulatory standard of 10 mrem/yr (0.1 mSv/yr) at both the PNNL Campus and the Marine Sciences Laboratory. PNNL was in compliance.
Clean Water Act	Point-source discharges to United States surface waters and indirect discharges to sewer systems.	PNNL Campus operated under permits issued by the Washington State Department of Ecology and the City of Richland. PNNL Campus facilities have no stormwater discharges requiring monitoring under the federal or state National Pollutant Discharge Elimination System (NPDES) stormwater regulations. There were no permit exceedances in 2014. MSL operated under an NPDES permit issued by the Washington State Department of Ecology; there were no permit violations at MSL in 2014. Two wetland permits were obtained under Section 404 of the Clean Water Act in 2014.
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 and protects coastal resources and the fish and wildlife that use those habitats. PNNL was in compliance.
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 2014. PNNL was in compliance.
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.	In 2014, PNNL submitted two Tier Two reports. PNNL was not required to submit a Toxic Release Inventory Report for 2014. PNNL was in compliance.

Endangered Species Act of 1973	Rare plant and animal species.	In 2014, an annual biological field survey of the PNNL Site was conducted, as well as 12 ecological reviews for PNNL projects. No endangered or threatened species were observed. No threatened or endangered species were observed during the survey of biological resources on lands encompassing MSL. PNNL was in compliance.
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 eight buildings under EISA energy and water evaluation requirements. A total of 36% of PNNL buildings met U.S. Department of Energy (DOE) criteria as high-performance and sustainable buildings. PNNL also implemented stormwater management practices to promote water drainage and reduce runoff. PNNL was in compliance.
Federal Facility Compliance Act of 1992	Amends Resources Conservation Act of 1976 (RCRA) and CERCLA 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. PNNL was in compliance.
Federal Insecticide, Fungicide, and Rodenticide Act	Storage and use of pesticides.	Commercial pesticides were applied at locations on the PNNL Campus and at MSL either by licensed PNNL staff or by a licensed commercial applicator, thereby meeting compliance requirements.
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 growth to maturity). The PNNL biological review process is used to evaluate fulfillment. PNNL was in compliance.
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. PNNL was in compliance.
Migratory Bird Treaty Act	Migratory birds or their feathers, nests, or eggs.	In 2014, an annual biological field survey of the PNNL Site was conducted and 12 ecological reviews were conducted for PNNL projects. A number of migratory birds were observed and compliance with the Act was maintained.
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 1,286 NEPA reviews during CY 2014 for research and support activities. The DOE-Richland Operations Office approved seven generic categorical exclusions and one project-specific categorical exclusion in 2014; Pacific Northwest Site Office (PNSO) approved three new project-specific categorical exclusions in 2014. PNNL was in compliance.
Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990	Prevents the spread of nonindigenous aquatic nuisance species to non-infested waters.	An aquatic invasive plant and animal species interception program has been developed and implemented by PNNL. PNNL was in compliance.
Resource Conservation and Recovery Act of 1976 (RCRA)	Tracking hazardous waste from generation to treatment, storage, or disposal (referred to as cradle-to-grave management).	Washington State Department of Ecology personnel inspected PNNL facilities four times in 2014; administrative issues were identified during one inspection and promptly corrected.
Rivers and Harbors Appropriation Act of 1899	Prohibits obstruction or alteration of navigable waters.	PNNL obtained permits under Section 10 of this Act for 4 projects in 2014.

Safe Drinking Water Act of 1974	Drinking water systems.	The PNNL Campus receives all drinking water for uses in non-laboratory and laboratory spaces from the City of Richland drinking water supply, and is not subject to requirements pursuant to the *Safe Drinking Water Act of 1974*. *Safe Drinking Water Act of 1974* regulations require that underground injection control wells be registered; this has been completed. At MSL, water is provided exclusively from onsite wells and PNNL is considered the water purveyor. PNNL was in compliance.
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. PNNL was in compliance.
Toxic Substances Control Act	Hazardous chemical regulation and tracking; primarily polychlorinated biphenyls (PCBs).	During 2014, PNNL contributed to the 2013 PCB annual document log report for the Hanford Site and 2013 PCB annual report; both were submitted to the U.S. Environmental Protection Agency as required, thereby meeting compliance requirements.
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. Washington State Department of Ecology personnel inspected PNNL facilities four times in 2014; administrative issues were identified during one inspection and promptly corrected.
Revised Code of Washington Chapter 17.10	Control of noxious weeds.	PNNL implemented an invasive terrestrial plant species control program. PNNL was in compliance.
State Environmental Policy Act (SEPA)	Identifies environmental impacts of state and local decisions and gives agencies the authority to deny a proposal when adverse environmental impacts are identified.	PNNL environmental compliance representatives and staff review research and support activities, completing SEPA checklists as required. PNNL was in compliance.
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. PNNL was in compliance.
Washington Clean Air Act	Implements and supplements the *Clean Air Act*, overseeing air quality.	PNNL operated under permits issued by the Washington State Department of Health, Washington State Department of Ecology, Benton Clean Air Agency, and Olympic Region Clean Air Agency. No events were reported for air emissions of regulated substances or substances of concern. PNNL was in compliance.
Washington Pesticide Application Act	Control of pesticide application and use to protect public health and welfare.	Licensed PNNL staff or certified commercial applicators are used to apply pesticides.
Washington Pesticide Control Act	Proper use and control of pesticides.	Licensed PNNL staff or certified commercial applicators are used to apply pesticides.

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 2014 (Section 4.3).

Radiation Protection of Biota: Potential media exposure pathways (air, soil, water, and food) were considered in conjunction with both gaseous and particulate radioactive contamination of air pathways. Calculated dose rates for 2014 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 2014.

Radioactive particulates in ambient air are monitored using a particulate air-sampling network located at the perimeter of the PNNL Campus. In 2014, there was no indication that any PNNL activities increased the ambient air concentrations at the air-sampling locations. Population exposure to radionuclide air emissions was determined using the maximum exposed individual (MEI) dose estimate (2.7×10^{-5} mrem [2.7×10^{-8} mSv]) effective dose equivalent (EDE) times the population (432,000) found within the 80-km (50-mi) radius of the PNNL Campus. The 2014 total collective dose from radionuclide air emissions estimated from nuclides that originate from the PNNL Campus was 0.012 person rem (1.2×10^{-4} person Sv). The PNNL Campus MEI location was 0.70 km (0.43 mi) south-southeast of the Physical Sciences Facility (Section 4.2.1).

MSL has two nonpoint-source minor emission units. The associated potential-to-emit registrations indicate emission unit characteristics are primarily particulates with contributions of less than 5.0×10^{-4} mrem/yr (5.0×10^{-6} mSv/yr) EDE. The MSL MEI location was assumed to be 0.19 km (0.12 mi) from the emission point. The EDE to the MEI from routine and non-routine point-source emissions was 9.0×10^{-5} mrem (9.0×10^{-7} mSv; Section 4.2.2). The MEI dose multiplied by the U.S population found within the 48-km (30-mi) radius of MSL (132,000) resulted in a collective dose of 1.2×10^{-2} person-rem (1.2×10^{-4} 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. Contaminants of concern (uranium, tritium, trichloroethylene, and nitrate) either were not detectable or were present in concentrations well below drinking water standards with the exception of nitrate, which exceeded drinking water standards. Nitrate is not a result of PNNL operations; it originates from offsite agricultural and industrial activities.

A ground-source heat pump is used to heat and cool the Biological Sciences Facility/Computational Sciences Facility. 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 production wells. The discharge permit requires sampling and analysis of the seven groundwater monitoring wells in addition to the four heat pump injection wells, the results of which are reported monthly to the Washington State Department of Ecology. PNNL is in compliance with all sampling requirements of the discharge permit (Section 6.0), and results show no concern with respect to the ground-source heat pump water affecting movement of Hanford Site contaminant plumes.

No groundwater sampling is required for environmental compliance at MSL.

Quality Assurance

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

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)
ca.	circa (approximately)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
Ci	curie
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
DQO	data quality objective(s)
EDE	effective dose equivalent
EISA	Energy Independence and Security Act of 2007
EMS	Environmental Management System
EMSL	William R. Wiley Environmental Molecular Sciences Laboratory
EO	Executive Order(s)
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
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(es)
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(s)
hr	hour(s)
in.	inch(es)
ISB2	Information Sciences Building 2
ISO	International Organization for Standardization
IT	information technology
k	thousand
kg	kilogram(s)
KiBe	Kiona-Benton School District
km	kilometer(s)
km^2	square kilometer(s)
kW	kilowatt(s)
L	liter(s)
L/min	liter(s) per minute
lb	pound(s)
LEED	Leadership in Engineering and Environmental Design
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	non-detectable
NEPA	National Environmental Policy Act of 1969
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit(s)
OSHA	Occupational Safety and Health Administration
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
PTE	potential-to-emit
PUE™	Power usage effectiveness
QA	quality assurance
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
RTL	Research Technology Laboratory
s	second(s)
SEPA	State Environmental Policy Act
SSPP	Strategic Sustainability Performance Plan
Sv	sievert(s)
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
yr	year(s)

Contents

Figures


Pacific Northwest
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ENERGY

Tables

1 Introduction

This environmental report was prepared to meet the requirements of U.S. Department of Energy (DOE) Order 231.1B, Administrative Change 1 (2012), "Environment, Safety and Health Reporting," by providing a synopsis of calendar year (CY) 2014 information related to environmental management performance and compliance efforts at the Pacific Northwest National Laboratory (PNNL).

As one of 10 DOE Office of Science (DOE-SC) national laboratories, PNNL is a multi-program facility that delivers breakthrough science and technology in the areas of energy and environment, fundamental and computational science, and national security. Operated by Battelle Memorial Institute (Battelle) under contract to DOE-SC's Pacific Northwest Site Office (PNSO), PNNL also 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.

This report is the primary document for reporting PNNL annual site environmental and operating performance, in addition to providing environmental 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, along with environmental management performance benchmarks.

After the context-setting background information provided in this Introduction, ensuing chapters present a summary of PNNL's 2014 record of operational activities related to environmental compliance, environmental management, environmental monitoring and dose assessment, environmental nonradiological program, groundwater protection program, 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 in Sequim, Washington.

1.1 Location

PNNL includes facilities in Richland, Washington, at the PNNL Campus and 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 North Bonneville and 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 and south of the DOE-Richland Operations Office's (DOE-RL's) Hanford Site 300 Area. 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 Washington State University Tri-Cities campus (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.

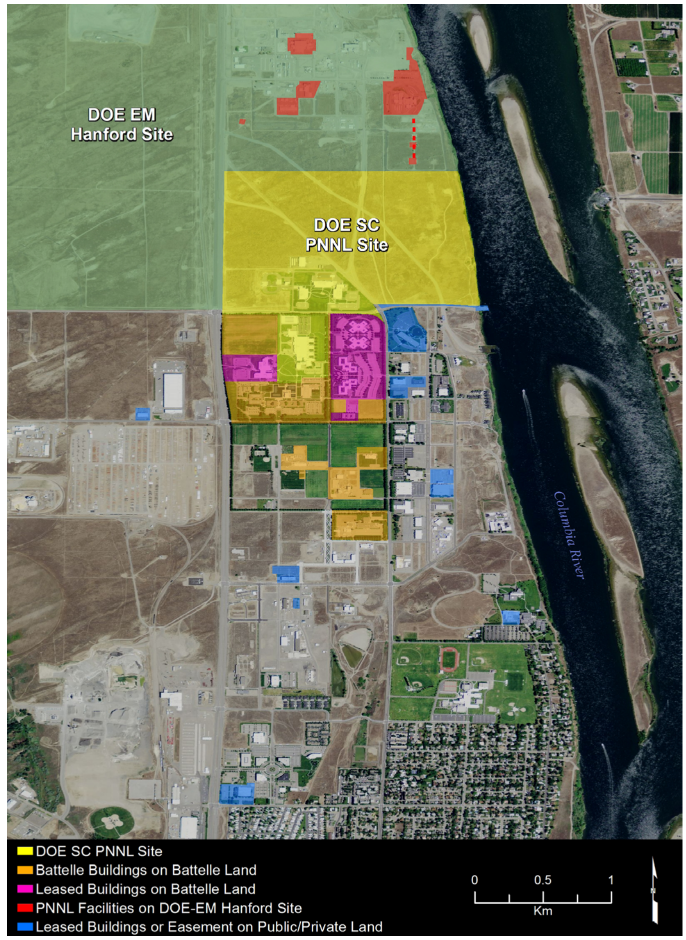

Figure 1.2. Pacific Northwest National Laboratory Campus and Surrounding Area

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

1.1.2 PNNL Marine Sciences Laboratory

In the rain shadow of the Olympic Mountains and less than 16 km (10 mi) north of Olympic National Park, the Battelle Land–Sequim area encompasses 60.7 ha (150 ac) of uplands and tidelands, about 3 ha (7.4 ac) of which have been developed for research operations on the northern portion of the Olympic Peninsula, in Clallam County, Washington. The developed portion of Battelle Land–Sequim includes MSL facilities, an innovative seawater treatment system, research docks, and outdoor experimental tanks and ponds (Figure 1.3), where research scientists and engineers conduct evaluations and investigate and develop technologies in marine research, and support intelligence, national security, and homeland security operations. DOE has exclusive use of MSL facilities, with operations consolidated under PNSO oversight.

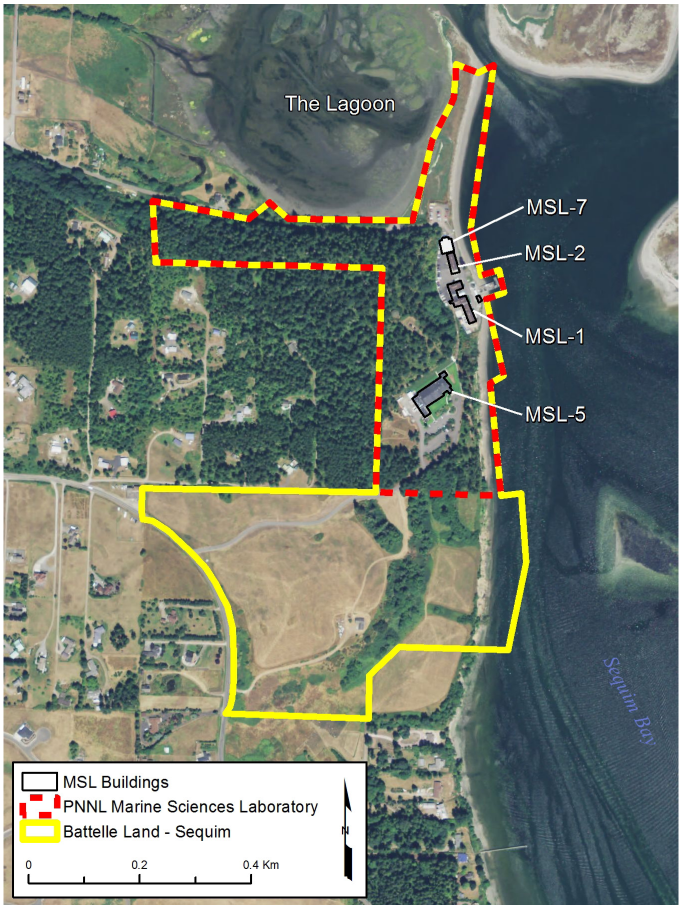

Figure 1.3. Battelle Land–Sequim, Encompassing the Marine Sciences Laboratory Facilities and Surrounding Environment

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 around the Pacific Northwest.

In the late 1970s, research expanded into energy, health, environmental, 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, and Innovation awards 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 Physical Sciences Facility (PSF) complex, the Engineering Development Laboratory, Life Sciences Laboratory 2, and Biological Sciences Facility/Computational Sciences Facility (BSF/CSF). The PSF complex includes the Materials and Science Technology Laboratory for the development and analysis of high-performance materials for energy, construction, and transportation technologies and systems, as well as 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 an emphasis on electromagnetics/radiography, optics/infrared spectroscopy, and acoustics/ultrasonics. Life Sciences Laboratory 2 is a biology and vivarium research facility, containing special support systems to control environmental conditions within the facility. BSF is solely 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. CSF investigations include the development of visual analytics technologies, cyber analytics, and critical infrastructure assessment and protection. In April 2014, construction began on the 3820 Systems Engineering Building located in the PSF complex, which will be used for energy research and was completed in June 2015.

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 at 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.

1.3 Demographics

The PNNL Campus is located in Benton County, south of the Hanford Site, an area of approximately 247 ha (610 ac). The Hanford Site is mostly flat, semi-arid, and primarily restricted from public access. Residents to the north, east, and west generally live on farms or in farming communities. Residents to the south and southwest live in the urban communities of Richland, Kennewick, Pasco, and West Richland.

