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PNNL-22691

Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2012

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September 2013

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Department of Energy
Pacific Northwest Site Office
P.O. Box 350, K9-42
Richland, Washington 99352

Addressees:

PACIFIC NORTHWEST NATIONAL LABORATORY ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 2012 (PNNL-22691), RICHLAND, WASHINGTON, SEPTEMBER 2013

The Pacific Northwest National Laboratory (PNNL) Annual Site Environmental Report is prepared and published annually by the U.S. Department of Energy (DOE) for distribution to local, state, and federal government agencies, Congress, the public, news media, and PNNL and Hanford Site employees. This report includes information for Calendar Year 2012 but may also include Fiscal Year 2012 and early 2013 data. The purpose of the 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 environmental laws and regulations, and; 2) regional environmental monitoring efforts.

The report addresses the operations occurring on the PNNL Campus in Richland, Washington, which includes PNNL Site facilities, Battelle Land–Richland (Battelle privately-owned land in Richland), Battelle-owned and -leased facilities, and DOE Office of Science-owned land and exclusive-use facilities. 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). The report also includes environmental information regarding the PNNL Marine Sciences Laboratory (MSL) and Battelle Land-Sequim (Battelle privately-owned land located near Sequim, Washington). 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 Annual Site Environmental Reports.

This report was prepared for DOE by PNNL staff. If you have any questions or comments about this report, please contact Theresa Aldridge of my staff on (509) 372-4508, or via e-mail at theresa.aldridge@pnso.science.doe.gov.

Sincerely,

Theodore P. Pietrok

for Roger E. Snyder
Manager

PNNL-22691

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Pacific Northwest National Laboratory
Richland, Washington 99352

Pacific Northwest National Laboratory
Annual Site Environmental Report for 2012

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Theresa Aldridge
Pacific Northwest Site Office, P.O. Box 350 MS K9-42, Richland, WA 99352

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- ☐ To learn general information about PNNL
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- ☐ To learn about site compliance
- ☐ Other:______________________________

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☐ Public Interest Group ☐ Member of Native American Nation ☐ Local Agency

☐ Member of the public ☐ University ☐ Industry

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, as well as its facilities in Sequim, Seattle, and North Bonneville, Washington, and Corvallis and Portland, Oregon.

This site environmental report provides a synopsis of ongoing environmental management performance and compliance activities conducted during 2012. The report addresses the operations occurring on the PNNL Campus in Richland, Washington, which includes PNNL Site facilities, Battelle Land–Richland (Battelle privately owned land in Richland), Battelle-owned and -leased facilities, and DOE Office of Science-owned land and exclusive-use facilities. 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). The report also includes environmental information regarding the PNNL Marine Sciences Laboratory (MSL) and Battelle Land–Sequim (Battelle privately owned land located near 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 methods used for data verification.

Compliance with Federal, State, and Local Laws and Regulations in 2012

PNNL is committed to complying with all applicable federal, state, and local laws and regulations and site-specific permits. In 2012, PNNL was in compliance with applicable requirements identified below, with the exception of temporary conditions of noncompliance, which were reported to the appropriate regulatory agencies (as required) and rectified expeditiously.

Pollution Prevention Program. The Pollution Prevention (P2) Program addresses PNNL's continuing effort to reduce the quantity and toxicity of hazardous, radioactive, mixed, and sanitary waste, fulfilling conditions of the *Pollution Prevention Act of 1990*. PNNL reduces or eliminates environmental hazards, conserves natural resources by recycling, manages energy usage, conserves water, and purchases environmentally preferable products and services (Sections 2.1.4 and 3.0).

***Clean Air Act* Compliance**. The Washington State Department of Health, Washington State Department of Ecology, Benton Clean Air Agency, and Olympic Region Clean Air Agency have issued permits for PNNL air emissions. Periodic inspections of emission sources occur to verify compliance with applicable requirements and permits. During calendar year (CY) 2012, PNNL maintained compliance with state and federal regulations and with issued air emissions permits. No events associated with air emissions of regulated substances or substances of concern were identified. Radioactive air emissions in CY 2012 were more than 100,000 times lower than the regulatory standard of 10 mrem/yr (0.1 mSv/yr) effective dose equivalent (EDE) for the period (Sections 2.4 and 4.2).

***Clean Water Act* Compliance**. During 2012, PNNL operated under permits issued by the Washington State Department of Ecology and the City of Richland (Section 2.5.1). In 2012, there were five accidental discharges or spills to the City of Richland sewer system (Section 2.9.3). Liquid effluents at MSL complied with their National Pollutant Discharge Elimination System permit in 2012.

CERCLA Compliance. No *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) compliance issues were identified in 2012 (Section 2.6.2).

RCRA Compliance. PNNL is responsible for one *Resource Conservation and Recovery Act of 1976* (RCRA)-permitted storage and treatment unit on the Hanford Site, operated by the DOE-Richland Operations Office. Issues identified during routine inspections in 2012 were corrected (Section 2.6.4). There are no RCRA permits applicable to MSL.

EISA Compliance. *Energy Independence and Security Act of 2007* (EISA) requirements are satisfied through building energy and water evaluations, stormwater management practices, fleet management, and energy savings practices (Section 2.2).

Compliance with Biological Resources Statutes. An annual baseline biological survey of undeveloped sections of the PNNL Campus was conducted in 2012, as were 15 ecological reviews for PNNL projects, 11 on the PNNL Campus and 4 in the 300 Area of the Hanford Site. Potential project impacts were evaluated for protected plant or animal species or candidates for listing under the *Endangered Species Act of 1973*; species listed by the state of Washington as threatened or endangered; Washington State priority habitats; and bird species protected under the *Migratory Bird Treaty Act* or *Bald and Golden Eagle Protection Act*. PNNL implements an interception program to control aquatic invasive plant and animal species, conforming to the requirements of the *Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990*. PNNL also implements a program to control invasive terrestrial plant species, following Washington State weed control laws (RCW 17.10) and regulations (WAC 16-750-011) (Section 2.7.1). There were no project impacts that violated related federal or state laws, regulations, or conservation concern guidance in 2012 (Sections 2.7.1 and 2.7.2).

Compliance with Cultural Resources Statutes. Several federal Acts and Orders are applicable to protecting cultural resources. *National Historic Preservation Act of 1966* Section 106 reviews are performed prior to any ground-disturbing actions. Six Section 106 reviews occurred on the PNNL Campus in 2012, and four occurred in the 300 Area of the Hanford Site. No cultural/historic resource compliance issues were identified (Section 2.7.3). No cultural resource reviews occurred at MSL in 2012.

Environmental Performance Measures. PNNL environmental performance measures address the goals and requirements of Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management;" and Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance." Performance measures include energy efficiency, water conservation, sustainable buildings, and transportation fleet management activities. Objectives and goals were achieved for the majority of performance measures in 2012 (Section 3.0).

Table S.1 summarizes PNNL compliance with federal and state statutes in 2012. Section 2.0 provides further details regarding compliance issues.