In 2014, an estimated 186,500 people lived in Benton County and 87,800 people lived in adjacent Franklin County, increases of 6.5 percent and 12.3 percent, respectively, over 2010 figures (USCB 2015a, b). During 2014, 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 72,700 people lived in Clallam County in 2014; this is an increase of approximately 2 percent over 2010 figures and equivalent to approximately 1 percent of Washington's population (USCB 2015c). Sequim, the nearest population center to MSL, had a population of 6,670 people in 2013 (USCB 2015d). An estimated 132,000 people (on the U.S. side of the border) live within 48 km (30 mi) of Sequim and an estimated 1.45 million reside 48–80 km (30–50 mi) from Sequim. Victoria, British Columbia, the closest major city, has an estimated population of 358,000 people. Seattle, Washington, within 80 km (50 mi) of MSL, has a population greater than 652,000.

1.4 Environmental Setting – PNNL Campus

The PNNL Campus occupies land with 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).

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, forming an aquitard between the base of the unconfined aquifer and the confined aquifers within the basalt formations.

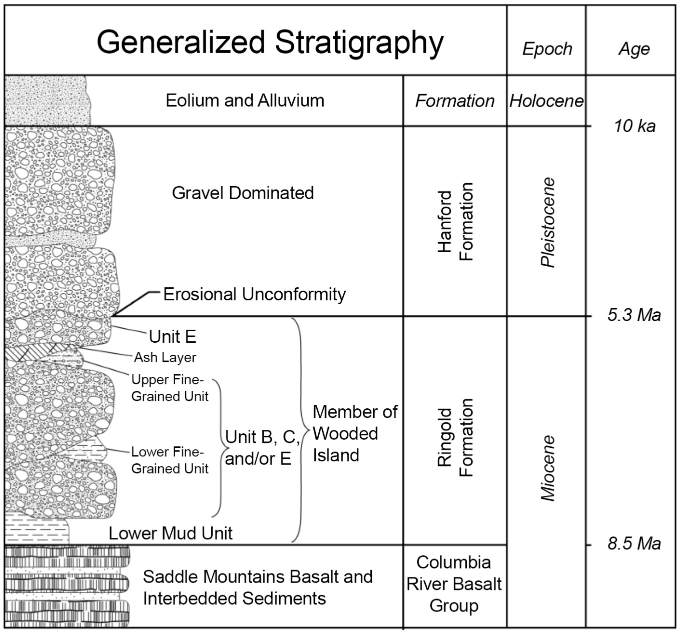

Figure 1.4. Generalized Stratigraphic Column Depicting the Stratigraphy Underlying the PNNL Campus (modified from Reidel et al. 1992; Thorne et al. 1993; Lindsey 1995; Williams et al. 2000; DOE-RL 2002; and Williams et al. 2007)

1.4.2 Hydrology

The general direction of groundwater flow under the PNNL 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.

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 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 Meteorology Station operates an array of remote meteorological towers across the Hanford Site. Located north of the PNNL Campus, the Hanford Meteorology 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 (77.1°F) in July (DOE-RL 2014a). The normal annual relative humidity at the Hanford Meteorology Station is 55 percent. Humidity is highest during winter, when it averages approximately 76 percent, and lowest during summer, when it averages approximately 36 percent (DOE-RL 2014a). Normal annual precipitation at the Hanford Meteorology Station is 18.1 cm (7.14 in.). Most precipitation occurs during late autumn and winter, with

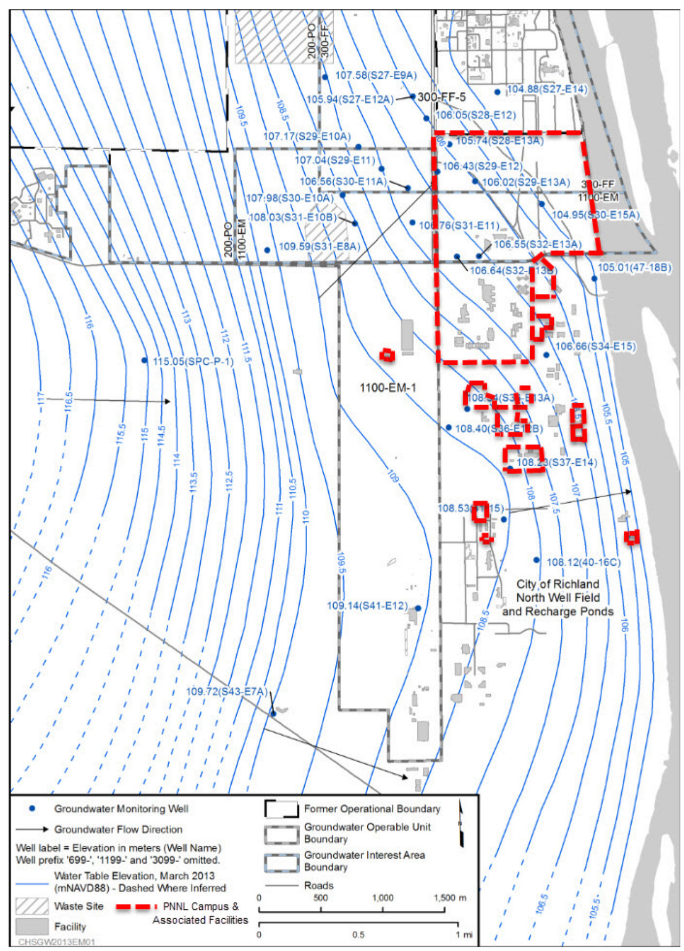

Figure 1.5. Water Table Elevations (m) in 2013 (modified from DOE-RL 2014b). Groundwater flow direction is normal to the water table contour lines. The approximate PNNL Campus is bordered in red. Data for 2014 are not provided; the conditions shown are typical of recent years.

more than half of the annual amount occurring from November through February.

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 (6 to 7 mph), and highest during summer, averaging about 4 m/s (8 to 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 (1945–2014).

1.4.4 Ecology

The PNNL Campus is located in the lowest and most arid portion of the Columbia Plateau Ecoregion (EPA 2014)—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 2014). 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 2014); 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 the native biodiversity and community structure. Plant communities in this region are classified based on the dominant species of overstory (shrubs) and understory (grasses and forbs).

A baseline biological survey of undeveloped sections of the PNNL Campus north of Horn Rapids Road was conducted by PNNL ecologists in July and August 2014. This baseline included a survey of the riparian zone that was limited by high water. The most recent complete survey of the riparian corridor was completed in 2010 (Chamness et al. 2010). A list of plant and animal species identified in the PNNL Campus areas surveyed in 2014 and their status is provided in Appendix C. Because of annual variability in wildlife use and detectability, plant species occurrences, survey routes, and observers, the 2014 survey data must be combined with data from previous surveys (Larson and Downs 2009; Chamness et al. 2010; Becker and Chamness 2012; Duncan et al. 2013; Duncan et al. 2014) to produce the most complete list of plants and animals known to occur on the undeveloped portion of the PNNL Campus.

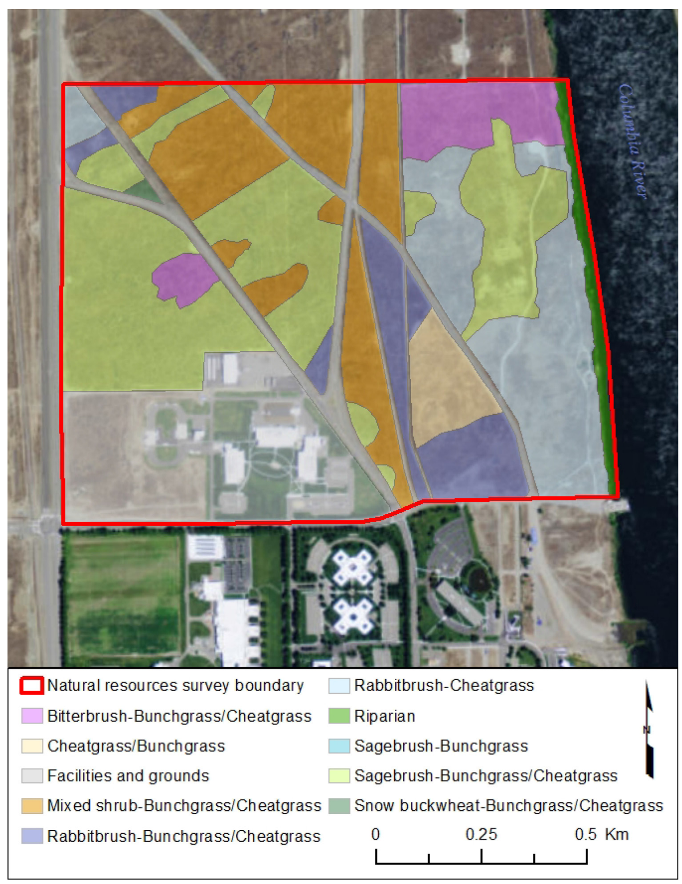

Figure 1.6. Plant Communities Found on the Undeveloped Portions of the PNNL Campus.

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 species of overstory (shrubs) and understory (grasses and forbs). 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. The non-native cheatgrass (*Bromus tectorum*) occurs in all plant communities on the PNNL Campus north of Horn Rapids Road. 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 tumble knapweed (*Centaurea diffusa*), rush skeletonweed (*Chondrilla juncea*), Russian knapweed (*Acroptilon repens*), summer cyperus (*Bassia scoparia*), puncturevine (*Tribulus terrestris*), and yellow starthistle (*Centaurea solstitialis*). Common Class C noxious weeds include field bindweed (*Convolvulus arvensis*), Russian olive (*Elaeagnus angustifolia*), and tree-of-heaven (*Ailanthus altissima*). 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. 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 reed canarygrass (*Phalaris arundinacea*), also a Class C noxious weed (WAC 16-750-015), 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).

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 2008). Priority habitats are those habitat types or elements with unique or significant value to a diverse assemblage of species.

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, and sockeye salmon. The Columbia River constitutes essential fish habitat for Upper Columbia River spring Chinook salmon and critical habitat and essential fish habitat for Upper Columbia River steelhead (70 FR 52630). 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 2013). The primary invertebrate fauna include caddisfly (*Trichoptera*) and chironomid larvae, crayfish (*Pacifasticus leniusculus towbridgii*), and western floater (*Anodonta kennerlyi*) (Mueller et al. 2011).

Table 1.1. Wildlife, Fish, and Plant Species of Conservation Concern Known to Occur or That Potentially Occur on the PNNL Campus North of Horn Rapids Road or in 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
Sage sparrow	*Artemisiospiza nevadensis*		Candidate
Townsend ground squirrel	*Urocitellus townsendii townsendii*		Candidate
Fish			
Upper Columbia River spring Chinook salmon	*Oncorhynchus tschawytscha*	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
Persistentsepal yellowcress	*Rorippa columbiae*	Species of Concern	Endangered

Sources: WDFW (2015a) and WDNR (2014)

(a) The black-tailed jackrabbit, burrowing owl, and sage sparrow have been observed on the Pacific Northwest National Laboratory (PNNL) Campus north of Horn Rapids Road. 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 2014; 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 2015a). 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 2014).

1.5 Environmental Setting – PNNL Marine Sciences Laboratory Vicinity

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 (90 ft) higher in elevation on the bluff overlooking the ocean.

The geology immediately underlying MSL is composed of glacial till from the Vashon glaciations 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). No meteorological data are currently collected onsite. 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

MSL (Figure 1.3) lies in the Olympic Rain Shadow subdivision of the Puget Lowlands Ecoregion, a north-south depression between the Olympic Peninsula and western slopes of the Cascade Mountains (Ecology 2007) that flanks the coastline of Puget Sound, and features many islands, peninsulas, and bays (EPA 2014). Timber harvesting and cultivation have fragmented the original vegetation of the Puget Lowlands that once consisted of coniferous forest and expanses of prairie-oak woodland (WWF 2015). Today, second-growth coniferous forest and agricultural fields occupy much of the ecoregion's glacial moraines, outwash plains, floodplains, and terraces (EPA 2014; LandScope Washington 2015). 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 second annual biological survey of the MSL was conducted in May, 2014; all species observed during this survey 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, western hemlock, and western red cedar. Other common tree species include Pacific madrone, bigleaf maple, red alder, 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 MSL. 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 2014. 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.

About 6.6 ha (16.4 ac) of estuarine/marine wetland and a total of 1.2 ha (2.9 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).

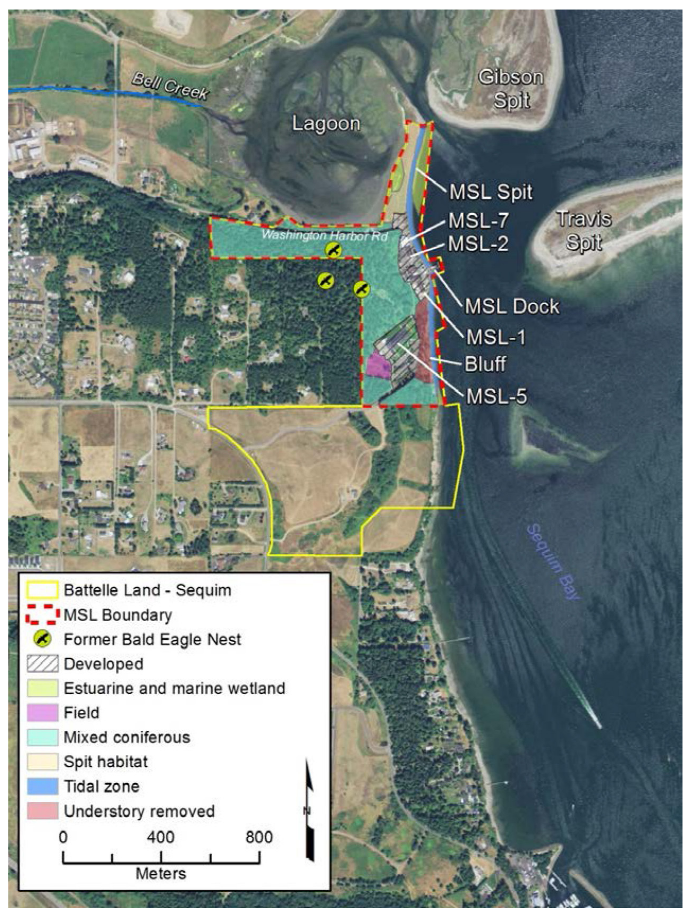

Figure 1.7. Plant Communities and Locations of Former Bald Eagle Nests at MSL

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 2008), 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 at MSL, which are an important source of sediments that form and sustain beaches (WDFW 2008).

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), and is proposed as critical habitat for Puget Sound steelhead (78 FR 2726). 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). Sequim Bay contains proposed nearshore and deepwater critical habitat for yelloweye rockfish, Puget Sound canary rockfish, and bocaccio (78 FR 47635). Critical habitat for the marble murrelet occurs at the southwest end of Sequim Bay about 4 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 2015b).

Common mammal species in the Puget Lowlands ecoregion include raccoon (*Procyon lotor*), mink (*Mustela vison*), coyote, and black-tailed deer (*Odocoileus hemionus*) (WWF 2015). These species likely are also common in the MSL vicinity. Kiapot 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 2015c). Avian species found at the site are representative of the rich bird diversity of the north Olympic Peninsula (Dungeness River Audubon Center 2010). 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 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. At least 48 avian species were observed at MSL in May 2014 (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

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 has 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 Peroid

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 residents

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 (2015a)
(a) The bald eagle, peregrine falcon, and western toad are known to occur on the Pacific Northwest National Laboratory Marine Sciences Laboratory (MSL) property. Taylor's checkerspot butterfly and sand-verbena moth potentially occur in the vicinity of MSL 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 Washington Department of Fish and Wildlife 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).

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* 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 in 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.

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

Cultural Period	Years Before Present	Site Type	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.
	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
	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).

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* (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

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 BP (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). One winter village was located approximately 12.4 km (20 mi) upstream along the Elwha River.

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

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 in 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 at Sequim was intended to "provide facilities for research projects which require ocean waters or oceanic environments" (Battelle-Northwest 1967).

2 Compliance Summary

Operations at PNNL are conducted in compliance with all applicable federal, state, and local environmental laws, regulations, and guidance; presidential Executive Orders; and DOE Orders, directives, policies, and guidance. PNNL endeavors to conduct operations in a sustainable manner that is protective of the environment. This chapter summarizes PNNL's compliance status for 2014.

2.1 Sustainability and Environmental Management System

The DOE-Battelle Prime Contract for the management and operation of PNNL (DOE-PNSO 2015) 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 2014), incorporation of sustainable acquisition requirements into applicable processes, and the development of an Environmental Management System (EMS) that is certified to 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 ISO-certified EMS and the status of sustainability goals.

2.1.2 Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management"

Executive Order 13423 of January 24, 2007 (72 FR 3919), established a policy for federal agencies to conduct legally, environmentally, economically, and fiscally sound environmental, transportation, and energy-related activities in an integrated, efficient, continuously improving, and sustainable manner. The Order requires federal agencies to set goals for the following: improved energy efficiency; reduced GHG emissions; use of renewable energy sources; renewable energy generation; reduced water consumption; acquisition of goods and services; reduced use of toxic and hazardous chemicals and materials, including ozone-depleting substances; increased waste minimization, prevention, and recycling; use of sustainable building practices; reduced use of petroleum products for vehicles; and use of electronic products. In addition, Executive Order 13423 (72 FR 3919) requires that an EMS be used as the mechanism for managing environmental goals, as well as other impacts on the environment from site operations, and that environmental objectives and targets be established. It also requires establishment of environmental management training, environmental compliance review and auditing, and leadership awards to recognize outstanding environmental, energy, or transportation management performance. PNNL has developed detailed plans and milestones for achieving site-specific energy efficiency objectives and goals as directed by Executive Order 13423 (72 FR 3919); details are available in Section 3.0.