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Table S.1. Compliance Actions and Status of Federal and Washington State Statutes at PNNL, 2012

Regulation	What It Encompasses	2012 Compliance Actions and Standing
	Federal Statutes	
American Indian Religious Freedom Act; *Antiquities Act of 1906*; *Archaeological and Historic Preservation Act of 1974*; *Archaeological Resources Protection Act of 1979*; *Historic Sites Act of 1935*; *National Historic Preservation Act of 1966*; and *Native American Graves Protection and Repatriation Act of 1990*	Cultural resources.	Ten Section 106 cultural resource reviews were conducted for Pacific Northwest National Laboratory (PNNL) projects in fiscal year (FY) 2012, six on the PNNL Campus and four in the Hanford Site 300 Area. No cultural/historic resource compliance issues were identified. In addition, 12 projects were reviewed by cultural resource staff to ensure that they were covered by previously conducted Section 106 cultural resource reviews. No cultural resources reviews were conducted at PNNL Marine Sciences Laboratory (MSL) in 2012.
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 2012 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 MSL. PNNL was in compliance.
Clean Water Act	Point-source discharges to United States surface waters and indirect discharges to sewer systems.	PNNL operated under permits issued by the Washington State Department of Ecology and the City of Richland. PNNL has no stormwater discharges requiring monitoring under the federal or state National Pollutant Discharge Elimination System (NPDES) stormwater regulations. In 2012, there were five permit exceedances resulting from accidental discharges to the sewer under City of Richland permits. MSL operated under a permit issued by the Washington State Department of Ecology; there were no permit violations at MSL in 2012.

Table S.1. (contd)

Regulation	What It Encompasses	2012 Compliance Actions and Standing
Coastal Zone Management Act of 1972	Encourages the development of coastal zone management plans to preserve, protect, and enhance natural coastal resources and the wildlife using coastal habitats.	PNNL considers 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 2012. 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 2012, PNNL submitted a 302 (extremely hazardous substance) inventory, two Material Safety Data Sheet list reports, and two Tier Two reports to the Washington State Emergency Response Commission, the local emergency planning committee, and Richland Fire Department. PNNL was not required to submit a Toxic Release Inventory Report for 2012. PNNL was in compliance.
Endangered Species Act of 1973	Rare plant and animal species.	In 2012, a baseline biological survey of the PNNL Campus was conducted, as well as 15 ecological reviews for PNNL projects: 11 on the PNNL Campus and 4 in the Hanford Site 300 Area. No endangered or threatened species were observed. Five federal species of concern potentially occur on the PNNL Campus. The first annual survey of biological resources on lands encompassing MSL occurred in 2013. 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; improvements in energy and water use were observed. Stormwater management practices to promote water drainage and reduce runoff were implemented as well.
Federal Facility Compliance Act of 1992	Amends RCRA and CERCLA and requires new mixed waste reporting requirements.	PNNL provides information as part of the Hanford Site Mixed Waste Land Disposal Restrictions Summary Reports pursuant to Tri-Party Agreement Milestone M-26. 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 Fisheries Conservation and Management Act	Essential fish habitat.	Provides for protection of essential fish habitat (waters and substrate for spawning, breeding, feeding, and growth to maturity). PNNL was in compliance.

Table S.1. (contd)

Regulation	What It Encompasses	2012 Compliance Actions and Standing
Marine Mammal Protection Act of 1972	All marine mammals.	The biological resource review process is the primary means by which PNNL determines if 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 2012, an annual baseline biological survey of the PNNL Campus was conducted and 15 ecological reviews were conducted for PNNL projects: 11 on the PNNL Campus and 4 in the Hanford Site 300 Area. 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 1,583 NEPA reviews during fiscal year 2012 for research and support activities. The Pacific Northwest Site Office (PNSO) approved three sitewide and four project-specific categorical exclusions in 2012. Also, the DOE-Richland Operations Office approved six project-specific categorical exclusions. 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.
Pollution Prevention Act of 1990	Reduction or prevention of wastes by treatment, control, reuse, and/or recycling.	An annual pollution prevention plan was prepared and submitted to the Washington State Department of Ecology. In 2012, PNNL was in compliance, meeting the target diversion rate of 50 percent for non-hazardous sanitary wastes, and exceeding the 50 percent target for construction and demolition wastes, with 98 percent being diverted.
Resource Conservation and Recovery Act of 1976 (RCRA)	Tracking hazardous waste from generator to treatment, storage, or disposal (referred to as cradle-to-grave management).	PNNL is responsible for one RCRA-permitted storage and treatment unit. Washington State Department of Ecology personnel inspected PNNL three times in 2012. Issues identified were promptly corrected. There are no RCRA permits applicable to MSL.

Table S.1. (contd)

Regulation	What It Encompasses	2012 Compliance Actions and Standing
Rivers and Harbors Act of 1899	Prohibits obstruction or alteration of navigable waters.	PNNL had no projects applicable to this Act in 2012.
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.	The U.S. Environmental Protection Agency (EPA) Integrated Cleanup Initiative continued in its second year, envisioned to identify and implement improvements to land cleanup programs. PNNL was in compliance.
Toxic Substances Control Act	Hazardous chemical regulation and tracking; primarily polychlorinated biphenyls (PCBs).	During 2012, PNNL contributed to the 2011 PCB annual document log report for the Hanford Site and 2011 PCB annual report; both were submitted to EPA 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. PNNL was in compliance.
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 condition 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 process ensures the policies of the Act are met. PNNL was in compliance.

Table S.1. (contd)

Regulation	What It Encompasses	2012 Compliance Actions and Standing
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.

Environmental Monitoring and Dose Assessment

Air Emissions. Airborne emissions from PNNL facilities are monitored to assess the effectiveness of emission treatment and control systems and 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 2012 (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. During 2012, there were five accidental discharges or spills to the sewer. As a result, all PNNL spaces were evaluated to identify potential spill pathways and corrective actions are being implemented to prevent future accidental discharges at PNNL. Liquid effluent discharges from MSL operations are monitored under a permit issued by the Washington State Department of Ecology. No additional releases of regulated pollutants or contaminated wastewater were 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).

Radiological Release of Property. PNNL uses the pre-approved guideline limits defined 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 2012 (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 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 2012.

Radioactive particulates in ambient air are monitored using a particulate air-sampling network located at the perimeter of the PNNL Campus. In 2012, 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 (9.0×10^{-6} mrem [9.0×10^{-8} mSv]) EDE times the 80-km (50-mi) population (432,117). The 2012 total population dose from radionuclide air emissions estimated from nuclides that originate from the PNNL Campus was 4.0×10^{-3} person-rem (4.0×10^{-5} person-Sv). The PNNL Campus MEI location was 0.55 km (0.34 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 5×10^{-4} mrem/yr (5×10^{-6} mSv/yr) EDE. Radioactive material emissions for 2012 were on the order of a few nanocuries. 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 nonroutine point-source emissions was 9.2×10^{-6} mrem (9.2×10^{-8} mSv; Section 4.2.2). The MEI dose multiplied by the 30-mi U.S. population resulted in a population dose of 1.2 × 10^{-3} person-rem (1.2 × 10^{-5} person-Sv). Including the Victoria, British Columbia metropolitan area would result in an additional 3.3 × 10^{-3} person-rem (3.3 × 10^{-5} person–Sv).

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. No chemicals are added to the system; it is an open-loop system where groundwater is extracted and re-injected into the aquifer. 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 at flow rates up to 7,200 L/min (1,900 gpm) and requiring injection of the water back to the aquifer. 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 the contaminant plumes.

No groundwater sampling is required for environmental compliance at MSL.

Quality Assurance

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

Acknowledgments

This annual site report was produced by staff of the Pacific Northwest National Laboratory (PNNL) for the U.S. Department of Energy Office of Science's Pacific Northwest Site Office (PNSO). The compilation of this report incorporates the collaboration of knowledgeable professional staff who are hereby acknowledged for their efforts.

The authors express their gratitude to Rodger K. Woodruff, who provided a comprehensive review of the draft report.

A special thanks to Theresa Aldridge for coordinating the PNSO review and approval process.

Support for the preparation of this report was provided by Susan Ennor, editor, and Kathy Neiderhiser, text processor. Printing was performed by staff of the Pacific Northwest National Laboratory Duplicating Center. This report was formatted for and uploaded to the PNSO website by Larry Moore.

Acronyms and Abbreviations

ºC	degrees Celsius
ºF	degrees Fahrenheit
ac	acre(s)
A.D.	Anno Domini
ALARA	as low as reasonably achievable
Battelle	Battelle Memorial Institute
BCAA	Benton Clean Air Agency
B.P.	Before Present
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
DOE	U.S. Department of Energy
DOE-EM	DOE Office of Environmental Management
DOE-RL	DOE-Richland Operations Office
DOE-SC	DOE Office of Science
DQO	data quality objectives
EDE	effective dose equivalent
EISA	*Energy Independence and Security Act of 2007*
EMS	Environmental Management System
EMSL	William R. Wiley Environmental Molecular Sciences Laboratory
EPA	U.S. Environmental Protection Agency
EPCRA	*Emergency Planning and Community Right-to-Know Act of 1986*
FLC	Federal Laboratory Consortium
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
FY	fiscal year
µg/L	microgram(s) per liter

g	gram(s)
gal	gallon(s)
GBq	gigabecquerel
GHG	greenhouse gas
gpd	gallon(s) per day
gpm	gallon(s) per minute
GRI	Global Reporting Initiative
ha	hectare(s)
HPSB	High Performance Sustainable Building
in.	inch(es)
ISO	International Organization for Standardization
k	thousand
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kW	kilowatt(s)
L	liter(s)
L/min	liter(s) per minute
lb	pound(s)
µS/cm	microSiemens per centimeter
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MAPEP	Mixed-Analyte Performance Evaluation Program
mGy/d	milligray per day
m/s	meter(s) per second
M&O	management and operations
MEI	maximum exposed individual
meq	milliequivalents
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mph	mile(s) per hour
mrem/yr	millirem per year
MRL	Marine Research Laboratory
MSL	Marine Sciences Laboratory

mSv	millisievert
NEPA	*National Environmental Policy Act of 1969*
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NTU	nephelometric turbidity unit(s)
P2	Pollution Prevention
PCB	polychlorinated biphenyl
pCi/m^3	picocurie(s) per cubic meter
pCi/mL	picocurie(s) per milliliter
PNL	Pacific Northwest Laboratory
PNNL	Pacific Northwest National Laboratory
PNSO	Pacific Northwest Site Office
PTE	potential-to-emit
QC	quality control
R&D	research and development
RAEL	radioactive air emission license
RCRA	*Resource Conservation and Recovery Act of 1976*
RTL	Research Technology Laboratory
µS/cm	microsiemen(s) per centimeter
s	second(s)
SEPA	*State Environmental Policy Act*
SSPP	Strategic Sustainability Performance Plan
WAC	*Washington Administrative Code*
WDFW	Washington Department of Fish and Wildlife
yr	year

Contents

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1.0 Introduction

This environmental report was prepared to meet the requirements of U.S. Department of Energy (DOE) Order 231.1B, "Environment, Safety and Health Reporting," by providing a synopsis of calendar year (CY) 2012 information related to environmental management performance and compliance efforts at the Pacific Northwest National Laboratory (PNNL). It summarizes site compliance with federal, state, and local environmental laws, regulations, policies, directives, permits, and Orders and environmental management performance benchmarks. This is the second annual report specific to PNNL; previously information for PNNL was incorporated in Hanford Site environmental reports (e.g., Poston et al. 2011).

While meeting DOE reporting guidelines, this report also provides environmental information to Native American tribes, public officials, regulatory agencies, other interested groups, and the public. 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.

PNNL, one of 10 DOE Office of Science (DOE-SC) National Laboratories, 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 (DOE-EM), 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 annual site environmental report covers the PNNL Campus, including Battelle privately owned land in Richland (referred to as Battelle Land–Richland), leased facilities, and DOE-SC facilities. Environmental activities at other locations are also included if they are under PNNL's responsibility (e.g., permitted waste storage and treatment unit on the Hanford Site). This year's report also includes relevant environmental information concerning the PNNL Marine Sciences Laboratory (MSL) near Sequim, Washington. As DOE's only marine research laboratory, MSL is located on Sequim Bay just east of the city of Sequim. Revisions of the PNNL operating contract in October 2012 gave DOE exclusive use of the facility, consolidating its operations under PNSO oversight. MSL is emerging as a leader in sustainable development of ocean energy, understanding and mitigating long-term impacts of human activities on marine resources, and protecting coastal environments from security threats.

1.1 Location

JP Duncan

PNNL includes facilities in Richland and Sequim, Washington (Figure 1.1).