2.1.3 Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance"

Executive Order 13514 of October 5, 2009 (74 FR 52117) reaffirmed, and in some cases, bolstered the policy and goals established by Executive Order 13423 (72 FR 3919), including increased GHG accounting and reporting. Executive Order 13514 (74 FR 52117) set goals for the following: the reduction of Scope 1, 2, and 3 GHGs[(1)]; improved water-use efficiency and management; the promotion of pollution prevention and waste elimination; the advancement of regional and local integrated planning; the implementation of sustainable building lifecycle management practices; the advancement of sustainable acquisition; and the promotion of electronics stewardship. Executive Order 13514 also requires the continued implementation of a formal sustainable EMS. Details of PNNL's conformance with the Order are available in Section 3.0.

2.2 Energy Independence and Security Act of 2007

The Energy Independence and Security Act of 2007 (EISA) 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) 2014, PNNL completed the second of a 4-year cycle for eight buildings subject to EISA Section 432 energy and water evaluation requirements. In addition, 36 percent of PNNL buildings met the criteria for DOE Federal Energy Management Program Guiding Principles for high-performance and sustainable buildings. Whole-building metering for electricity, natural gas, and water has been completed for all viable buildings, enabling facility system analyses, as needed. Stormwater management practices are implemented to promote water drainage and reduce runoff. In accordance with requirements to implement cool roof technologies (roofs with thermal resistances of at least R-30) on DOE buildings and facilities (DOE 2010), PNNL has realized a total cool roof area of 60,600 m^2 (652,000 ft^2), or 49 percent, in FY 2014. Also, a 125-kW

(1) Scope 1 emissions are generated from site operations and activities; Scope 2 emissions are associated with the purchase of energy (electricity, heat, or steam) used by site contractors; and Scope 3 emissions are associated with ancillary activities related to site operations, including business travel, employee commuting, vendor activities, and delivery services.

photovoltaic array continued operation in 2014, contributing to onsite energy generation, and together with renewable energy certificate purchases, provided over 50 percent of the PNNL electricity consumption from renewables.

2.3 National Environmental Policy Act of 1969

The *National Environmental Policy Act of 1969* (NEPA) 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). Program activities include preparing sitewide project- and activity-specific categorical exclusions, environmental assessments, and Washington State 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 1,286 NEPA reviews during CY 2014 for research and support activities (871 Electronic Prep and Risk System reviews, 382 EMSL user proposals, and 33 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 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 assessment documents in 2014.

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 with potentially significant impacts. PNNL categorical exclusions were updated in November and December 2011 to reflect the changes to Title 10 of the *Code of Federal Regulations* Part 1021 (10 CFR 1021). A total of seven PNNL-related generic categorical exclusions were approved by DOE-RL in 2014, covering the following types of activities on the Hanford Site:

- routine maintenance in the 300 Area
- small-scale R&D, laboratory operations, and pilot projects in the 300 Area
- microbiological and biomedical research projects in the 300 Area
- siting, constructing, modifying, and operating small-scale structures on the Hanford Site
- site characterization and environmental monitoring on the Hanford Site
- facility, safety, and environmental improvements in the 300 Area
- small-scale R&D projects using nanoscale materials.

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 categorical exclusions is available at http://www.hanford.gov/page.cfm/CategoricalExclusions. DOE-RL also approved one activity-specific categorical exclusion in 2014, for upgrades to the 325 Building Hazardous Waste Treatment Unit.

There were no new PNSO-approved generic categorical exclusions in 2014. PNSO previously approved 13 sitewide categorical exclusions to cover PNNL research and operations activities.

In instances where 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 three project-specific categorical exclusions in 2014, all for the deployment of wind characterization buoys (for testing in the Strait of Juan de Fuca and deployment off the coast of Virginia and Oregon).

NEPA staff also reviewed a randomly generated statistical subset of 473 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

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 USC 7401) is administered by the EPA. It regulates air emissions from stationary and mobile sources, both criteria and hazardous. 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*, 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 40 CFR 52, 40 CFR 60, 40 CFR 61, 40 CFR 63, 40 CFR 68, 40 CFR 82, and 40 CFR 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 implements and enforces most federal and state requirements at MSL.

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 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. 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 61, Subpart H, require the measurement and reporting of radionuclides emitted from DOE facilities and the resulting 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 61 standard in its regulations (WAC 246-247) that require the calculation and reporting of the EDE to the maximum exposed individual (MEI) from both point-source emissions and from fugitive source emissions of radionuclides. WAC 246-247 further requires the reporting of radionuclide emissions, including radon, from all PNNL Campus sources. On the PNNL Campus, the PSF, EMSL, the Research Technology Laboratory (RTL), and the Life Sciences Laboratory 2 have the potential to emit radionuclides. In 2014, one sitewide radioactive air permit, commonly called Potential Impact Category 5 (PIC-5) permit, was issued for very low potential emissions associated with facilities restoration of potentially contaminated systems. A second PIC-5 permit application was submitted for low-level radioactive sources used for instrument and operational checks. Details regarding ambient air, stack emissions monitoring, and PIC-5 programs for the PNNL Campus and at MSL are reported annually. Data for 2014 are available in the "Pacific Northwest National Laboratory Campus Radionuclide Air Emissions Report for Calendar Year 2014" (Snyder et al. 2015). Radioactive air emissions results for MSL are available in the "Marine Sciences Laboratory Radionuclide Air Emissions Report for Calendar Year 2014" (Snyder and Barnett 2015). During CY 2014, 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 100,000 times lower than the regulatory standard of 10 mrem/yr (0.1 mSv/yr) EDE for the period.

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 point sources are major, minor, and fugitive emissions units. MSL has two nonpoint minor emission units. The regulatory standard for a maximum dose to any member of the public is 10 mrem/yr (0.1 mSv/yr) EDE (40 CFR 61, Subpart H), and applies to radionuclide air emissions, other than radon, from DOE facilities. During 2014, radioactive emissions from both the PNNL Campus and MSL were well below the federal and state 10-mrem/yr (0.1-mSv/yr) standard.

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 (RAEL–005), and the nonradiological approval orders issued by the BCAA, listed below:

- Battelle Inhalation Laboratory (Order of Approval No. 06004-00, Rev. 3)
- Environmental Molecular Sciences Laboratory (Order of Approval No. RO 2012-0009)

- Life Sciences Laboratory 2 (Order of Approval No. 20070006, 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 radioactive air emission license issued by the Washington State Department of Health (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

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* 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. Responsibility for the NPDES program has been delegated from EPA to the Washington State Department of Ecology.

While there are no direct discharges of wastewater from the PNNL Campus to surface waters, 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 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 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 001 and Outfall 003. Permit CR IU005 regulates discharges from EMSL. The process wastewater from EMSL is collected in four retention tanks. Each retention tank is monitored prior to release to verify permit compliance. Permit CR-IU011 regulates process wastewater discharged from the PSF. All process wastewater from PSF is monitored at a single compliance point. 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. Stormwater discharges to the grassy swales do not require registration. Best management practices are used to minimize pollution in stormwater. These practices include storing chemicals inside or under cover to prevent contact with stormwater, routinely sweeping and cleaning parking lots, prompt notification and cleanup of spills, and 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 the federal or state pollutant discharge elimination system 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 2014).

2.5.3 Safe Drinking Water Act of 1974

The *Safe Drinking Water Act of 1974* is the main federal law that assures the quality of Americans' drinking water. Under the Act, 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 drinking use, whether from above-ground or underground sources. The Act authorizes EPA to establish minimum standards to protect tap water, and requires all owners or operators of public water systems to comply with these primary (health-related) standards. State governments, which can be approved to implement these rules for EPA, also encourage attainment of secondary standards.(2) Under the *Safe Drinking Water Act of 1974*, EPA also establishes 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 non-laboratory and 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

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) and the *Resource Conservation and Recovery Act of 1976* (RCRA). 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*. 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

(2) Secondary standards are set 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.

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 2013* (DOE-RL 2014b).

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*, 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, "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 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 2014, 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.

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—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 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).

With the exception of the 325 Hazardous Waste Treatment Units, PNNL facilities operate under the generator requirements of WAC 173-303. During CY 2014, 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 underground storage tanks for the storage of diesel fuel for two emergency generators. In 2012, new major requirements for personnel training for underground storage tank operation were adopted by the Washington State Department of Ecology and implemented at PNNL.

Washington State Department of Ecology and EPA personnel inspected PNNL facilities for RCRA compliance four times in 2014. No violations were identified as part of two inspections. A third identified administrative issues (labeling and recordkeeping), which were promptly addressed. The Washington State Department of Ecology has not yet issued the final report for the fourth inspection (conducted in March 2014) as of July 1, 2015.

No RCRA permits are applicable to MSL.

2.6.5 Federal Facility Compliance Act of 1972

The *Federal Facility Compliance Act of 1992*, 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 2015).

2.6.6 Toxic Substances Control Act

Toxic Substances Control Act requirements that apply to PNNL primarily involve regulation of polychlorinated biphenyls (PCBs). Federal regulations for PCB use, storage, and disposal are provided in 40 CFR 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 is transferred to extended storage at the Hanford Site, pending the development of adequate treatment and disposal technologies and capacities.

The "2013 Hanford Site Polychlorinated Biphenyl Annual Document Log" (DOE-RL 2014c) and the "2013 Hanford Site Polychlorinated Biphenyl Annual Report" (DOE-RL 2014d) 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 2014.

2.6.7 Federal Insecticide, Fungicide, and Rodenticide Act

The *Federal Insecticide, Fungicide, and Rodenticide Act* 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 2014, 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) 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 in support of emergency planning.

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.

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 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 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 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 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 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 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.

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 24, 2015.(3) 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 2014. 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 24, 2015(4) 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.

(3) Tilden HT. February 19, 2015. "EPCRA Tier Two Inventory Report – PNNL Site." [Email to J Beck, Benton County Emergency Services, Richland, Washington, and KR Hubele, Richland Fire Department, Richland, Washington]. Submitted to Ecology 2/19/15 via Secure Access Washington website.
(4) Tilden HT. February 19, 2015. "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 Ecology 2/19/15 via Secure Access Washington website.

Neither the PNNL Campus nor MSL was required to submit a Toxic Release Inventory Report for 2014, 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 2014.

Table 2.2. *Emergency Planning and Community Right-to-Know Act of 1986* Compliance Reporting, Calendar Year 2014

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 2014 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 Natural and Cultural Resources

The "Pacific Northwest Site Office Cultural and Biological Resources Management Plan" (DOE-PNSO 2008) provides direction and guidance relative to protecting and managing biological and cultural resources on the PNNL Campus. The Resources Management Plan 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 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.

2.7.1 Biological Resources

A number of federal laws and Executive Orders contain requirements for protecting biological resources. This section summarizes the requirements and catalogs PNNL's compliance activities in 2014.

The *Endangered Species Act of 1973* 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 2014 demonstrated PNNL compliance.

The *Migratory Bird Treaty Act* 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 ecological compliance review process as described in the *Pacific Northwest Site Office Cultural and Biological Resources Management Plan* (DOE-PNSO 2008).

The *Bald and Golden Eagle Protection Act* 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 midday, thereby minimizing impacts by avoiding eagle roosting periods.

The *Magnuson–Stevens Fishery Conservation and Management Act* 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 fishery resources.

The *Marine Mammal Protection Act of 1972* 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.

The *Rivers and Harbors Appropriation Act of 1899* 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 review for each project. In 2014, PNNL obtained permits for four projects under Section 10 of this Act.

The *Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990* 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, "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 review process at PNNL.

Executive Order 11988, "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, "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.

The *Coastal Zone Management Act of 1972* 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 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 the National Oceanic and Atmospheric Administration. PNNL maintains compliance with this Act through its biological review process.

The Washington State *Shoreline Management Act of 1971* 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 (20 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 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.

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

PNSO prepared the "Pacific Northwest Site Office Cultural and Biological Resources Management Plan" (DOE-PNSO 2008) 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. The region of the PNNL Campus north of Horn Rapids Road is surveyed to fulfill these guidance requirements.

As stipulated in the Resources Management Plan (DOE-PNSO 2008), projects involving soil 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. Twelve ecological reviews were conducted for PNNL projects in CY 2014, eight on the Richland Campus and four at MSL or for MSL-related projects. 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 monitored; Washington State priority habitats; and bird species protected under the *Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act*. No project impacts 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 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 reviews. A List of plant and animal species identified on the PNNL Campus north of Horn Rapids Road and on MSL lands surveyed in 2014 and their status is 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 Campus north of Horn Rapids Road (Larson and Downs 2009). 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. Class B species include tumble knapweed, rush skeletonweed, Russian knapweed, summer cyperus, 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) conforming to Washington State weed control laws (RCW 17.10).

Starting in 2010, licensed PNNL staff, in coordination with staff ecologists, have used hand-spraying methods to control populations of these specific weeds while minimizing impacts on other vegetation. The herbicide Milestone™ (along with a water conditioner, drift control and sticking agents, and blue dye for visibility) is applied 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 Campus north of Horn Rapids Road.

Hand-spraying began on May 22 and was completed for the season on June 30, 2014; approximately 1.5 ha (4 ac) were treated (Figure 2.1). Target species in 2014 were rush skeletonweed, yellow starthistle, and Russian knapweed. Figure 2.1 shows areas where the target species were known to occur. These areas were covered thoroughly on foot and any target species were treated with herbicide. Tumble knapweed was not targeted in 2014 because a seed-eating weevil (*Larinus minutus*)

(Figure 2.2) has been documented parasitizing numerous plants within the PNNL Campus north of Horn Rapids Road (Duncan et al. 2013). The seed weevils do not kill all of the plants, but are keeping the plants from spreading. If the seed weevils become ineffective, tumble knapweed will be targeted for herbicide treatment. Russian knapweed (Figure 2.3) has no approved biocontrol agents and is reportedly difficult to control using herbicides. The results of our 2012 trial to determine the effectiveness of a spring application of Milestone™ on Russian knapweed indicated almost total eradication of Russian knapweed within the plots, while the population outside the plots was still thriving (Duncan et al. 2013). Consequently, Russian knapweed was specifically targeted in 2013 and again in 2014.

2.7.2 Cultural Resources

A number of federal Acts and Orders provide the framework for protection of cultural resources at the PNNL Campus and MSL. This section summarizes the requirements and catalogs PNNL's compliance activities in 2014.

The *National Historic Preservation Act of 1966* (54 USC 300101) 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. At PNNL, compliance with the *National Historic Preservation Act of 1966* is achieved through the cultural resource review process.

The *Antiquities Act of 1906* (16 USC 431) 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 USC 470aa).

The *Archaeological Resources Protection Act of 1979* (16 USC 470aa) 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*.

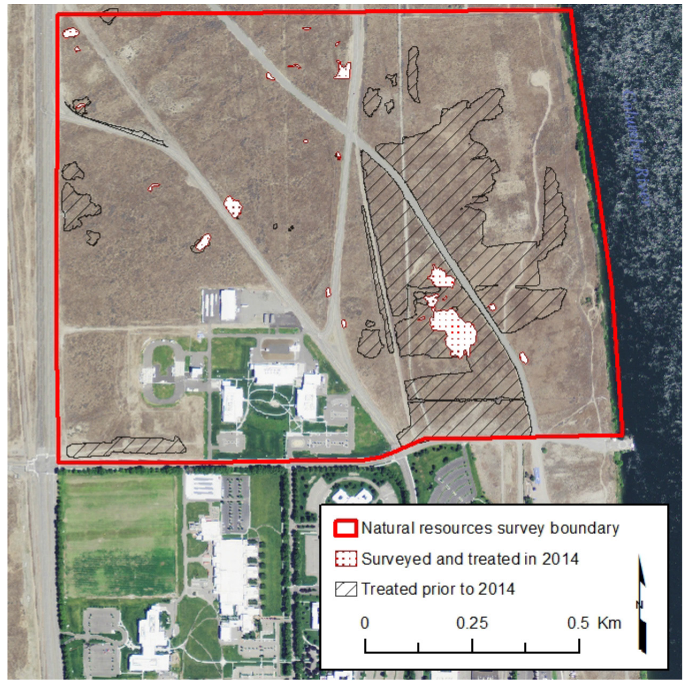

Figure 2.1. Areas Treated for Noxious Weeds on the PNNL Campus in 2014

Figure 2.2. Seed-Eating Weevils Found on Tumble Knapweed on the PNNL Campus

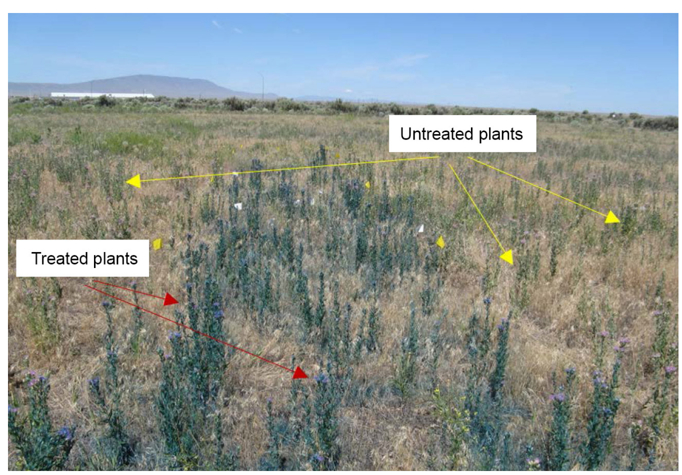

Figure 2.3. A Russian Knapweed Test Plot Immediately after Treatment

The *Native American Graves Protection and Repatriation Act of 1990* (25 USC 3001) 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 USC 1996) 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* (16 USC 469) 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.