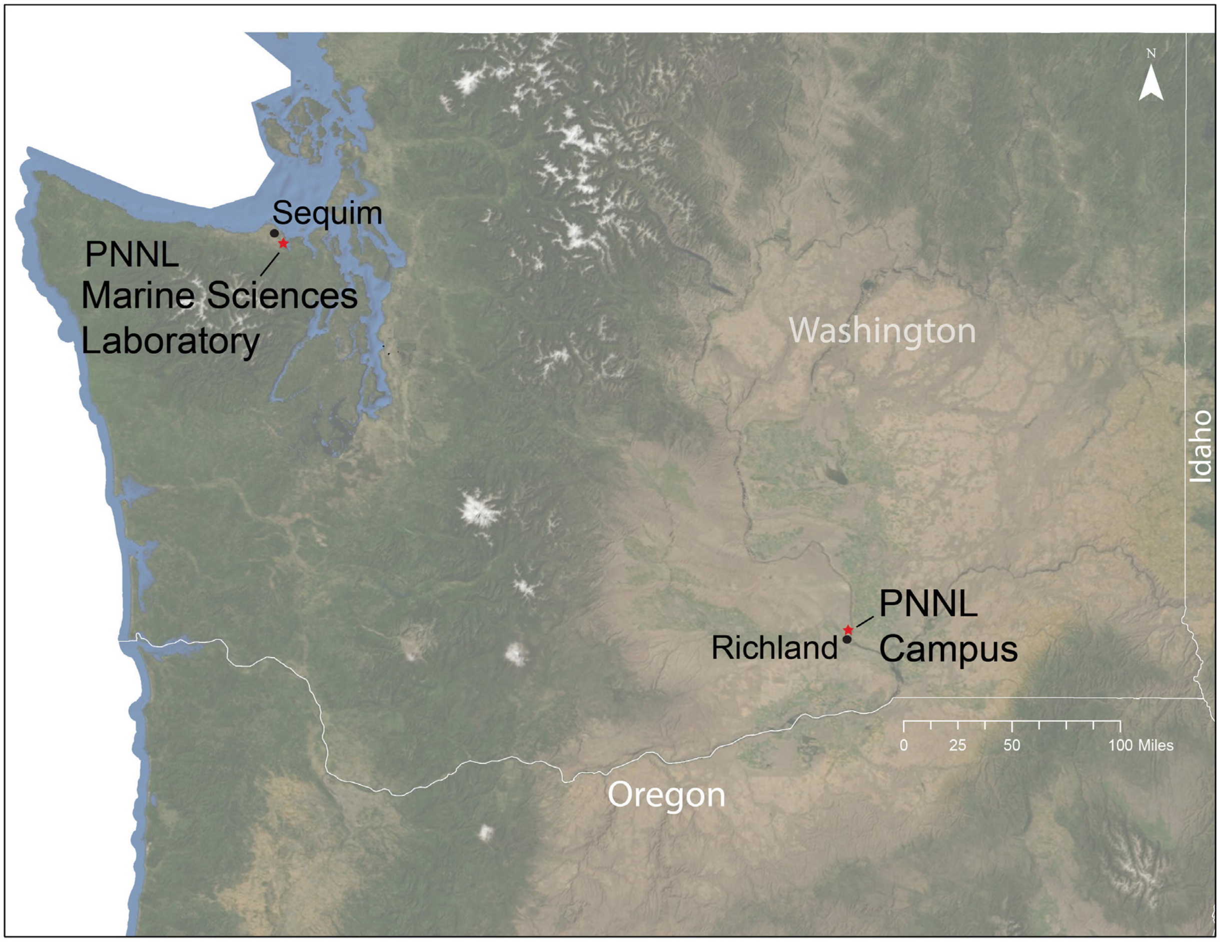

Figure 1.1. Map Showing the Locations of the PNNL Campus and PNNL Marine Sciences Laboratory in Washington State

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 (Figure 1.1). It is located at the northern boundary of the City of Richland and south of the DOE-Richland Operations Office (DOE-RL) Hanford Site 300 Area. The PNNL Campus, adjacent to the Columbia River, encompasses DOE-SC federally owned land, designated as the PNNL Site, as well as adjacent land owned by Battelle (referred to as Battelle Land–Richland), Battelle-owned facilities, and leased facilities. On October 1, 2012, the adjacent Battelle-owned facilities became DOE-SC exclusive-use facilities (Figure 1.2). The exclusive-use designation grants DOE-SC control of these facilities for PNNL operations. The PNNL Site occupies approximately 140 ha (346 ac); the additional Battelle Land–Richland adds 107 ha (264 ac). The area immediately south of the PNNL Campus comprises public and privately owned land. As currently planned, the land will be developed with office, laboratory, residential, and retail space as part of the Tri-Cities Research District. In addition, PNNL conducts research at MSL near Sequim and at satellite offices at various other locations including North Bonneville and Seattle, Washington, and Portland and Corvallis, Oregon.

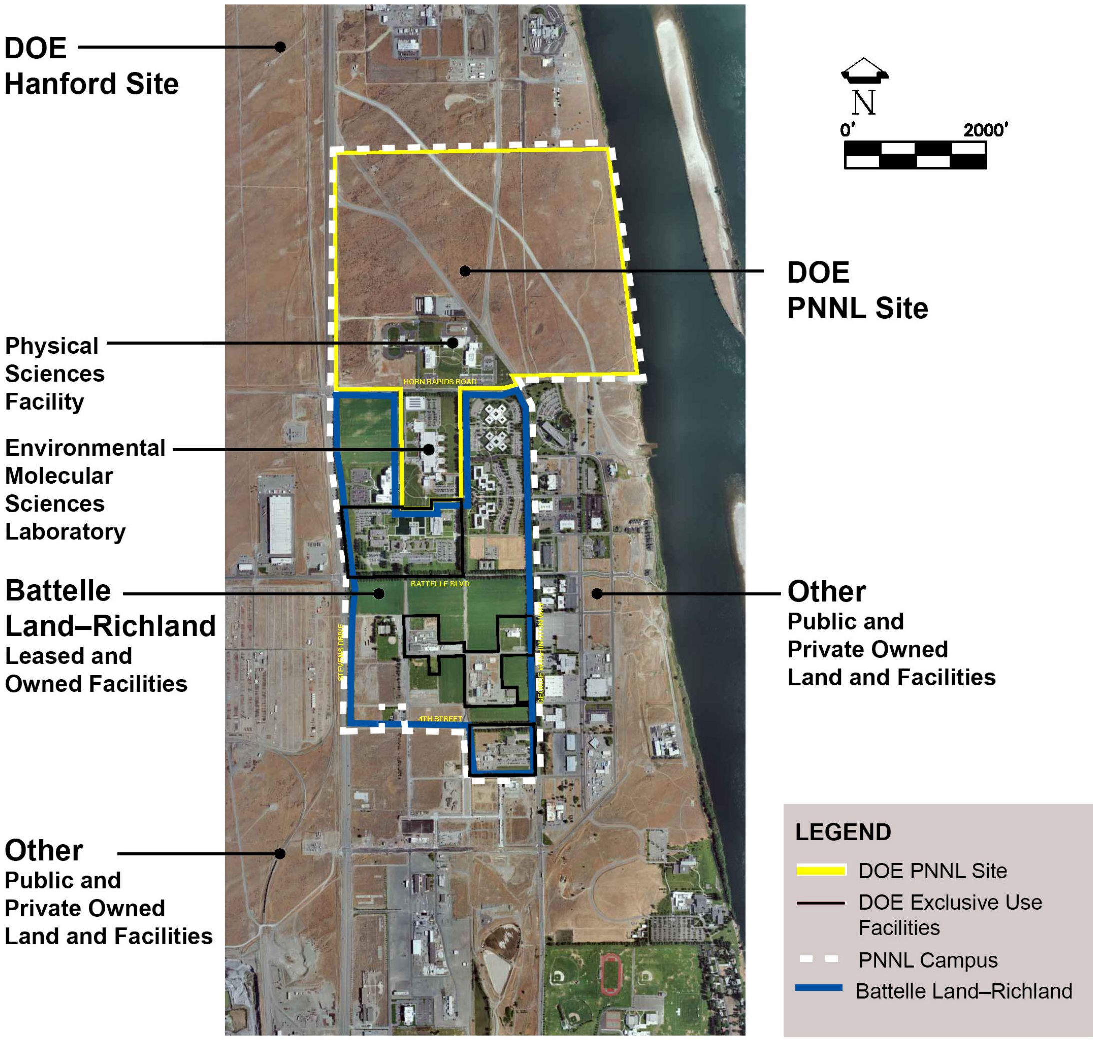

Figure 1.2. Pacific Northwest National Laboratory Campus and Surrounding Area

1.1.2 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 (Figure 1.3), hereafter referred to as Battelle Land–Sequim. In the rain shadow of the Olympic Mountains and less than 16 km (10 mi) north of Olympic National Park, the 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 laboratory facilities, an innovative seawater treatment system, research docks, and outdoor experimental tanks and ponds (Figure 1.4), where research scientists and engineers investigate and develop technologies to address marine research, national defense, homeland and global security, and intelligence analysis. In October 2012, the PNNL operating contract was revised, giving DOE exclusive use of MSL facilities and consolidating operations under PNSO oversight.

Figure 1.3. Battelle Land–Sequim (yellow boundary) and the PNNL Marine Sciences Laboratory Facilities

Figure 1.4. PNNL Marine Sciences Laboratory Shoreline Facilities on Sequim Bay in Washington State

1.2 History and Mission

JP Duncan

The history and mission of the PNNL facilities managed by PNSO are discussed in the following sections.

1.2.1 PNNL Campus

The Hanford Engineer Works was established in 1943 for the production of plutonium for nuclear weapons for World War II. The federal government used the power of eminent domain to displace the residents of Richland and the small farming communities of White Bluffs and Hanford to acquire the land. Native American tribes in the area were also displaced. Demolition of the original Richland buildings began after land condemnation and project construction began immediately thereafter. Construction workers were housed primarily in temporary barracks at the site during construction of the facilities and a new Richland community was built to house the 16,000 Hanford Engineer Works employees.

With the advent of the Cold War, the Atomic Energy Commission expanded reactor construction and Hanford Site operations were transferred to the General Electric Company. Between 1947 and 1955, five new reactors were added to the Hanford Site to increase plutonium-production capacity. The present site of PNNL and the surrounding area was used as a construction housing camp for postwar development. From 1951, when expansion construction was nearly complete, to 1961 the land was known as Camp Hanford. It was used for housing anti-aircraft defense personnel and support activities.

In 1964, the federal government issued a request for contractors to bid to operate the Hanford Site laboratories to conduct R&D activities related to nuclear energy and the non-destructive use of nuclear materials. In January 1965, Battelle was awarded the Pacific Northwest Laboratory (PNL) contract and, as part of the successful proposal, was able to invest its own funds to construct facilities to conduct non-Hanford Site research to promote R&D around the Pacific Northwest. Battelle bought 93 ha (230 ac) of former Camp Hanford land from the City of Richland to build its facilities. Under the original contract, more than 2,200 former General Electric employees joined the Battelle workforce.

In 1977, PNL was transferred to DOE management and research expanded into energy, health, environmental, and national security endeavors. With the expanded areas of research, PNL contributed to areas such as robotics, environmental monitoring, material coatings, veterinary medicine, and the formation of new plastics. In 1995, PNL was renamed as Pacific Northwest National Laboratory. Throughout the ensuing years, PNNL researchers have developed multidisciplinary technologies, earning numerous R&D 100 awards, Federal Laboratory Consortium (FLC) awards, and Innovation awards for their R&D work and contributions to new technologies.

PNNL is operated by Battelle for DOE-SC's PNSO, which was established in 2003. PNSO is responsible for overseeing all activities conducted at PNNL and for monitoring laboratory compliance with applicable laws, policies, and DOE Orders. In August 2004, approximately 53 ha (130 ac) of land in the southernmost portion of the Hanford Site were reassigned from DOE-EM to DOE-SC (Roberson 2004). Soon thereafter, 90 additional ha (220 ac) adjacent to the 53 ha (130 ac) were reassigned from DOE-EM to PNSO to further expand the PNNL Site (Rispoli 2007). The purpose of the reassignments was to establish a federal PNNL Site (Figure 1.2) that would support DOE-SC's long-term goals and science and technology mission.

These reassignments clarified the difference in missions between DOE-EM and DOE-SC. DOE-SC missions include strengthening scientific foundations for innovation, increasing energy capacity and reducing dependence on imported oil, counter terrorism and preventing the proliferation of weapons of mass destruction, reducing the environmental effects of human activity, and creating sustainable systems. PNNL's research interests align closely with DOE-SC missions. DOE-EM continues to focus on Hanford Site cleanup and closure.

Research facilities on the PNNL Site include William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) and the Physical Sciences Facility complex (Figure 1.2). The Physical Sciences Facility 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, and the Radiation Detection Laboratory and Ultra-Trace Laboratory for the development of radiation detection methodologies. The Radiation Portal Monitoring Test Track and Large Detector Laboratory, also part of the Physical Sciences Facility complex, are designed to develop and test radiation detection technologies for border entry points and national and homeland security research projects.

As a result of revisions to the PNNL operating contract in October 2012, Battelle-owned facilities adjacent to the PNNL Site became DOE-SC exclusive-use facilities, granting DOE operational control of these facilities.

1.2.2 PNNL Marine Sciences Laboratory

Construction of the Marine Research Laboratory (MRL) began in 1967. Part of the acreage was originally a Native American village listed in the Washington Heritage Register in 1972 as *Suxtcikwi'in*, Washington Harbor Indian Village. Before being selected as the site of the MRL, the land was the site of the Bugge Clam Cannery, which was established in 1907. The original cannery, destroyed in a fire in 1929, was rebuilt and continued operation until Battelle acquired the land in 1967 (Russell 1971).

As part of Battelle's commitment to develop research facilities that would benefit the region and serve the environment, the MRL at Sequim was conceived to provide laboratories for marine-related work involving biology, physiology, histology, chemistry, physics, and engineering. In 1973, the MRL opened; it was later renamed Marine Research Operations and is now referred to as MSL.

In 2002, PNNL established a Coastal Security Institute as a new component of MSL. The Institute's mission is to support intelligence, national security, and homeland security operations in coastal regions and marine environments both domestically and globally.

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 include environmental chemistry, water and ecosystem modeling, remote sensing, remediation technology research, environmental sensors, ecotoxicology, biotechnology, and national and homeland security.

1.3 Demographics

JP Duncan

The PNNL Campus is located in Benton County, south of the Hanford Site. 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 2012, an estimated 182,400 people lived in Benton County and 85,800 people lived in adjacent Franklin County, increases of 4.1 percent and 9.8 percent, respectively, over 2010 figures (USCB 2013a, b). During 2012, 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) in the northwestern corner of Washington State. An estimated 71,900 people lived in Clallam County in 2012; this is an increase of approximately 0.6 percent over 2010 figures and equivalent to approximately 1 percent of Washington's population (USCB 2013c). Sequim, the nearest population center to MSL, had a population of 6,624 people in 2012 (USCB 2013d). An estimated 132,000 people (on the U.S. side of the border) live within 48 km (30 mi) of Sequim; an estimated 1.45 million reside 48–80 km (30–50 mi) from Sequim. Victoria, British Columbia, the closest major city, has a population greater than 350,000 people. Seattle, Washington, within 80 km (50 mi) of MSL has a population greater than 634,000.