The Executive Order for *Protection and Enhancement of the Cultural Environment* (Executive Order 11593) 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.

Executive Order 13007, *Indian Sacred Sites*, 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, *Consultation and Coordination with Indian Tribal Governments*, 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, *Preserve America*, directs federal agencies to increase their knowledge of historic resources in their care, enhance the management of these assets, and to 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:

1. assure that the DOE programs and field elements integrate cultural resources management into their missions and activities and
2. 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, *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 Alaska Native Tribal Government Policy* including its guiding principles and implementation framework.

In accordance with *National Historic Preservation Act of 1966* 54 USC 300101) Section 106 requirements, cultural resources reviews are conducted for all federal undertakings to identify their potential to affect cultural resources. If the undertaking is determined to be the type of activity that does not have the potential to affect historic properties (assuming such historic properties are present), the agency has no further obligations under NHPA Section 106. Three PNNL projects in 2014 were reviewed and determined to have No Potential to Cause Effect on historic properties as defined by 36 CFR 800.3(1): two at MSL and one in the Sequim, Washington vicinity. 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. Three Section 106 cultural resource reviews were conducted for PNNL projects in 2014: one on the PNNL Campus, one in the Coos Bay, Oregon, vicinity, and one near Virginia Beach, Virginia. All three reviews resulted in a finding of No Historic Properties Affected. 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 notifications were sent to potential consulting parties about project activities, but it was determined that these 4 particular projects did not require a Section 106 review.

To assure that important cultural resources are protected on the PNNL Campus, the 2008 DOE *Pacific Northwest Site Office Cultural and Biological Resources Management Plan* (DOE-PNSO 2008) requires annual monitoring of three eligible properties to identify potential threats and recommend appropriate actions, if necessary. As stipulated in the Management Plan, 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 November 21, 2014. 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 to add to 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. Based on the amount of vegetation both in the excavation and on the push pile it appears that this feature is likely associated with original construction activities. The area of off-road driving identified during the previous monitoring trip (in November 2013) was revisited; no new off-road driving was apparent since the last monitoring trip, indicating that protection measures have been effective. Erosion impacts were identified during the 2013 monitoring trip at a site near the Columbia River, revealing historical debris including metal objects, brick, and bottle glass protruding from the cut bank face. Continued erosional activities are evident, likely during high river levels. In addition, some new, and fairly recent animal burrows (likely badger or coyote) were identified during monitoring activities. No archaeological materials appear to have been affected by the burrowing, but this area will continue to be monitored.

2.8 Radiation Protection

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

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

DOE Order 458.1, issued in February 2011, superseded DOE Order 5400.5, Chg 2. Administrative changes were made to DOE Order 458.1 in March 2011 (Chg 1), June 2011 (Chg 2), and January 2013 (Chg 3). Section 2.d (As Low As Reasonably Achievable [ALARA]) 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. During the reporting period of this site environmental report, PNNL was working under the requirements of DOE Order 458.1.

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 members of the public and releases to the environment are kept ALARA. The ALARA process must be applied to the design or modification of facilities and the conduct of radiological work activities.

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. This notification is done through the issuance of this annual site environmental report. No property with detectable residual radioactivity above guideline limits was released in 2014.

PNNL radiation protection procedures implement DOE Order 458.1 to include guidance on the environmental ALARA program, the use of process knowledge and historical knowledge when releasing property, the preparation and approval of authorized limits requests, and the preparation of an annual site environmental 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 835, "Occupational Radiation Protection"
- DOE Order 440.1A, "Worker Protection Management for DOE Federal and Contractor Employees"

- DOE Order 458.1, "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, and 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.

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* 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 820, 10 CFR 830, and 10 CFR 835) and directives (e.g., DOE Order 435.1, Chg 1 [Section 2.8.2] and DOE Order 458.1 [Section 2.8.1]) to protect public health and the environment from potential risks associated with radioactive materials. PNNL complies with the *Atomic Energy Act of 1954* through its Radiation Protection Management and Operation Program and Radioactive Waste Management Basis Program.

2.9 Major Environmental Issues and Actions

Releases of radioactive and regulated materials to the environment are reported to DOE and other federal, state and/or local agencies as required by law. The specific agencies notified depend on the type and amount of material released, and the location of each release event. This section describes releases to the environment that occurred at PNNL during CY 2014.

2.9.1 Continuous Release Reporting

A continuous release is a hazardous release exceeding reporting thresholds under CERCLA (Section 2.6.2) 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 2014.

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

DOE Order 232.2 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 2014.

2.10 Summary of Permits

Table 2.3 summarizes air, liquid, and hazardous waste permits for the PNNL Campus and MSL during 2014.

Table 2.3. PNNL Air, Liquid, and Hazardous Waste Permits, 2014				
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	6/24/2015
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. 1	Physical Science Facility complex (PNNL Site)	Nonradioactive air emissions	None
Benton Clean Air Agency	Approval Order 2012-0016	PNNL Campus (PNSO R&D Activities)	Nonradioactive air emissions	None
Benton Clean Air Agency	Approval Order 2012-0017	PNNL Campus (Battelle building support systems)	Nonradioactive air emissions	None
Benton Clean Air Agency	Approval Order RO 2012-0009	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
Benton Clean Air Agency	Approval Order 06004-00, Rev. 3	Battelle Inhalation Laboratory	Nonradioactive air emissions	None
Olympic Region Clean Air Agency	Notice of Intent 13NOI968	PNNL Marine Sciences Laboratory	Nonradioactive air emissions	None
Liquid Effluents[d]				
City of Richland	CR-IU001	PNNL Campus	Liquid effluent discharges to city sewer	3/31/2015
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
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	6/30/2015

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[(a)]
Washington State Department of Ecology	ST-9274	Biological Sciences Facility and Computational Sciences Facility	Reinjection of well water used in ground-source heat pump	6/4/2015
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 300 Area)	Treatment and storage of dangerous waste (primarily mixed waste)	9/27/2004

(a) Expired permits generally remain in force while renewal applications are processed by the issuing agency.
(b) Permit issued to 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 Environmental Management System

PNNL has a mature, robust EMS that was established in 1996. Since 2002, ISO 14001 certification, which includes yearly independent third-party verification of the certification, has been maintained. The EMS is integrated into PNNL's Integrated Safety Management Program, which assures that staff are aware of 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 to accomplish 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 periodically to verify that it is operating as intended and in conformance with the ISO 14001 standards. The 2014 EMS recertification audit determined that the system remains in conformance with the ISO 14001:2004 Standard (Figure 3.1). The ISO 14001-registered EMS is a key component of PNNL's success in achieving sustainability.

In addition, the 2014 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.

PNNL is committed to its customers, employees, and the community, with a sustainability mission that includes water and energy conservation, improving staff comfort and productivity, and protecting and benefiting the environment.

- Environmental training procedures were established to assure that training requirements for individual competence and responsibility were identified, carried out, monitored, tracked, recorded, and refreshed as appropriate to maintain competence.
- EMS requirements were included in all appropriate contracts, and contractors fulfilled defined roles and specified responsibilities.
- EMS audit/evaluation procedures were established, audits were conducted, and nonconformities were addressed or corrected.
- Senior leadership review of the EMS was conducted and management responded to recommendations for continual improvement.


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):

ISO14001:2004

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

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.nst-isr.org

[illegible]

Figure 3.1. Certificate of Registration for PNNL Conformance to ISO 14001:2004 Standards

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 10 most significant aspects and the EMS controls used to minimize potential impacts of each aspect are as follows:

- **Chemical Use and Storage**. As a research laboratory, PNNL has many buildings where 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. In FY 2014, approximately 220 chemical containers were reallocated to internal staff.
- **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 non-hazardous 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 is achieved through the incorporation of electronic stewardship practices, reuse of materials, and operation of recycling programs. In FY 2014, all major employee events were zero waste; nearly 100 percent of the waste was recycled or reused. Food scraps from those events were provided to local farmers for animal feed. PNNL further reduces degradation and depletion of environmental resources by purchasing environmentally friendly items (e.g., those that contain recycled content).
- **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 through the acquisition of high-fuel-efficiency vehicles, including hybrids and all-electric vehicles. PNNL has recently acquired electric vehicles for on-campus transportation and has installed solar-powered electric vehicle charging stations across the main Richland campus. In addition, PNNL was instrumental in obtaining the first bio-fuel 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's comprehensive and diverse approach to fulfilling Executive Order 13514 requirements and advancing DOE's sustainability mission is captured in the PNNL Site Sustainability Plan (PNNL 2014), which details the annual status and strategy for achieving long-term goals. The plan 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 2014 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 Sustainability Goals and Targets

Signed in 2009, Executive Order 13514, "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. In addition to guidance, recommendations, and plans, which are due by specific dates, Executive Order 13514 has established numerical targets for agencies.

PNNL's comprehensive and diverse approach to fulfilling Executive Order 13514 requirements and advancing DOE's sustainability mission is captured in the PNNL Site Sustainability Plan (PNNL 2014), which details the annual status and strategy for achieving long-term goals. The plan 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 2014 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

Scope 3 GHG emissions, related to site operations including business travel, employee commuting, vendor activities, and delivery services, have decreased by 11 percent compared to the FY 2008 baseline (Figure 3.2). In FY 2012, a PNNL-wide telework program was started to reduce GHG emissions from employee commuting. By the end of FY 2013, more than 20,000 telework days were recorded, which has averted an estimated 196 metric tons of carbon dioxide equivalent ($MTCO_2e$). More staff took advantage of the telework option in FY 2014 as the culture shifted to greater acceptance of the modern way of working. Staff recorded 28,071 telework days, which has avoided an estimated 263 $MTCO_2e$.

As shown in Figure 3.3, 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 $MTCO_2e$ to just over 50,000 $MTCO_2e$ between FYs 2008 and 2014. This is primarily driven by an increase in computer equipment to support the growing computational sciences research area. PNNL will continue implementing energy-conservation measures, including procuring renewable energy, where cost-effective. In FY 2014, PNNL procured enough renewable energy to offset 50 percent of its electrical use and meet the FY 2020 goals of 20 percent annual electrical consumption.

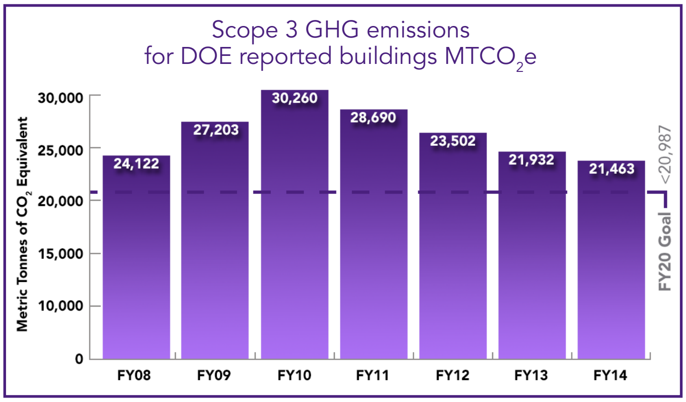

Figure 3.2. Scope 3 Greenhouse Gas Emissions from DOE Buildings on the PNNL Campus, FY 2008–2014 ($MTCO_2e$ = metric tons of carbon dioxide equivalent)

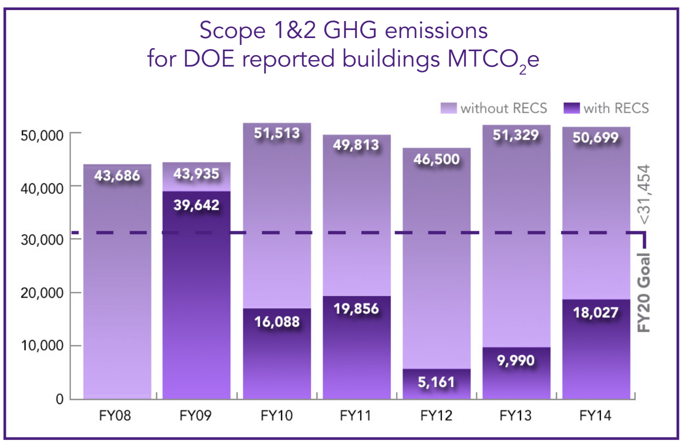

Figure 3.3. Scope 1 and 2 Greenhouse Gas Emissions from DOE Buildings on the PNNL Campus, FY 2008–2014 ($MTCO_2e$ = metric tons of carbon dioxide equivalent)

3.1.2 High-Performance Sustainable Buildings

In FY 2014, PNNL documented two additional existing buildings as being compliant with the Guiding Principles for High-Performance Sustainable Buildings (HPSBs) and began construction of a new laboratory facility that will be certified Leadership in Engineering and Environmental Design (LEED) Gold. PNNL has met HPSB criteria for 36 percent of its portfolio, exceeding DOE's FY 2015 goal of 15 percent (Figure 3.4).

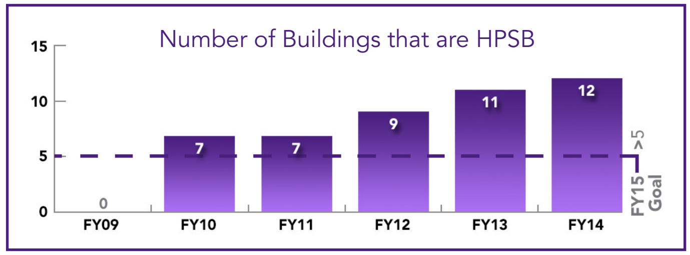

Figure 3.4. High-Performance Sustainable Building Totals Have Exceeded DOE Goals

3.1.3 Fleet Management

PNNL continues to trend in the right direction through expanded use of alternative fuel vehicles, including electric vehicles. In FY 2014, PNNL achieved the 2 percent annual reduction and met the cumulative target of 18 percent since FY 2005 (Figure 3.5).

PNNL has exceeded the alternative fuel use goal consistently since FY 2006 (Figure 3.6).

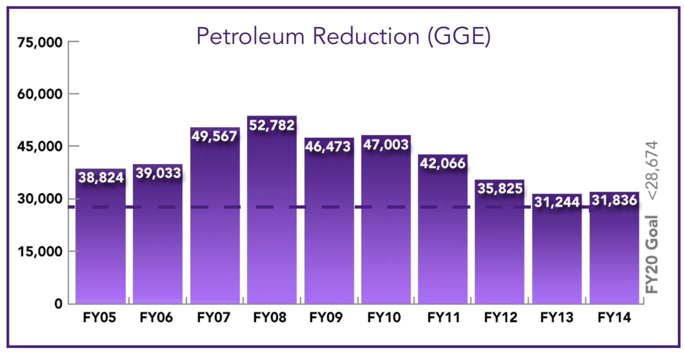

Figure 3.5. Petroleum Fuel Use, FY 2005–2014 (GGE = gallon gas equivalent)

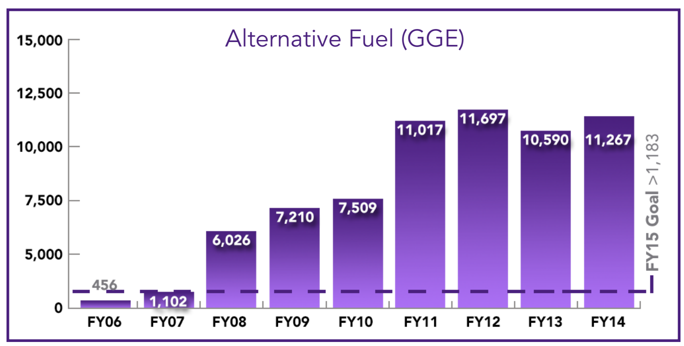

Figure 3.6. Alternative Fuel Use, FY 2006–2014 (GGE = gallon gas equivalent)

3.1.4 Water-Use Efficiency and Management

In FY 2014, implementation of water-saving projects and operational improvements resulted in an overall reduction of approximately 63 percent compared with the 2007 baseline (Figure 3.7). PNNL has met the FY 2020 potable water-reduction goal.