1.4 Environmental Setting – PNNL Campus

BG Fritz

The PNNL Campus occupies lands with varying degrees of previous disturbance, the severity and duration of which are indicated somewhat by 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 shrub-steppe 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 1.5. 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 a construction site adjacent to 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 borings 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.

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 1.6). 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 at 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) at PNNL. In general, the thickness of the vadose zone decreases with proximity to the Columbia River, as the ground surface slopes toward the river.

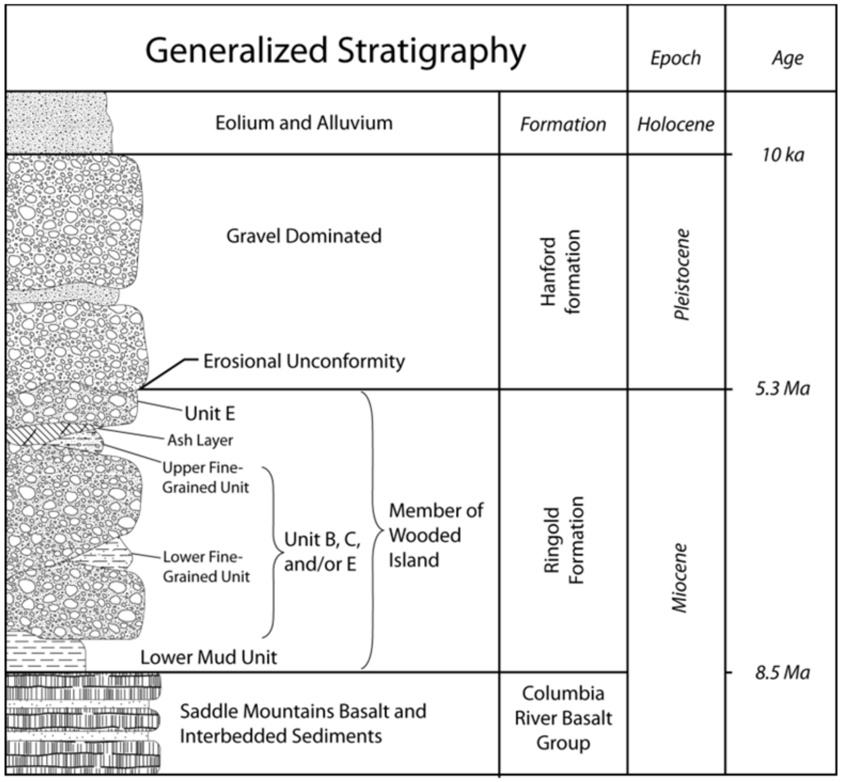

Figure 1.5. Generalized Stratigraphic Column Depicting the Stratigraphy Underlying the PNNL Campus (Modified from Reidel et al. 1992; Thorne et al. 1993; Lindsey 1995; Williams et al. 2000; DOE/RL 2002; and Williams et al. 2007)

1.4.3 Climate and Meteorology

Temperatures, precipitation, and winds across the Columbia 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 winter storms associated with them. The Hanford Meteorology Station located north of the PNNL Campus 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 2013). 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 (Poston et al. 2011). Normal annual precipitation at the Hanford Meteorology Station is 18.1 cm (7.14 in.). Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February. The average temperature for CY 2012 was 12.4°C (54.4°F), 0.2°C (0.5°F) above normal (12.2°C [53.9°F]). Total precipitation for 2012 was also above normal, totaling 20.8 cm (8.18 in.) (DOE/RL 2013).

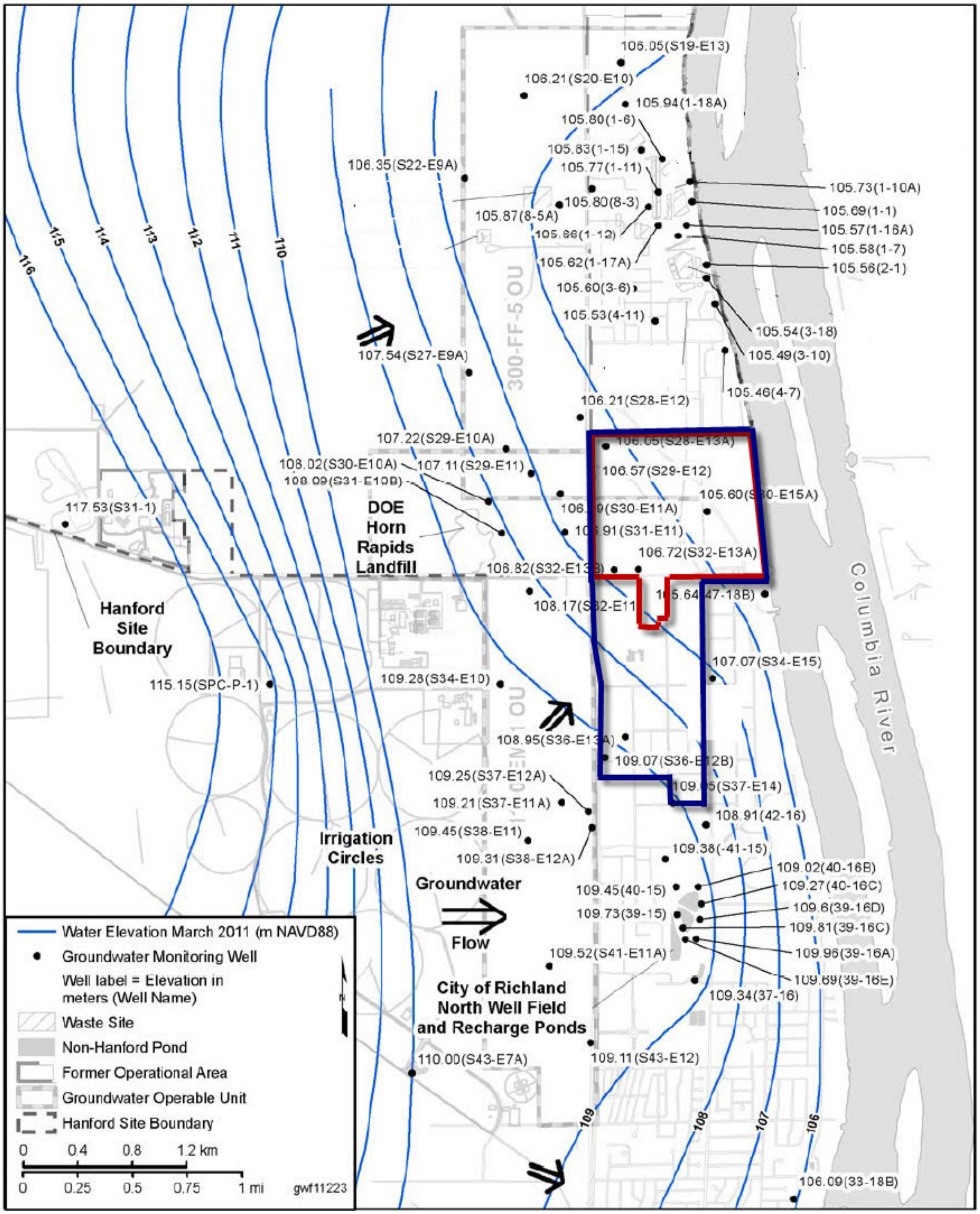

Figure 1.6. Water Table Elevation (m) in 2011 (modified from DOE/RL 2012a). Groundwater flow direction is normal to the water table contour lines. The PNNL Campus is designated by the blue border; the PNNL Site is bordered in red.