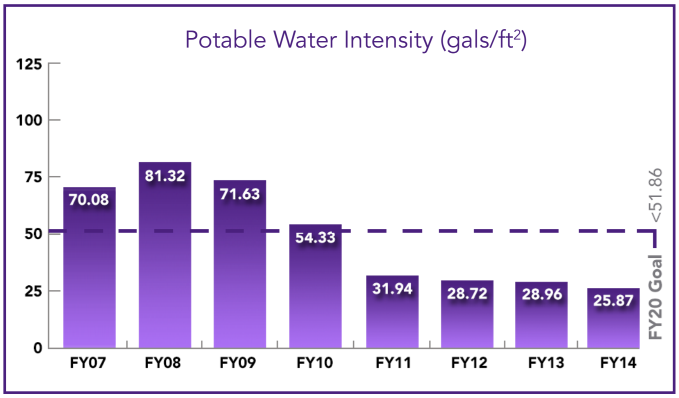

Figure 3.7. Potable Water-Use Intensity, FY 2007–2013

3.1.5 Pollution Prevention and Waste Reduction

In FY 2014, approximately 54 percent of non-hazardous sanitary waste was diverted through recycling and composting. Nearly 100 percent of the waste from construction and demolition projects was recycled (Figure 3.8).

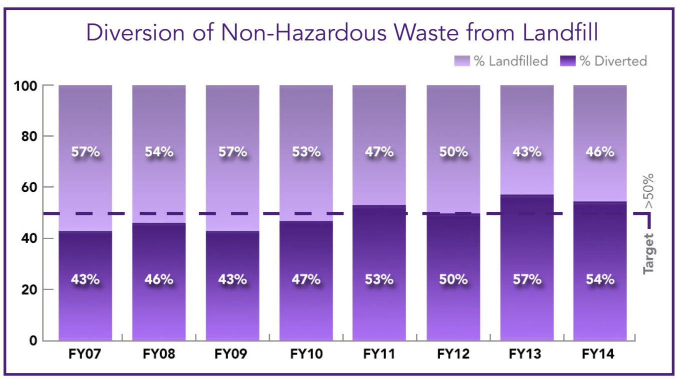

Figure 3.8. Diversion of Non-Hazardous Waste from Landfills, FY 2007–2013

3.1.6 Power Usage Effectiveness

Power usage effectiveness (PUE™) is a measure of the amount of energy used by information technology (IT) computer equipment contrasted with the total amount of energy used by the data center (i.e., the amount of power used to run the computer infrastructure). PNNL met DOE's power usage effectiveness goal of 1.4 PUE in FY 2014. Twenty small, inefficient production server centers across the PNNL Campus have been consolidated into three main energy efficient data centers located in EMSL, CSF, and the Information Sciences Building 2 (ISB2). To achieve further PUE reduction, improvement plans were developed for each data center. Since FY 2006, PNNL has aggressively pursued virtualization as a tool to minimize server sprawl, conserve energy, and reduce the equipment footprint in ISB2. PNNL's business visualization was over 85 percent in FY 2014, a 5 percent increase over FY 2013 levels. Innovative technologies have been incorporated into the EMSL and CSF data centers, contributing to the PUE target. PNNL's newest supercomputer, Cascade, located at EMSL can do in 1 hour what would take a typical laptop over 20 years to complete. Recently ranked thirteenth on the Top 500 List of the world's fastest supercomputers, Cascade uses nearly eight times less energy (0.59 kW per teraflop of computing capability) than its predecessor (over 8 kW per teraflop) and is water cooled via rear door heat exchangers, which enabled the removal of four inefficient computer room air conditioners, conserving even more energy, as well as space. In CSF, a new adiabatic cooling system was installed to augment the capacity of the groundwater cooling system, further reducing the CSF data center PUE.

3.1.7 Ozone-Depleting Substances

Executive Order 13423 (72 FR 3919) requires DOE sites to reduce ozone-depleting substances through sustainable acquisition of products and services. PNNL's approach to reducing ozone-depleting substances includes implementing administrative controls through procedures for maintenance, repair, and disposal as well as minimizing procurement of Class I ozone-depleting substances for new and replacement refrigeration systems.

3.2 Awards and Recognition

PNNL received several awards for its environmental efforts during CY 2014.

- On October 16, 2014, the City of Richland awarded PNNL its 2014 "Green Program of the Year" award for its Sustainable Campus program.
- On December 5, 2014, the Eastern Washington Chapter of the Academy of Certified Hazardous Materials Managers awarded PNNL its 2014 "Environmental Management System Award" for establishing and maintaining a sustainable campus.

The Sustainable Campus program, which is a continuing PNNL initiative, is attaining a campus and workplace that has been designed or modified to promote sustainable operations. Significant sustainability accomplishments in FY 2014 included the following:

- Continued emphasis on double-sided printing and use of electronic communication and recordkeeping where possible. Paper purchases were decreased by 25 percent during the year, and have been reduced by 70 percent since 2010.
- The sustainability features in PNNL's new 3820 Systems Engineering Laboratory, which began construction in 2014 and opened in spring 2015, are sufficient to earn LEED Gold certification. The Systems Engineering Laboratory will operate with a 32 percent total energy savings over similar sized buildings without LEED features, saving approximately $11,000/year in energy costs.

Table 3.1. DOE Strategic Sustainability Performance Plan (SSPP) Goals and Targets for FY 2014

DOE Goal	Performance Status Through FY14	Planned Actions and Contribution	Risk[a] of Non-Attainment
Goal 1: Greenhouse Gas Reduction			
28% Scope 1 & 2 GHG reduction by FY20 from a FY08 baseline (FY14 target: 19%)	FY08 Baseline: 43,686 metric tons of carbon dioxide equivalent ($MTCO_2e$) FY14 Actual: 18,027 $MTCO_2e$ (50,699 $MTCO_2e$ without renewable energy certificates [RECs]) FY20 Goal: 31,454 $MTCO_2e$ Status: 58.7% reduction	Continue REC purchases for near-term GHG reduction goal and implement energy-conservation measures, where cost-effective.	Low
13% Scope 3 GHG reduction by FY20 from a FY08 baseline (FY14 target: 5%)	FY08 Baseline: 24,122 $MTCO_2e$ FY14 Actual: 23,616 $MTCO_2e$ (21,463 $MTCO_2e$ adjusted for RECs) FY20 Goal: 20,987 $MTCO_2e$ Status: 11% reduction	Continue promoting telework and high-end video usage to reduce travel; encourage staff through bus and carpool promotions and incentives.	Low
Goal 2: Sustainable Buildings			
30% energy intensity (British thermal units [Btu] per gross square foot [GSF]) reduction by FY15 from a FY03 baseline (FY14 target: 27%)	FY03 Baseline: 213,700 Btu/GSF FY14 Actual: 181,976 Btu/GSF FY15 Goal: 149,590 Btu/GSF Status: 14.8% reduction	Continue implementing Consolidated Energy Data Report projects and operational improvements.	High
Energy Independence and Security Act of 2007 (EISA) Section 432 energy and water evaluations	Completed second year of the 4-year EISA cycle of eight buildings	Continue executing EISA evaluations.	Low
Individual buildings metering for 90% of electricity (by October 1, 2012); for 90% of steam, natural gas, and chilled water (by October 1, 2015)[b] (FY14 target: 90% and 75%, respectively)	FY14: 97.9% metering of electricity, 98.5% metering of natural gas, 100% metering of water	Improve building performance through data analysis from the meters. Assessment will be completed for new Facilities Information Management System (FIMS) buildings in FY15.	Low
Unless uneconomical, install cool roof replacements unless project has Critical Decision-2 (CD-2) approval. New roofs must have thermal resistance of at least R-30.	FY14: 49% of PNNL roof area per FIMS building are cool roofs	Unless uneconomical, all new roofs will have a thermal resistance of at least R-30 and be solar reflective, consistent with former DOE Secretary Chu requirements.	Low
15% of existing buildings greater than 5,000 GSF are compliant with the High-Performance Sustainable Building (HPSB) Guiding Principles by FY15 (FY14 target: 13%)	36% of PNNL buildings >5,000 GSF per FIMS are HPSB compliant	Continue trending toward 100% of facilities meeting HPSB.	Low
All new construction, major renovations, and building alterations greater than 5,000 GSF must comply with the Guiding Principles.[c]	Institutionalized the Guiding Principles commitment in PNNL Engineering Standards	Achieve Guiding Principles for all new construction, major renovations, and building alterations greater than 5,000 GSF.	Low
Efforts to increase regional and local planning coordination and involvement	Collaborated with DOE-RL and Hanford Site contractors on sustainability topics	Continue to leverage partnerships to achieve SSPP goals.	Low

DOE Goal	Performance Status Through FY14	Planned Actions and Contribution	Risk[a] of Non-Attainment
Goal 3: Fleet Management			
10% annual increase in fleet alternative fuel consumption by FY15 relative to FY05 baseline (FY14 target: 136% cumulative since FY05)	FY06 Baseline: 456 gallons (gal) of gasoline equivalent (GGE) fuel (note: FY05 usage not measured) FY14 Actual: 11,267 (GGE) FY20 Goal: 1,183 (GGE) Status: Exceeded goal	Actively manage alternate fuel use through fleet oversight and staff member training; increase percentage of alternative fuel vehicles (AFVs) when available.	Low
2% annual reduction in fleet petroleum consumption by FY20 relative to FY05 baseline (FY14 target: 18% cumulative since FY05)	FY05 Baseline: 38,824 (GGE) FY14 Actual: 31,836 (GGE) FY20 Goal: 28,674 (GGE) Status: 18.0% reduction	Continue assessing the transition to AFVs.	Low
100% of light-duty vehicle (LDV) purchases must consist of AFV by FY15 and thereafter (75% FY00–FY15)	Of the 38 LDVs in PNNL's fleet, 34 (89%) are AFVs; added 5 E85 AFVs and 1 hybrid in FY14	Continue working with fleet vendors to replace vehicles with AFV types where available.	Low
Goal 4: Water-Use Efficiency and Management			
26% potable water intensity (gal/GSF) reduction by FY20 from a FY07 baseline (FY14 target: 14%)	FY07 Baseline: 70.08 gal/GSF FY14 Actual: 25.87 gal/GSF FY20 Goal: 51.86 gal/GSF Status: Exceeded goal	As feasible, continue implementing potable water projects to reduce overall use.	Low
20% water consumption (gal) reduction of industrial, landscaping, and agricultural (ILA) water by FY20 from a FY10 baseline (FY14 target: 8%)	FY11 Baseline: 176,248,000 gal FY14 Actual: 143,184,541 gal FY20 Goal: 140,998,400 gal Status: 18.8% decrease	Continue implementing Landscaping Plan with focus on reducing ILA where possible.	Low
Goal 5: Pollution Prevention and Waste Reduction			
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition (C&D) debris, by FY15.	FY14: Diverted 54% of non-hazardous solid waste	Continue conducting assessments for waste reduction opportunities.	Low
Divert at least 50% of C&D materials and debris by FY15.	FY14: Diverted nearly 98% of C&D waste	Continue monitoring C&D recycling performance and raising awareness on waste diversion requirements.	Low
Goal 6: Sustainable Acquisition			
Procurements meet requirements by including necessary provisions and clauses in 95% of applicable contracts.	100% of acquisitions have sustainability requirements and clauses.	Continue being proactive with sustainable item procurement.	Low

DOE Goal	Performance Status Through FY14	Planned Actions and Contribution	Risk[a] of Non-Attainment
Goal 7: Electronic Stewardship and Data Centers			
All core data centers are metered to measure a monthly power utilization effectiveness (PUE) of 100% by FY15 (FY14 target: 90%).	All of PNNL's three data centers are now fully metered.	Complete data center metering.	Low
Core data centers maximum annual weighted average PUE of 1.4 implemented by FY15 (FY14 target: 1.50)	FY14: Annual weighted average PUE is 1.33	Implement projects to maintain the goal.	Low
Electronic stewardship: 100% of eligible personal computers, laptops, and monitors with power management implemented and in use by FY12	100% of eligible equipment is compliant.	Assure new equipment has power-management features.	Low
Goal 8: Renewable Energy			
20% of annual electricity consumption from renewable sources by FY20 (FY14 target: 7.5%)	FY14: 50.1% of annual electric consumption from onsite generation and REC purchases	Continue operating our 125 kilowatt (kW) onsite photovoltaic (PV) array and purchasing RECs.	Low
Goal 9: Climate Change Resilience			
Address DOE Climate Change Adaptation Plan goals	Completed all actions planned for FY14	Continue to seek opportunities to participate in existing partnership with agencies in the Pacific Northwest region.	Low
Goal 10: Energy Performance Contracts			
Utilization of Energy Performance Contracts	Three Energy Savings Performance Contracts have been implemented at PNNL.	Future projects will leverage the use of alternate financing, if applicable.	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 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 (U.S. Code Section 8253), 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 LEED-EB (Leadership in Engineering and Environmental Design for Existing Buildings) 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 CIEB (Continual Improvement of Existing Buildings) rating of three; any building that has been occupied for more than 1 year that achieves 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 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

With the exception of the PSF, all other PNNL Campus and MSL facilities that contain radiological materials are prohibited from discharging wastewater to the receiving sewer or wastewater treatment systems. Wastewater from laboratories in the PSF that use radiological materials is discharged to four retention tanks. Once a tank is filled, the wastewater is analyzed for radiological components based on screening limits in WAC 246-221-190, "Disposal by Release into Sanitary Sewerage Systems." If the analytical results indicate that 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.

4.2 Radiological Discharges and Doses from Air

Radionuclide air emissions are routinely monitored at both the PNNL Campus and MSL. Monitoring results are reported in an annual air emission report for each location (Snyder et al. 2015; Snyder and Barnett 2015). CY 2014 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 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 found in 40 CFR 61, Subpart H (WAC 246-247-040(1)). In addition to the maximum dose attributable to radionuclides emitted from point sources, WAC 246-247-060(6) required 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 2014, the PNNL Campus MEI location was 0.70 km (0.43 mi) south-southeast of the Physical Sciences Facility. Table 4.1 lists the relative contributions of each nuclide to the MEI dose.

Table 4.1. PNNL Emissions and Dose Contributions by Radionuclide, 2014 (Snyder et al. 2015)

Radionuclide	Releases (Ci)	Dose to MEI (mrem EDE)	% of Total EDE Percent
Tritium[a]	7.4E-05	4.8E-08	<1%
Cobalt-60[a]	4.1E-10	7.2E-10	<1%
Nickel-57[a]	5.0E-10	8.1E-12	<1%
Strontium-90[b]	9.9E-07	4.2E-06	16%
Cadmium-109[a]	3.1E-09	6.1E-10	<1%
Iodine-131[a]	2.0E-08	1.9E-07	1%
Iodine-132[a]	2.9E-08	4.8E-11	<1%
Iodine-133[a]	3.2E-08	2.3E-09	<1%
Xenon-133[a]	9.3E-05	5.5E-10	<1%
Cesium-137[b]	7.2E-09	2.0E-08	<1%
Barium-140[a]	2.0E-08	3.7E-09	<1%
Lanthanum-140[a]	3.9E-08	8.2E-10	<1%
Gold-194[a]	1.1E-09	7.9E-12	<1%
Gold-196[a]	5.0E-09	7.5E-11	<1%
Lead-210[a]	1.0E-09	3.7E-08	<1%
Radium-226[a,c]	1.2E-09	5.2E-08	<1%
Uranium-233/234	2.2E-08	4.0E-07	2%
Uranium-235[a]	9.1E-10	1.5E-08	<1%
Uranium-236[a]	9.2E-11	1.6E-09	<1%
Plutonium-239/240[d]	3.1E-07	1.9E-05	71%
Americium-240[a]	5.4E-12	5.8E-14	<1%
Americium-241[e]	3.5E-10	4.6E-08	<1%
Americium-243[a]	2.6E-15	5.2E-13	<1%
Curium-243/244	5.5E-11	2.1E-09	<1%
Table 2.3 nuclides	3.5E-06	7.4E-09	<1%
PIC-5 emissions – VRRM	NA	9.4E-07[f]	3%
PIC-5 emissions – Facilities Restoration	NA	8.4E-07[f]	3%
PIC-5 emissions – LLS	NA	1.0E-06[f]	4%
PIC-5 emissions – NDRM	NA	6.6E-08[f]	<1%
Total	**1.7E-04**	**2.7E-05**	**100%**[g]

(a) Release based on 40 CFR 61, Appendix D or release records.
(b) Gross beta from PSF building sampling assumed to be strontium-90. Gross beta from RTL-520 sampling assumed to be Cesium-137. Also, calculated cesium-137 release based on 40 CFR 61, Appendix D and Life Sciences Laboratory 2 gross beta.
(c) Dose includes progeny isotope Radon-222.
(d) Gross alpha from PSF building and RTL-520 sampling assumed to be plutonium-239. Also includes plutonium-239 and plutonium-240 calculated based on 40 CFR 61, Appendix D.
(e) Gross alpha from Life Sciences Laboratory 2 assigned as americium-241.
(f) The Potential Impact Category 5 (PIC-5) emissions doses are assigned based on permit value.
(g) Tabulated nuclide-specific values do not add to 100% because of rounding.
To convert Ci to GBq, multiply Ci by 37.
To convert from mrem to μSv, multiply mrem by 10.
NA = not applicable

There were no nonroutine emissions from the PNNL Campus in 2014. The CAP88-PC code was used for estimating dose. The dose of 2.7 × 10^{-5} mrem (2.7 × 10^{-7} mSv) EDE is more than 100,000 times smaller than the 10 mrem/yr WAC 246-247 compliance standard.

The estimated regional collective dose from PNNL Campus air emissions in 2014 was calculated using a simplified method that overestimates dose. The population consists of approximately 432,000 people residing within a 50-mi (80-km) 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 50 mi of the PNNL Campus permits the Hanford Site 300 Area 50-mi population estimate to be applicable. Pathways evaluated for population exposure include inhalation, air submersion, ground-shine, and consumption of food.

Population exposure to radionuclide air emissions was determined using the MEI dose estimate (2.7 × 10^{-5} mrem [2.7 × 10^{-8} mSv]) times the 80-km (50-mi) population (432,000). The 2014 total collective dose from radionuclide air emissions estimated in this very conservative manner from nuclides that originate from the PNNL Campus was 0.012 person rem (1.2 × 10^{-4} person Sv) (Snyder et al. 2015). This represents a slight increase compared to the 2013 estimate of 7.8 × 10^{-3} person-rem (7.8 × 10^{-5} person-Sv) and is a dose many orders of magnitude below the average annual individual background dose of 279 mrem (2.79 mSv) from natural terrestrial and cosmic radiation and inhalation of naturally occurring radon (DOE-RL 2012).

No operations from the storage and disposal of radium-bearing material resulting in radon emissions are conducted at the PNNL Campus; therefore, 40 CFR 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 61, Subpart T, does not apply to PNNL operations.

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

In October 2012, MSL transitioned from private operation under Battelle to an exclusive-use contract with PNSO. Operations for the two MSL nonpoint-source minor emission units associated with the MSL-1 and MSL-5 facilities (Figure 1.3) are registered with the state of Washington under RAEL–014. For CY 2014, the MSL MEI location was determined to be 0.19 km (0.12 mi) away. Radiological operations at MSL facilities emit very low levels of radioactive materials; Table 4.2 lists the gross beta/gamma and gross alpha contributions to the MEI dose.

There were no nonroutine emissions from MSL in 2014. The 40 CFR 61, Appendix D, method of determining unabated emissions was used. The COMPLY Code Version 1.6 (Level 4) was used for estimating dose. The americium-241 unit dose factor was applied to all alpha-emitters and the cesium-137 unit dose factor was applied to all beta/gamma-emitters, as a conservative measure. The dose to the MSL MEI was 9.0 × 10^{-5} mrem (9.0 × 10^{-7} mSv) EDE.

An estimated 132,000 people (on the U.S. side of the border) live within 48 km (30 mi) of Sequim, Washington; another estimated 1.45 million Americans reside 48 – 80 km (30 – 50 mi) from Sequim. The Victoria, British Columbia metropolitan area (32–48 km [20–30 mi] distant) has an estimated population of 358,000 people, almost three times the U.S. population within 48 km (30 mi) of MSL. The collective dose was calculated using a simplified method that greatly overestimates the dose. The MEI dose multiplied by the 30-mi U.S. population results in a collective dose of 1.2 × 10^{-2} person-rem (1.2 × 10^{-4} person Sv). These extremely overestimated doses are 1 percent or less of the average annual individual background dose from natural terrestrial and cosmic radiation and inhalation of naturally occurring radon.

Table 4.2. Marine Sciences Laboratory Emissions and Dose Contributions, 2014 (Snyder and Barnett 2015)

	MSL-1	MSL-5	Total
Releases (Ci)			
Beta/gamma	0	2.23E-09	2.23E-09
Alpha	3.40E-09	4.19E-09	7.59E-09
MEI EDE (mrem)			
Beta/gamma[(a)]	0	1.0E-06	1.0E-06
Alpha[(b)]	4.0E-05	4.9E-05	8.9E-05
Total (mrem)	**4.0E-05**	**5.0E-05**	**9.0E-05**
Dose Contribution (%)			
Beta/gamma	–	2%	**1%**
Alpha	100%	98%	**99%**

(a) Unit dose factor for cesium-137 applied to estimate dose for all nuclide emissions except iodine-129.
(b) Unit dose factor for americium-241 applied to estimate dose.
MEI = maximum exposed individual
EDE = effective dose equivalent
Ci = curies

No storage or disposal of radium-bearing materials occurs at MSL; therefore, 40 CFR 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 61, Subpart T, does not apply to MSL operations.

4.3 Release of Property Having Residual Radioactive Material

Principal requirements for the release of DOE property having residual radioactivity are set forth in DOE Order 458.1, 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 release.
- The level of residual radioactivity in property to be released is as near background levels as is reasonably practicable, as determined through 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.

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 2014.

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 2014.

Table 4.3. Pre-Approved Surface Activity Guideline Limits

Radionuclides	Allowable Total Residual Surface Contamination Limits (dpm/100 cm²)		
	Removable	Total: Average	Total: 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	NA	NA

(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.
cm^2 = square centimeter(s)
NA = not applicable

In 2013, in accordance with PNNL Prime Contract Section J, Appendix J, paragraph eight (DOE-PNSO 2015), 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, the Physical Sciences Laboratory, and Life Sciences Laboratory 2 on the PNNL Campus, and the MSL-1 and MSL-5 facilities at MSL in Sequim, Washington. Program activities completed during CY 2014 included characterization surveys at select areas in the facilities and development of detailed radiological release plans for the facilities.

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 2014, PNNL released hundreds of liquid research samples with a total volume on the order of 1,100 L (290 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.

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 above rows	45
Tritium	450

4.4 Radiation Protection of Biota

DOE Order 458.1 (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 equally applied to the PNNL Campus and MSL.

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 2014—there were no unplanned radiological emissions. The resultant external dose rates were less than 1×10^{-4} rad/d (1×10^{-3} mGy/d) from contaminated water to aquatic animals and terrestrial plants and less than 9×10^{-4} rad/d (9×10^{-3} mGy/d) from contaminated soil to riparian and terrestrial animals (Table 4.5). These conservative dose rates are well below dose rate limits, which are based on the PNNL-reported total particulate radionuclide emissions for CY 2014 (Snyder et al. 2015). Assumptions are that all of the particulate radioactive material is concentrated into either 1 m^3 (35 ft^3) of contaminated water or 1 m^2 (10.8 ft^2) of contaminated soil with a soil density of 224 kg m^2 (14 lb/ft^2) to a depth of 15 cm (6 in.) (Napier 2006). The screening-level dose coefficients used are found in DOE-STD-1153-2002, Module 3, (DOE 2002). The resulting water and soil concentrations are very conservative and used for basic screening and simplicity of calculation for comparison to the adopted biota dose rate limits.

Table 4.5. Screening-Level Dose Rates for the PNNL Campus, Calendar Year 2014

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 α[e,f]	1.1×10^{4}	6.8×10^{-9}	1.4×10^{-5}	1.1×10^{4}	4.8×10^{1}	2.0×10^{-4}	1.8×10^{-3}
Gross β[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}
Cobalt-60	1.5×10^{1}	6.6×10^{-9}	1.3×10^{-5}	1.5×10^{1}	6.8×10^{-2}	2.7×10^{-7}	2.4×10^{-6}
Nickel-57[g]	1.9×10^{1}	6.6×10^{-9}	1.3×10^{-5}	1.9×10^{1}	8.3×10^{-2}	3.3×10^{-7}	2.9×10^{-6}
Rubedium-83[g]	1.1×10^{2}	6.6×10^{-9}	1.3×10^{-5}	1.1×10^{2}	5.1×10^{-1}	2.1×10^{-6}	1.8×10^{-5}
Cadmium-109[g]	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}
Iodine-131	1.1×10^{3}	6.6×10^{-9}	1.3×10^{-5}	1.1×10^{3}	4.8×10^{0}	1.9×10^{-5}	1.7×10^{-4}
Iodine-132[g]	1.2×10^{3}	6.6×10^{-9}	1.3×10^{-5}	1.2×10^{3}	5.3×10^{0}	2.1×10^{-5}	1.9×10^{-4}
Iodine-133[g]	1.7×10^{1}	2.0×10^{-9}	4.0×10^{-6}	1.7×10^{1}	7.8×10^{-2}	9.5×10^{-8}	8.5×10^{-7}
Cesium-137	7.4×10^{2}	6.6×10^{-9}	1.3×10^{-5}	7.4×10^{2}	3.3×10^{0}	1.3×10^{-5}	1.2×10^{-4}
Barium-140[g]	1.4×10^{3}	6.6×10^{-9}	1.3×10^{-5}	1.4×10^{3}	6.4×10^{0}	2.6×10^{-5}	2.3×10^{-4}
Lanthanum-140[g]	4.1×10^{1}	6.6×10^{-9}	1.3×10^{-5}	4.1×10^{1}	1.8×10^{-1}	7.4×10^{-7}	6.5×10^{-6}
Gold-194[g]	1.9×10^{2}	6.6×10^{-9}	1.3×10^{-5}	1.9×10^{2}	8.3×10^{-1}	3.3×10^{-6}	2.9×10^{-5}
Gold-196[g]	3.7×10^{1}	1.1×10^{-9}	2.2×10^{-6}	3.7×10^{1}	1.7×10^{-1}	1.1×10^{-7}	1.0×10^{-6}
Lead-210	4.4×10^{1}	6.8×10^{-9}	1.4×10^{-5}	4.4×10^{1}	2.0×10^{-1}	8.3×10^{-7}	7.6×10^{-6}
Radium-226	8.1×10^{2}	3.2×10^{-11}	6.5×10^{-8}	8.1×10^{2}	3.6×10^{0}	7.1×10^{-8}	6.5×10^{-7}
Uranium-233/234	3.4×10^{1}	9.4×10^{-10}	1.8×10^{-6}	3.4×10^{1}	1.5×10^{-1}	8.7×10^{-8}	7.4×10^{-7}
Uranium-235[f]	3.4×10^{0}	6.8×10^{-9}	1.4×10^{-5}	3.4×10^{0}	1.5×10^{-2}	6.3×10^{-8}	5.8×10^{-7}
Uranium-236	1.1×10^{4}	2.5×10^{-11}	4.9×10^{-8}	1.1×10^{4}	5.0×10^{1}	7.6×10^{-7}	6.7×10^{-6}
Plutonium-239/240	2.0×10^{-1}	6.8×10^{-9}	1.4×10^{-5}	2.0×10^{-1}	8.9×10^{-4}	3.7×10^{-9}	3.4×10^{-8}
Americium-240[f]	1.2×10^{1}	1.4×10^{-10}	2.9×10^{-7}	1.2×10^{1}	5.5×10^{-2}	4.7×10^{-9}	4.3×10^{-8}
Americium-241	9.6×10^{-5}	1.3×10^{-9}	2.5×10^{-6}	9.6×10^{-5}	4.3×10^{-7}	3.4×10^{-13}	2.9×10^{-12}
Americium-243	2.0×10^{0}	6.4×10^{-10}	1.3×10^{-6}	2.0×10^{0}	9.1×10^{-3}	3.6×10^{-9}	3.2×10^{-8}
Curium-243-244	1.1×10^{4}	6.8×10^{-9}	1.4×10^{-5}	1.1×10^{4}	4.8×10^{1}	2.0×10^{-4}	1.8×10^{-3}
					Total	**9.6×10^{-4}**	**8.5×10^{-3}**

(a) Data from Table 2.4 of Snyder et al. (2015).
(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 soil density of 224 kg m^2 (14 lb/ft^2) to a depth of 15 cm (6 in.) (Napier 2006).
(e) Maximum of the bi-weekly or semi-annual average measurement (Snyder et al. 2015).
(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.

4.4.2 Radiation Protection of Biota – PNNL Marine Sciences Laboratory

Environmental media pathways were evaluated during the development of MSL's DQOs in support of radiological emissions monitoring. Potential media exposure pathways such as air, soil, water, and food were considered in conjunction with potential releases of radioactive contamination to the air pathway. 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 2014—there were no unplanned radiological emissions. The external dose rates for operations in CY 2014 were less than 7×10^{-7} rad/d (7×10^{-6} mGy/d) from contaminated water to aquatic animals and terrestrial plants and less than 6×10^{-6} rad/d (6×10^{-5} 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 2014 (Snyder and Barnett 2015). Assumptions are that all of the particulate radioactive material is concentrated into either 1 m^3 (35 ft^3) of contaminated water or 1 m^2 (10.8 ft^2) of contaminated soil with a soil density of 224 kg m^2 (14 lb/ft^2) to a depth of 15 cm (6 in.) (Napier 2006).

Table 4.6. Screening-Level Dose Rates for the PNNL Marine Sciences Laboratory, Calendar Year 2014

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 α[e]	2.8×10^{2}	6.8×10^{-9}	1.5×10^{-5}	2.8×10^{2}	1.3×10^{0}	5.2×10^{-6}	4.8×10^{-5}
Gross β[f]	8.3×10^{1}	6.6×10^{-9}	1.3×10^{-5}	8.3×10^{1}	3.7×10^{-1}	1.5×10^{-6}	1.3×10^{-5}
					Total	**6.7×10^{-6}**	**6.1×10^{-5}**

(a) Data from Table 3.3 in Snyder and Barnett (2015).
(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 soil density of 224 kg m² (14 lb/ft²) to a depth of 15 cm (6 in.) (Napier 2006).
(e) Radium-226 dose rate factor used as a conservative alpha surrogate.
(f) Cobalt-60 dose rate factor used as conservative beta surrogate.
Conversion factors: 1 Ci = 3.7×10^{10} Bq. 1 Gy = 100 rad.

The screening-level dose coefficients used are found in DOE-STD-1153-2002, Module 3 (DOE 2002). The resulting water and soil concentrations are very conservative and used for basic screening and the simplicity of calculation for comparison to the adopted biota dose rate limits.

4.5 Unplanned Radiological Releases

No radiological releases to the environment exceeded permitted limits at the PNNL Campus or MSL in 2014.

4.6 Environmental Radiological Monitoring

The DOE Handbook "Environmental Radiological Effluent Monitoring and Environmental Surveillance," provides information about basic program implementation requirements and activities (DOE 2015). In addition, the Washington State Department of Health 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 (Figure 4.1). The first full calendar year of air monitoring was 2011. The air-monitoring locations were reevaluated in 2012 (Barnett et al. 2012a) due to the expanded footprint of DOE-permitted radiological operations locations (i.e., the addition of LSL2 and RTL facilities). The current particulate air-sampling network consists of four samplers (Figure 4.1).

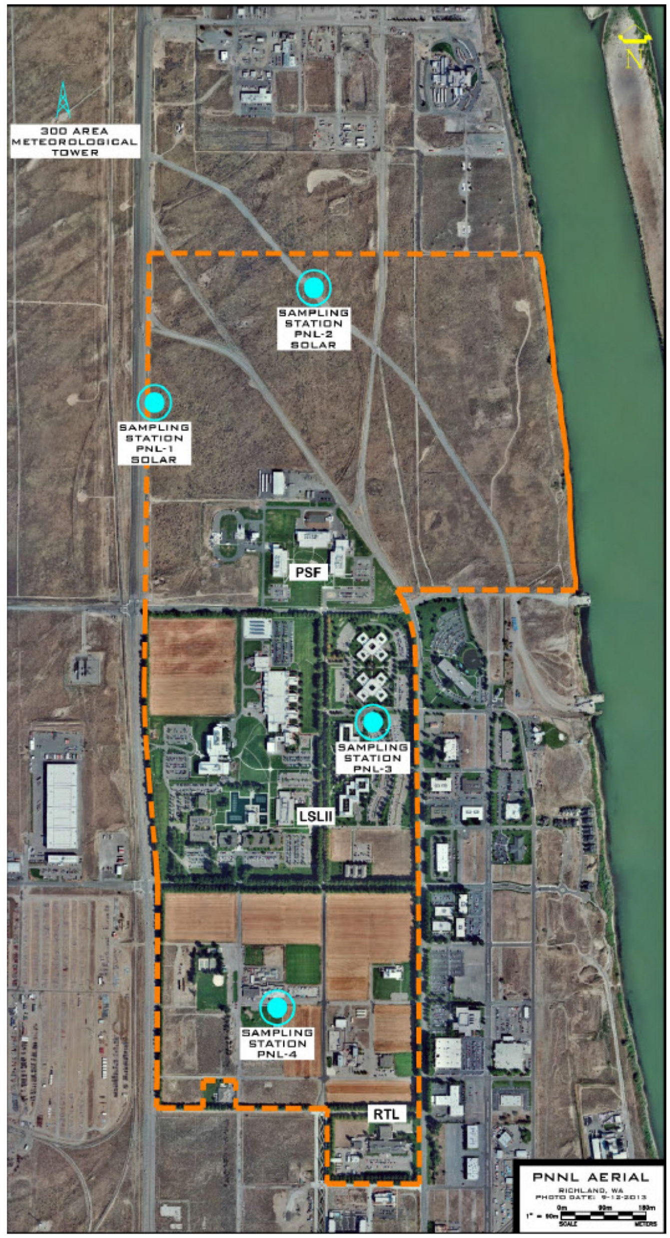

Figure 4.1. Air Surveillance Station Locations for the PNNL Campus (Snyder et al. 2015)

During 2014, collection of air samples occurred at four sampling stations: PNL-1, PNL-2, PNL-3, and PNL-4. Airborne particulate radionuclides are sampled and analyzed at all PNNL monitoring stations. Particulate air samples are routinely analyzed for gross alpha activity, gross beta activity, gamma-emitting isotopes, uranium isotopes (uranium-234,[5] uranium-235, and uranium-238), and plutonium isotopes (plutonium-238 and plutonium-239/240). In addition, americium isotopes (americium-241 and americium-243) and curium-243 are analyzed.