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). The average wind speed in 2012 was 3.5 m/s (7.9 mph), which was 0.2 m/s (0.4 mph) above normal. The peak gust for the year was 29.9 m/s (67 mph) on December 17, 2012 (DOE/RL 2013).

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, there are extended periods of poor dispersion conditions, primarily during winter, that are associated with stagnant air in stationary high-pressure systems. Fog has been recorded during every month of the year at the Hanford Meteorology Station; however, fog occurs mostly from November through February. In 2012, there were 70 days with fog (visibility less than or equal to 9.6 km [6 mi]), 45 percent more than the normal 48 days of fog for the entire period of record (1945-2012). Two dust storms were recorded at the Hanford Meteorology Station in 2012; the region has averaged four dust storms per year for the entire period of record (1945-2012).

The Hanford Meteorology Station operates an array of remote meteorological towers across the Hanford Site. PNNL uses data from the nearest tower (500 m [1,640 ft] northwest) for applications requiring PNNL Campus-specific climatology including engineering design and atmospheric dispersion modeling.

1.4.4 Ecology

JM Becker and MA Chamness

The PNNL Campus is located in the lowest and most arid portion of the Columbia Plateau Ecoregion (EPA 2010), 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 2012). 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 2012), with the exception of portions of 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.

Soils on the PNNL Campus are primarily sandy and support mostly native shrub-steppe vegetation. Shrub-steppe plant communities found on the campus 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 the 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. Common native forb species include Carey's balsamroot (*Balsamorhiza careyana*), long-leaved phlox (*Phlox longifolia*), yarrow (*Achillea millefolium*), turpentine springparsley (*Cymopterus terebinthinus*), and daisy fleabane (*Erigeron* spp.). Common non-native forbs include tumblemustard (*Sisymbrium altissimum*), Russian thistle (*Salsola tragus*), and several species listed as Class B noxious weeds, including diffuse knapweed (*Centaurea diffusa*), rush skeletonweed (*Chondrilla juncea*), Russian knapweed (*Acroptilon repens*), and yellow starthistle (*Centaurea solstitialis*). The Class B noxious weeds listed above are all classified as such by the state of Washington (WAC 16-750-011).

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 in the region include, but are not limited to, mourning doves (*Zenaida macroura*), lark sparrows (*Chondestes grammacus*), horned larks (*Eremophila alpestris*), California quail (*Callipepla californica*), western meadowlarks (*Sturnella neglecta*), and sage sparrows (*Amphispiza belli*). Several Washington State candidate animal species are known to occur or potentially occur on the PNNL Campus (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. 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*). Shrub willows (*Salix exigua*) and wild rose (*Rosa woodsii*) are common shrub species in the riparian band downstream of the Hanford Site 300 Area. Common herbaceous species along the shoreline include reed canarygrass (*Phalaris arundinacea*), 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).

Riparian habitats along the Columbia River in Washington support a diverse assemblage of wildlife. The area managed by PNSO, extending from a point south of the Hanford Site 300 Area along the river shore, consists of multilayered trees, shrubs, and herbaceous species. The area may be used for daytime perching by wintering bald eagles (*Haliaeetus leucocephalus*), and the riparian zone along with the upland area is used by nesting osprey (*Pandion haliaetus*). A large number of migratory bird species, such as western kingbird (*Tyrannus verticalis*) and Bullock's oriole (*Icterus bullockii*), use riparian trees and shrubs as nesting habitat. Many migratory bird species use the riparian habitats for resting and feeding during spring and fall migration.

Both shrub-steppe and riparian habitats are listed by the Washington Department of Fish and Wildlife 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.

Table 1.1. Wildlife and Plant Species of Conservation Concern Known to Occur or That Potentially Occur on the Pacific Northwest National Laboratory Campus

Common Name[(a)]	Genus and Species	Federal Status[(b)]	State Status[(c)]
Wildlife			
Black-tailed jackrabbit	*Lepus californicus*		Candidate
Burrowing owl	*Athene cunicularia*	Species of Concern	Candidate
Loggerhead shrike	*Lanius ludovicianus*	Species of Concern	Candidate
Northern sagebrush lizard	*Sceloporus graciosus*	Species of Concern	Candidate
Sage sparrow	*Amphispiza belli*		Candidate
Townsend ground squirrel	*Spermophilus townsendii*	Species of Concern	Candidate
Plants			
Grand redstem	*Ammania robusta*		Threatened
Canadian St. John's-Wort	*Hypericum majus*		Sensitive
Persistent sepal yellowcress	*Rorippa columbiae*	Species of Concern	Endangered
Lowland toothcup	*Rotala ramosior*		Threatened

Sources: WDFW (2013a) and WDNR (2012)

(a) The black-tailed jackrabbit, burrowing owl, and sage sparrow have been observed on the Pacific Northwest National Laboratory (PNNL) Campus. Other wildlife species potentially occur on the PNNL Campus based on availability of suitable habitat. Plant species potentially occur in the riparian zone of the Columbia River on the PNNL Campus (Salstrom et al. 2012; WDNR 2012).

(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 will eventually be proposed for listing as threatened or endangered (USFWS 2013).

(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 by Washington State (WDFW 2013a). 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 2012).

1.5 Environmental Setting – PNNL Marine Sciences Laboratory Vicinity

BG Fritz

Battelle Land–Sequim (Battelle privately owned land near Sequim) surrounds MSL and consists of forests, sandy beach shoreline, a bluff line, agricultural fields, 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 Battelle Land–Sequim, the location of 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 over most of Battelle Land–Sequim, 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. The average temperature for 2012 was 9.4°C (48.9°F). Regional winds are primarily from the northwest averaging 3.5 m/s (7.8 mph); however, the local topography of Battelle Land–Sequim may result in localized wind patterns. The maximum wind speed recorded in 2012 was 18.5 m/s (41.4 mph) (NDBC 2013).

1.5.1 Ecology

JM Becker and MA Chamness

Battelle Land–Sequim (Figure 1.3) lies in the Olympic Rainshadow 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, which features many islands, peninsulas, and bays (EPA 2010). 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 2013). Today, second-growth coniferous forest and agricultural fields occupy much of the ecoregion’s glacial moraines, outwash plains, floodplains, and terraces (EPA 2010; LandScope Washington 2013). These patterns of disturbance have influenced the development of the current vegetation and cover types on Battelle Land–Sequim 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).