The Hanford Site has a single background monitoring station in Yakima, Washington. The Yakima station, which is approximately 75 km (47 mi) in the general upwind direction of 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 2014, there was no indication that any PNNL activities resulted in increased ambient air concentrations at the air-sampling locations (Table 4.7). For the isotopic

Table 4.7. Summary of 2014 Air-Sampling Results for PNNL (Snyder et al. 2015)

Nuclide	Location[a]	No. of Samples Analyzed	No. of Detections	Value ± 2σ (pCi/m³)
Gross Alpha	PNL-1	25	20	$7.8 \times 10^{-4} \pm 1.9 \times 10^{-3}$
	PNL-2	25	18	$6.7 \times 10^{-4} \pm 1.8 \times 10^{-3}$
	PNL-3	25	21	$6.6 \times 10^{-4} \pm 1.7 \times 10^{-3}$
	PNL-4	26	19	$6.9 \times 10^{-4} \pm 1.8 \times 10^{-3}$
	Yakima	26	20	$8.7 \times 10^{-4} \pm 1.9 \times 10^{-3}$
Gross Beta	PNL-1	25	25	$2.3 \times 10^{-2} \pm 7.6 \times 10^{-3}$
	PNL-2	25	25	$2.4 \times 10^{-2} \pm 7.6 \times 10^{-3}$
	PNL-3	26	26	$2.0 \times 10^{-2} \pm 6.6 \times 10^{-3}$
	PNL-4	26	26	$2.2 \times 10^{-2} \pm 7.3 \times 10^{-3}$
	Yakima	26	26	$1.9 \times 10^{-2} \pm 6.5 \times 10^{-3}$
Cobalt-60	PNL-1	2	0	$5.5 \times 10^{-5} \pm 1.5 \times 10^{-4}$
	PNL-2	2	0	$1.1 \times 10^{-4} \pm 3.8 \times 10^{-4}$
	PNL-3	2	0	$2.8 \times 10^{-4} \pm 6.9 \times 10^{-4}$
	PNL-4	2	0	$-1.7 \times 10^{-4} \pm 6.7 \times 10^{-4}$
	Yakima	2	0	$2.1 \times 10^{-4} \pm 6.0 \times 10^{-4}$
Uranium-233/234	PNL-1	2	2	$4.6 \times 10^{-5} \pm 1.8 \times 10^{-5}$
	PNL-2	2	2	$4.4 \times 10^{-5} \pm 1.7 \times 10^{-5}$
	PNL-3	2	2	$3.5 \times 10^{-5} \pm 2.1 \times 10^{-5}$
	PNL-4	2	2	$5.1 \times 10^{-5} \pm 1.9 \times 10^{-5}$
Uranium-234[b]	Yakima	2	2	$3.3 \times 10^{-5} \pm 1.7 \times 10^{-5}$
Plutonium-238	PNL-1	2	0	$-3.2 \times 10^{-7} \pm 2.3 \times 10^{-6}$
	PNL-2	2	0	$-1.1 \times 10^{-7} \pm 1.7 \times 10^{-6}$
	PNL-3	2	0	$5.1 \times 10^{-7} \pm 1.4 \times 10^{-6}$
	PNL-4	2	0	$5.9 \times 10^{-7} \pm 1.9 \times 10^{-6}$
	Yakima	2	0	$5.8 \times 10^{-7} \pm 1.6 \times 10^{-6}$
Plutonium-239/240	PNL-1	2	0	$1.9 \times 10^{-7} \pm 3.7 \times 10^{-7}$
	PNL-2	2	0	$2.8 \times 10^{-7} \pm 8.0 \times 10^{-7}$
	PNL-3	2	0	$1.6 \times 10^{-6} \pm 5.4 \times 10^{-6}$
	PNL-4	2	0	$1.3 \times 10^{-6} \pm 2.7 \times 10^{-6}$
	Yakima	2	0	$-1.4 \times 10^{-6} \pm 2.9 \times 10^{-6}$
Americium-241	PNL-1	2	0	$-1.0 \times 10^{-6} \pm 3.7 \times 10^{-6}$
	PNL-2	2	0	$1.4 \times 10^{-6} \pm 2.8 \times 10^{-6}$
	PNL-3	2	0	$2.0 \times 10^{-6} \pm 6.4 \times 10^{-6}$
	PNL-4	2	0	$1.4 \times 10^{-6} \pm 2.9 \times 10^{-6}$
	Yakima	0	0	not analyzed[c]
Americium-243	PNL-1	2	0	$2.4 \times 10^{-6} \pm 5.1 \times 10^{-6}$
	PNL-2	2	0	$1.9 \times 10^{-6} \pm 5.2 \times 10^{-6}$
	PNL-3	2	0	$3.7 \times 10^{-7} \pm 1.0 \times 10^{-6}$
	PNL-4	2	0	$1.1 \times 10^{-6} \pm 2.2 \times 10^{-6}$
	Yakima	0	0	not analyzed[c]
Curium-243/244	PNL-1	2	0	$1.0 \times 10^{-6} \pm 2.8 \times 10^{-6}$
	PNL-2	2	0	$1.1 \times 10^{-6} \pm 2.1 \times 10^{-6}$
	PNL-3	2	0	$-7.1 \times 10^{-7} \pm 4.2 \times 10^{-6}$
	PNL-4	2	0	$6.7 \times 10^{-7} \pm 5.2 \times 10^{-6}$
	Yakima	0	0	not analyzed[c]

(a) Refer to Figure 4.1.
(b) Hanford Site Monitoring Data from the Yakima location 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.
NA = not analyzed.
To convert pCi/m³ to Bq/m³, multiply pCi by 0.037.

(5) Uranium-234 is a naturally occurring radionuclide. It is co-reported with uranium-233 by the analytical laboratory because the emission peaks overlap.

analyses, only uranium-233/234, uranium-235, and uranium-238 samples were measured at detectable concentrations, making meaningful evaluation difficult. 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 2014, survey results were at background levels in areas that could be occupied by the public.

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 overestimating assumptions are applied (Barnett et al. 2012b). The emissions at MSL have historically met requirements for dose limit compliance based on estimates from 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 periodic external dose rate surveys around locations in MSL-1 and MSL-5 that contain radiological areas. For CY 2014, survey results were at background levels in areas that could be occupied by the public.

4.7 Future Radiological Monitoring

One future change to the radiological monitoring program is the addition of a PNNL-operated background air-monitoring station, anticipated for use in CY 2015. Contract negotiations with the Kiona-Benton (KiBe) School District to establish a background station at the KiBe High School are under way. 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).

5 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.

Effluent Management 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 PNNL Effluent Management Quality Assurance (QA) Plan (Ballinger and Beus 2013). The ALARA principle is applied to effluent activities to minimize potential effects of emissions to the public and the environment.

5.1 Liquid Effluent Monitoring

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 performed in accordance with the permits, and results are reported as required to the City of Richland.

Process wastewater from MSL is discharged to an onsite wastewater treatment plant and then directly discharged to Sequim Bay under the authorization of Washington State Department of Ecology NPDES Permit No. WA0040649. This permit identifies effluent limitations and monitoring requirements for this facility. Monitoring data required by the NPDES permit are listed in Table 5.1 for 2014. 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 that 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 (one grab sample with pH of 8.3, conductivity of 199 µS/cm, and total dissolved solids of 114 mg/L).

5.2 Air Effluent

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 approximately 30 percent.

Table 5.1. PNNL Marine Sciences Laboratory 2014 NPDES Monitoring Results for Outfall 008[(a)]

Parameter	Quantity Found Below Method Reporting Limit	Method Reporting Limit	Maximum Value
Maximum flow (gpd)	NA	NA	86,100
Bromoform (µg/L)	6	1[(b)]	1.4
Chlorine, total residual (µg/L)	12	50[(b)]	<50
Antimony (µg/L)	1	0.5	0.74
Arsenic (µg/L)	2	5	<5
Beryllium (µg/L)	2	0.2	<0.2
Cadmium (µg/L)	2	0.2	<0.2
Chromium (µg/L)	2	2	<2
Copper (µg/L)	5	1	3.5
Lead (µg/L)	9	0.2	0.5
Mercury (µg/L)	2	0.2	<0.2
Nickel (µg/L)	2	2	<2
Selenium (µg/L)	1	10	12.3
Silver (µg/L)	2	0.2	<0.2
Thallium (µg/L)	2	0.2	<0.2
Zinc (µg/L)	9	5	10.9
pH[(c)]	NA	NA	7.8

(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

Table 5.2. PNNL Campus Nonradiological Atmospheric Emissions for 2014 Reported in Accordance with the Global Reporting Initiative (GRI) Standards

GRI Indicator	Indicator Title	2014 Emissions	Units
EN16	Total direct and indirect greenhouse gas emissions	50,323	metric tons of carbon dioxide equivalent
EN17	Other relevant indirect greenhouse gas emissions	23,636	metric tons of carbon dioxide equivalent
EN19	Ozone-depleting substance R12	0.01887	metric tons
	Ozone-depleting substance R22	0.006139	metric tons
	Ozone-depleting substance R123	0	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	0.028	metric tons
E20	Nitrogen oxides	4336	kilograms
	Sulfur dioxide	39	kilograms
	Volatile organic compounds	978	kilograms
	Hazardous air pollutants	385	kilograms
	Particulate matter	502	kilograms
	Carbon monoxide	6,601	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

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 2014, 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, 2014[(a)]

Parameter	Minimum Value	Maximum Value
Depth (in.)	12	24
Moisture (%)	3.81	15.26
Exchangeable sodium (%)	0.08	2.19
Cation-exchange capacity (meq/100 g)	7.10	12.10
Organic matter (%)	0.74	2.63
Total Kjeldahl nitrogen (mg/kg)	389	1,150
Nitrate as nitrogen (mg/kg)	1.0	13.0
Ammonia as nitrogen (mg/kg)	3.3	20.6
Total phosphorus (mg/kg)	635	892
Conductivity 1:1 (mmhos/cm)	0.11	0.51
Sodium (meq/100 g)	0.01	0.17
Calcium (meq/100 g)	5.20	8.03
Magnesium (meq/100 g)	1.31	2.04
Potassium (mg/kg)	65	190
Sulfate (mg/kg)	8	21
pH 1:1	6.2	7.2
Redoximorphic features	Absent	Absent

(a) A total of eight samples from four locations were analyzed in 2014.

6 Groundwater Protection Program

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 (Figure 6.1), tritium, uranium, and trichloroethylene.

The BSF/CSF facility uses a novel technology for heating and cooling the building 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 found in regional contaminant plumes that might be drawn toward the ground-source heat pump during groundwater withdrawal, including uranium, tritium, nitrate, and trichloroethylene, 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

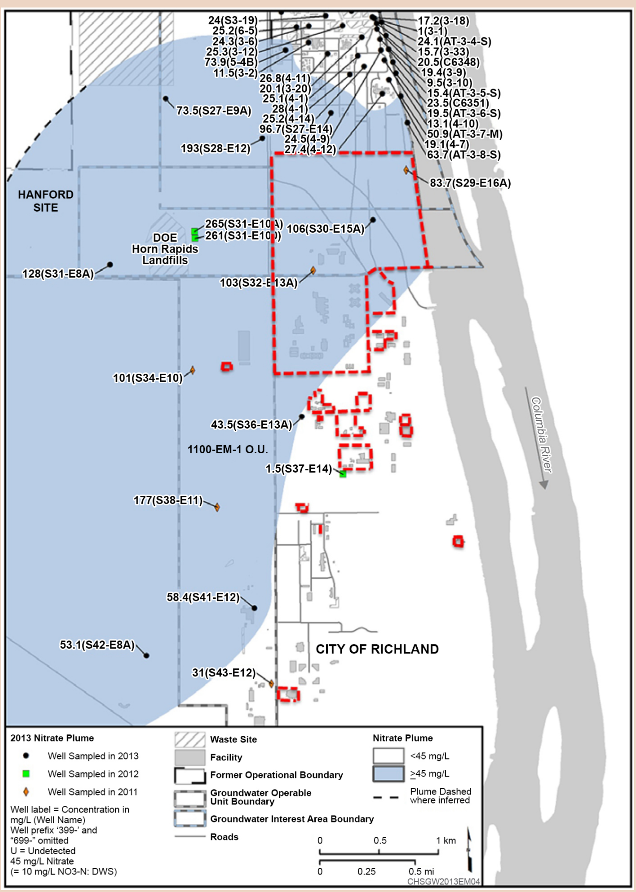

Figure 6.1. Nitrate Plume Beneath Portions of the PNNL Campus (modified from DOE-RL 2014b)

addition to the extraction and injection wells. Three of the monitoring wells located on the PNNL Campus are existing wells previously associated with the Hanford Site monitoring network. The other four monitoring wells were constructed and developed in accordance with the sampling and analysis plan (Fritz and Moon 2010). The sampling data are reported monthly to the Washington State Department of Ecology. Table 6.1 provides a summary of the monitoring results for the BSF/CSF ground-source heat pump for 2014. 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 by PNNL 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, 2014

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	0	1212
Temperature (°C)	NA	NA	NA	13.0	26.3
pH (pH units)	4	NA	NA	7.3	7.8
Dissolved oxygen (mg/L)	4	NA	NA	6.0	8.8
Conductivity (µS/cm)	4	NA	NA	682	792
Turbidity (NTU)	2	2	0.2	<0.2	0.08
Total dissolved solids (mg/L)	2	0	10	430	440
Nitrate-nitrite (mg/L)	2	0	0.5	18.8	19.0
Uranium (µg/L)	2	0	0.02	5.4	6.0
Tritium (pCi/L)	2	2	1,000	ND	ND
Trichloroethylene (µg/L)	2	2	5	ND	ND
Monitoring Wells Downgradient from the Injection Wells					
Temperature (°C)	NA	NA	NA	15.8	19.3
pH (pH units)	28	NA	NA	7.1	7.4
Dissolved oxygen (mg/L)	28	NA	NA	3.4	9.2
Conductivity (µS/cm)	28	NA	NA	675	815
Turbidity (NTU)	14	7	0.2	<0.2	1.87
Total dissolved solids (mg/L)	14	0	10	278	535
Nitrate-nitrite (mg/L)	14	0	0.5	13.7	23.8
Uranium (µg/L)	14	0	0.02	4.2	6.6
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 = non-detectable.
NTU = nephelometric turbidity unit.

7 Quality Assurance

Environmental sampling and monitoring activities were performed under PNNL's Environmental Management and Operations Program. These activities included sampling of wastewater, radiological air emissions, and ambient air and were subject to the PNNL QA program, which implements the requirements of DOE Order 414.1D, "Quality Assurance." Sampling is conducted by the Effluent Management Group or its delegates under QA plans that describe the specific QA elements that apply to each activity. The QA plans address requirements in DOE Order 414.1D and EPA QA/G-5 (EPA 2002). The plans were approved by the PNNL QA organization that monitors compliance with the plan. Work performed through contracts or statements of work, such as sample analyses, must meet the same QA 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 QA requirements were integrated into the Effluent Management Quality Assurance Plan (Ballinger and Beus 2013). The QA plan contains and references specific QA requirements for individual activities including environmental sampling and monitoring.

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. QA requirements for these activities have been integrated into the Effluent Management Quality Assurance Plan (Ballinger and Beus 2013) with specific requirements such as sampling locations, quality objective criteria, analytical methods, and detection limits included.

MSL uses trace quantities of radioactive material. Potential radioactive air emissions are permitted under a RAEL (radioactive air emissions license), and compliance is demonstrated through calculated emissions with no sampling or monitoring required. Wastewater sampling and monitoring are performed to comply with the NPDES permit for MSL. QA requirements specific to effluent monitoring at MSL have been integrated into the Effluent Management Quality Assurance Plan (Ballinger and Beus 2013).

7.1 Sample Collection Quality Assurance

Samples were collected by personnel trained to conduct sampling according to approved and documented procedures. Sampling protocols include use of appropriate sampling methods and equipment, a defined sampling frequency, specified sampling locations, and protocols for sample handling (which may include storage, packaging, and shipping) to maintain sample integrity. Chain-of-custody processes were used to track transfer of samples from the point of collection to the analytical laboratory. QA program requirements are integrated into the statement of work for subcontracted analytical laboratories and include 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 EPA-approved methods or methods 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 requirements and to demonstrate compliance with method requirements.

7.2 Quality Assurance Analytical Results

Four laboratories were used for analyses of environmental samples (i.e., wastewater, stack air emissions, and ambient air) from the PNNL Campus and MSL during 2014: 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; 3) wastewater samples were analyzed by ALS Environmental, Kelso, Washington; and 4) wastewater samples from MSL were analyzed for chlorine by an in-house accredited laboratory because of the 15-min sample hold time. 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 QA 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 quality control criteria), the issue was documented and resampling was required.

In 2014, 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 quality control program that included internal quality control measurements that provide estimates of precision and accuracy of the data. Both laboratories also participated in the Mixed-Analyte Performance Evaluation Program (MAPEP), an intercomparison program that provides an evaluation of laboratory performance. The 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 2014, GEL participated in two MAPEP studies (MAPEP 30 and 31), and 100 percent of the results for radiological analysis of air filters were within acceptable control limits. In 2014, GEL also participated in Multi-Media Radiochemistry Proficiency Testing studies (MRaDTM 20 and 21) 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 30 and also partially in MAPEP 31 (gross alpha and gross beta only), and 93 percent of the results were within the acceptable control limits.

Quality control (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 and an in-house laboratory at MSL analyzed all wastewater samples from the PNNL Campus and MSL during 2014. Both analytical laboratories are accredited by the Washington State Department of Ecology (C544 and 560, respectively) for the analysis of wastewater samples. To receive accreditation, a laboratory must implement a QA plan, perform periodic proficiency testing, and be periodically inspected by the Washington State Department of Ecology to assure that it is operating within regulatory and QA requirements. Both laboratories 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 136).

QA 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 data are valid. Analytical methods, method detection limits, holding times, sample containers, and preservation must meet 40 CFR 136 requirements and are verified for each sample collected. Resampling is required when an analysis fails to meet QC criteria or DQOs and the data are considered invalid.

7.3 Data Management and Calculations

QA is integrated into data management processes and calculations through documents such as QA plans, a data management plan, and procedures. Software QA 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, 2014

Quality Control Sample Type	Analytes[(a)]	Number of Samples	Results Within Control Limits
General Engineering Laboratories, LLC Air Filter Analyses			
Laboratory blanks	Gross alpha, gross beta, Am-241, Am-243, Be-7, Cm-243/244, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, K-40, Pu-238, Pu-239/240, Ru-106, Sb-125, U-233/234, U-235, U-238	34	74%[(b)]
Duplicate sample pairs	Am-241, Am-243, Be-7, Cm-243/244, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, K-40, Pu-238, Pu-239/240, Ru-106, Sb-125, U-233/234, U-235, U-238	3	100%[(c)]
Matrix spike samples	Am-241, Am-243, Cm-243/244, Pu-238, Pu-239/240, U-233/234, U-235, U-238	2	100%[(d)]
Laboratory control samples	Am-241, Am-243, Be-7, Cm-243/244, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, K-40, Pu-238, Pu-239/240, Ru-106, Sb-125, U-233/234, U-235, U-238	8	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 EPA 402-R-99-01 and Table of Nuclides at http://atom.kaeri.re.kr/ton/
(b) Percentage of results either below minimum detectable activity (MDA) or below reporting limits. Gross beta analyses were the only results outside of the control limits, but most of these results were at the control limit when rounded to one significant digit and the MDA was below reporting limits for all gross beta analyses.
(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.

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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. 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. Table A.4 includes selected conversions from curies to becquerels.

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

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

Table 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)		

Table A.4. Conversions for Radioactivity Units

aCi 27	fCi 1	fCi 27	pCi 1	pCi 27	nCi 1	nCi 27	μCi 1	μCi 27	mCi 1	mCi 27	Ci 1	Ci 27	kCi 1
1 μBq	37 μBq	1 mBq	37 mBq	1 Bq	37 Bq	1 kBq	37 kBq	1 MBq	37 MBq	1 GBq	37 GBq	1 TBq	37 TBq

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 parenthesis 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. Table A.5 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 Table A.5 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.6.

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.7.

A.5 Chemical and Elemental Nomenclature

Many of the chemical contaminants discussed in this report are listed in Table A.8 along with their chemical (or elemental) names and their corresponding symbols.

Table A.5. Conversions for Radiological Dose Units

μSv 0.01	μSv 0.1	μSv 1	μSv 10	μSv 100	mSv 1	mSv 10	mSv 100	Sv 1
1 μrem	10 μrem	100 μrem	1 mrem	10 mrem	100 mrem	1 rem	10 rem	100 rem

Table A.6. 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} rad)

A.6 Greater Than (>) or Less Than (<) Symbols

Greater than (>) or less than (<) symbols are used to indicate that the actual value may either be larger than the number given or smaller than the number given. For example, >0.09 would indicate that the actual value is greater than 0.09. A symbol pointed in the opposite direction (<0.09) would indicate that the number is less than the value presented. A symbol used with an underscore (≤ or ≥) indicates that the actual value is less than or equal to or greater than or equal to the number given, respectively.

Table A.7. Radionuclides and Their Half-Lives[(a)]

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

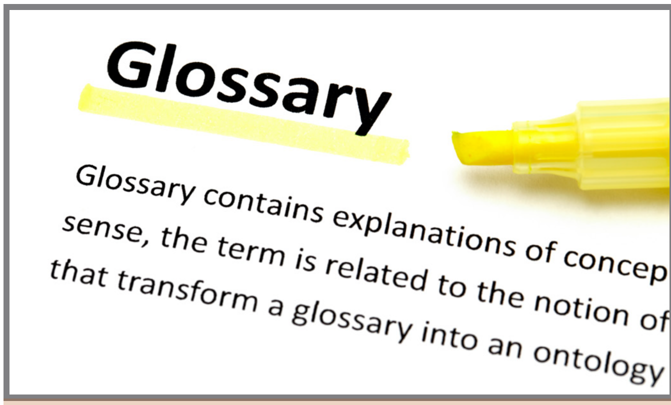
(a) From EPA 402-R-99-01 and Table of Nuclides at http://atom.kaeri.re.kr/ton/
(b) Natural uranium is a mixture dominated by uranium-238; thus, the half-life is ~4.5×10^{9} years.

Table A.8. Elemental and Chemical Constituent Nomenclature

Symbol	Constituent
Ag	silver
Al	aluminum
As	arsenic
B	boron
Ba	barium
Be	beryllium
Br	bromine
C	carbon
Ca	calcium
CaF_2	calcium fluoride
CCl_4	carbon tetrachloride
Cd	cadmium
$CHCl_3$	trichloromethane
Cl^-	chloride
CN^-	cyanide
Cr^{+6}	chromium (hexavalent)
Cr	chromium (total)
CO_3^{-2}	carbonate
Co	cobalt
Cu	copper
F^-	fluoride
Fe	iron
HCO_3^-	bicarbonate
Hg	mercury
K	potassium
LiF	lithium fluoride
Mg	magnesium
Mn	manganese
Mo	molybdenum
NH_3	ammonia
NH_4^+	ammonium
N	nitrogen
Na	sodium
Ni	nickel
NO_2^-	nitrite
NO_3^-	nitrate
Pb	lead
PO_4^{-3}	phosphate
P	phosphorus
Sb	antimony
Se	selenium
Si	silicon
Sr	strontium
SO_4^{-2}	sulfate
Ti	titanium
Tl	thallium
V	vanadium

A.7 Standard Deviation

The standard deviation (SD) of sample data relates to the variation around the mean of a set of individual sample results. If differences in analytical results occur among samples, then two times the standard deviation (or ±2 SD) implies that 95 percent of the time, a re-count or re-analysis of the same sample would give a value somewhere between the mean result minus two times the standard deviation and the mean result plus two times the standard deviation.



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 in 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 waste that contains both a nonradioactive U.S. Environmental Protection Agency or state-designated dangerous, extremely hazardous, or acutely hazardous component and an Atomic Energy Act-regulated radioactive component.

monitoring – As defined in DOE Order 5400.5, Chg 2, 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 the DOE-contracted elements on *Battelle Land–Sequim*.

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

quality control – All actions necessary to control and verify 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), as defined in 40 CFR 1508.4 and listed in Appendix A or B to subpart D of 10 CFR 1021, 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 5400.5, Chg 2, 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 Campus

Table C.1. Plant Species Observed on the PNNL Campus in 2014

Species Name	Common Name	State Status	Federal Status	Noxious Weed Class
Achillea millefolium	yarrow			
Achnatherum hymenoides	Indian ricegrass			
Acroptilon repens	Russian knapweed			B
Agropyron cristatum	crested wheatgrass			
Agropyron dasytachyum	thickspike wheatgrass			
Ambrosia acanthicarpa	bur ragweed			
Amsinckia lycopsoides	fiddleneck			
Artemisia tridentata	big sagebrush			
Asparagus officinalis	asparagus			
Astragalus caricinus	buckwheat milkvetch			
Balsamorhiza careyana	Carey's balsamroot			
Bassia scoparia	summer cyperus			B
Bromus tectorum	cheatgrass			
Cardaria draba	whitetop			
Centaurea diffusa	tumble knapweed			B
Chenopodium leptophyllum	slimleaf goosefoot			
Chenopodium rubrum	red goosefoot			
Chondrilla juncea	rush skeletonweed			B
Chrysothamnus viscidiflorus	green rabbitbrush			
Comandra umbellata ssp. pallida	bastard toadflax			
Convolvulus arvensis	field bind weed			C

Species Name	Common Name	State Status	Federal Status	Noxious Weed Class
Crepis atribarba ssp. originalis	slender hawksbeard			
Epilobium brachycarpum	tall willowherb			
Ericameria nauseosa ssp. nauseosa var. speciosa	gray rabbitbrush			
Eriogonum niveum	snow buckwheat			
Hesperostipa comata	needle-and-thread grass			
Hymenopappus filifolius	Columbia cutleaf			
Lactuca serriola	prickly lettuce			
Machaeranthera canescens	hoary aster			
Malus pumila	apple			
Medicago sativa	alfalfa			
Oenothera pallida	pale evening primrose			
Opuntia polyacantha	starvation pricklypear			
Phacelia hastata	whiteleaf scorpionweed			
Phlox longifolia	longleaf phlox			
Plantago patigonica	indian wheat			
Poa bulbosa	bulbous bluegrass			
Poa secunda	Sandberg's bluegrass			
Pseudoroegneria spicata	bluebunch wheatgrass			
Psoralidium lanceolatum	lemon scurfpea			
Pteryxia terebinthina var. terebinthina	turpentine spring parsley			
Purshia tridentata	bitterbrush *Chenopodiumin*			
Salsola tragus	Russian thistle			
Sisymbrium altissimum	Jim Hill's tumble mustard			
Sphaeralcea munroana	Munro's globemallow			
Sporobolus cryptandrus	sand dropseed			
Tragopogon dubius	yellow salsify			
Tribulus terrestris	puncturevine			B
Ulmus pumila	Siberian elm			

Noxious Weed Class:
A = Eradication required
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 Campus in 2014

Species Name	Common Name	State Status	Federal Status
Branta canadensis	Canada goose		
Buteo jamaicensis	red-tailed hawk		
Carpodacus mexicanus	house finch		
Eremophila alpestris	horned lark		
Pica pica	black-billed magpie		
Sturnella neglecta	western meadowlark		
Tyrannus verticalis	western kingbird		
Zenaida macroura	mourning dove		

Table C.3. Mammal Species Observed on the PNNL Campus in 2014

Species Name	Common Name	State Status	Federal Status
Canis latrans	coyote		
Lepus californicus	black-tailed jackrabbit	SC	
Odocoileus hemionus	mule deer		
small mammal	unknown/unidentified small mammal		
Sylvilagus nutalli	mountain cottontail		
Taxidea taxus	badger		
Thomomys talpoides	northern pocket gopher		

Appendix D Plant and Animal Species Found in the Vicinity of the PNNL Marine Sciences Laboratory

Table D.1. Plant Species Observed on PNNL Marine Sciences Laboratory Lands in 2014

Species Name	Common Name	State Status	Federal Status	Noxious Weed Class
Abies grandis	grand fir			
Acer circinatum	vine maple			
Acer macrophyllum	bigleaf maple			
Achillea millefolium	western yarrow			
Alnus rubra	red alder			
Ambrosia chamissonis	silver bur ragweed			
Arbutus menziesii	Pacific madrone			
Artemisia suksdorfii	coastal mugwort			
Blechnum spicant	deer fern			
Castilleja spp.	paintbrush			
Centaurea cyanus	bachelor's button			
Cerastium spp.	chickweed			
Cirsium arvense	Canada thistle			C
Cirsium spp.	thistle			
Claytonia perfoliata	miner's lettuce			
Conium maculatum	poison hemlock			B
Cornus stolonifera	red-osier dogwood			
Cytisus scoparius	Scotch broom			B
Dactylis glomerata	orchardgrass			
Distichlis spicata var. spicata	seashore saltgrass			
Elymus glaucus	blue wildrye			
Epilobium angustifolium	fireweed			
Equisetum spp.	horsetail			
Eschscholzia californica	poppy			

Species Name	Common Name	State Status	Federal Status	Noxious Weed Class
Fragaria virginiana	wild strawberry			
Frittilaria lanceolata	chocolate lily			
Galium spp.	bedstraw			
Gaultheria shallon	salal			
Grindelia integrifolia	Puget Sound gumweed			
Heracleum maximum	common cow-parsnip			
Holodiscus discolor	bachelor's button			
Leucanthemum vulgare	oxeye daisy			C
Lonicera ciliosa	honeysuckle			
Mahonia aquifolium	tall Oregon grape			
Mahonia nervosa	low Oregon grape			
Maianthemum racemosum ssp. amplexicaule	false Solomon's seal			
Medicago lupulina	black medick			
Mimulus guttatus	yellow monkey flower			
Mycelis muralis	wall lettuce			
Myosotis sp.	forget-me-not			
Oemleria cerasiformis	Indian plum			
Petasites palmatus	coltsfoot			
Plantago lanceolata	English plantain			
Plantago major	broadleaf plantain			
Plantago maritima	salt marsh plantain			
Polystichum munitum	sword fern			
Populus spp.	cottonwood			
Potentilla anserina	silverweed			
Pseudotsuga menziesii	Douglas fir			
Pteridium aquilinum	bracken fern			
Ranunculus ssp	buttercup			
Ribes sanguineum	red flowering currant			
Rosa gymnocarpa	baldhip rose			
Rosa nootkana	Nootka rose			
Rubus discolor	Himalayan blackberry			C
Rubus leucodermis	black cap raspberry			
Rubus parviflorus	thimbleberry			
Rubus ursinus	trailing blackberry			
Salicornia virginica	American glasswort			
Salix spp.	willow			
Sambucus racemosa ssp. pubens var. arborescens	red elderberry			
Symphoricarpos albus	snowberry			
Taraxacum officianale	common dandelion			
Tellima grandiflora	fringecup			
Thuja plicata	western red cedar			
Tolmiea menziesii	youth on age			
Trientalis latifolia	starflower			
Trifolium pratense	red clover			
Triglochin maritinum	seaside arrow-grass			
Tsuga heterophylla	western hemlock			
Urtica dioica	stinging nettle			
Vicia spp.	vetch			

Noxious Weed Class:
A = Eradication required.
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 in 2014

Species Name	Common Name	State Status	Federal Status
Accipiter cooperii	Cooper's hawk		
Anas platyrhynchos	mallard		
Branta canadensis	Canada goose		
Ardea herodias	great blue heron	Monitor	
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		
Cepphus columba	pigeon guillemot		
Columba livia	rock dove (pigeon)		
Corvus corax	common raven		
Cyanocitta stelleri	Steller's jay		
Empidonax difficilis	Pacific-slope 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 x L. occidentalis	Olympic gull		
Larus spp.	gull		
Megaceryle alcyon	belted kingfisher		
Melanitta sp.	scoter		
Melospiza melodia	song sparrow		
Oreothlypis celata	orange-crowned warbler		
Passerculus sandwichensis	savannah sparrow		
Petrochelidon pyrrhonota	cliff swallow		
Phalacrocorax auritus	double-crested cormorant		
Phalacrocorax sp.	cormorant		
Picoides villosus	hairy woodpecker		
Pipilo maculatus	spotted towhee		
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		
Sitta canadensis	red-breasted nuthatch		
Spinus tristis	American goldfinch		
Stelgidopteryx serripennis	Northern rough-winged swallow		
Sterna caspia	Caspian tern	Monitor	
Sturnus vulgaris	European starling		
Tachycineta thalassina	violet-green swallow		
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 in 2014

Species Name	Common Name	State Status	Federal Status
Anaxyrus boreas	western toad	SC	
Taricha granulosa	rough-skinned newt		

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