The distribution of forest species is affected by the rain shadow of the Olympic Mountains (Dungeness River Audubon Center 2013a; EPA 2010). The local rain-shadow results in some of the driest sites encountered in the ecoregion, including the vicinity of Battelle Land–Sequim and nearby San Juan Islands (Dungeness River Audubon Center 2013a). Moist areas tend to support stands of western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*), while drier sites tend to support mixed stands of Douglas fir (*Pseudotsuga menziesii*) with some Garry oak (*Quercus garryana*), Pacific dogwood (*Cornus nuttallii*), and arbutus (Pacific madrone; *Arbutus menziesii*) (WWF 2013). The Battelle Land–Sequim vicinity supports a mixed coniferous forest consisting of a mixture of such tree species, including Douglas fir, western hemlock, western red cedar, and Pacific madrone, as well as riparian species such as red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and willows (*Salix* spp.) (Dungeness River Audubon Center 2007).

The relatively undisturbed nearshore areas of Puget Sound and the open coast are listed by the Washington Department of Fish and Wildlife 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 on the Battelle Land–Sequim region, 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, the most notable of which include federally listed threatened species such as the bull trout (*Salvelinus confluentus*), Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*), Hood Canal summer-run chum (*Oncorhynchus keta*), and Puget Sound steelhead (*Oncorhynchus mykiss*). Sequim Bay is designated critical habitat for these four species (75 FR 63898; 78 FR 2726; 70 FR 52630). Sequim Bay also provides potential habitat for the federally threatened North American green sturgeon (*Acipenser medirostris*), Pacific eulachon (Columbia River smelt; *Thaleichthys pacificus*), yelloweye rockfish (*Sebastes ruberrimus*), Puget Sound canary rockfish (*Sebastes pinniger*), and marbled murrelet (*Brachyramphus marmoratus*), as well as federally endangered Puget Sound bocaccio (*Sebastes paucispinis*). 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 2013; MRC 2013; WDFW 2013b).

Common mammal species in the Puget Lowlands ecoregion include raccoon (*Procyon lotor*), mink (*Mustela viso*n), coyote, and black-tailed deer (*Odocoileus hemionus*) (WWF 2013). These species likely are also common in the Battelle Land–Sequim vicinity. 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 2013c). 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. Six salamander and five frog and toad species also occur in the Battelle Land–Sequim vicinity, the most common of which include the rough-skinned newt (*Taricha granulosa*) and Pacific tree frog (*Pseudacris regilla*) (Dungeness River Audubon Center 2013b). Three animal species of conservation concern are known to occur or potentially occur on Battelle Land–Sequim property (Table 1.2).

1.6 Cultural Setting – PNNL Campus

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The archaeological record of the Mid-Columbia Basin bears evidence of more than 8,000 years of human occupation. The arid climate provides favorable environmental conditions for preservation of materials that might otherwise decay more quickly. Regional development of hydroelectric dams, highways, commercial and residential real estate, and agriculture has obscured or destroyed much of this evidence. While there has been continual development in the region, there are still places that remain largely undisturbed. Within these undisturbed portions of the landscape there is a potential that evidence of past human behavior may be present in the archaeological record. 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.

Table 1.2. Animal Species of Conservation Concern Known to Occur or that Potentially Occur on Battelle Land–Sequim 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
Taylor's checkerspot butterfly	*Euphydryas editha taylori*	Proposed[d]	Endangered

Source: WDFW (2013a)

(a) The bald eagle and peregrine falcon are known to occur in the vicinity of the PNNL Marine Sciences Laboratory (MSL). Taylor's checkerspot butterfly likely occurs there as well, based on Washington Department of Fish and Wildlife (WDFW 2013c) and U.S. Fish and Wildlife Service (77 FR 61938) records. However, this is not certain, because these records do not mention MSL explicitly.

(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 will eventually be proposed for listing as threatened or endangered. Proposed species are those for which the U.S. Fish and Wildlife Service has sufficient information about biological vulnerability and threats to support issuance of a proposed rule to list as federally threatened or endangered (USFWS 2013).

(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).

(d) Proposed for listing as Federal endangered. Proposed designated critical habitat occurs approximately 5 km (3 mi) north of MSL (77 FR 61938).

1.6.1 Pre-Contact Period

Archaeological investigations conducted on the Columbia Plateau enabled the creation of a cultural chronology dating back to the end of the Pleistocene. 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 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).

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

Cultural Period		Years Before Present	Site Types	Architecture	Subsistence
General Columbia Plateau					
Windust Phase		11,000–8,000	Rock shelters, caves, game processing sites, lithic reduction sites; isolated lithic tools. Examples include: Marmes Rockshelter, Bernard Creek, Lind Coulee, Kirkwood Bar, Deep Gully, Granite Point, Fivemile Rapids, and Bobs Point	Rock shelters and caves; open habitation sites. No evidence of constructed dwellings or storage features	Large mammals supplemented with small mammals and fish. Toolset: Windust, Clovis, Folsom, and Scottsbluff points; contracting stemmed points and/or lanceolate points; cobble tools.
Mid-Columbia Region—Vantage Area					
Cascade/ Vantage Phase		8,000–4,500	Lithic scatters, quarry sites, resource processing sites, temporary camps	Rock shelters and caves; open habitation sites.	Mobile, opportunistic foragers subsisting on fish, mussels, seeds, and mammals. Basalt leaf-shaped Cascade and stemmed projectile points, ovate knives, edge-ground cobble tools, microblades, hammerstones, core tools, and scrapers.
Frenchman Springs Period		4,500–2,500	Habitation sites along major rivers, confluences, tributaries, canyons, and rapids. Lithic scatters, quarry sites, resource processing sites, seasonal rounds of upland to lowland travel for resource procurement; seasonal camps.	House dwellings, including semi-subterranean	As earlier, but with increased use of upland resources, seeds, and roots. Groundstone and cobble tools, mortars, pestles, contracting stemmed, corner-notched, and stemmed projectile points, hopper mortar bases and pestles, knives, scrapers, and gravers. Wider tool material variety.
Cayuse Phase	I	2,500–1,200	Habitation sites at major rivers, confluences, tributaries, canyons, and rapids. Lithic scatters, quarry sites, resource processing sites, seasonal round camps. Ideological and spiritual sites.	Pithouses with wall benches	Reliance on riverine resources, fish, and botanicals; basal-notched and corner-notched projectile points (most corner -notched); variety of tools including groundstone, scrapers, lanceolate and pentagonal knives, net weights, cobble tools, drills, etc.
	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)

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 turned out to be 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 into 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 bunch grass 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 to 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). The new agricultural towns of Hanford and White Bluffs as well as small communities of Allard-Vernita, Wahluke, and Fruitvale, and local rural residents relied almost exclusively on river transportation during the early development of the area.

The southern Columbia Basin area was unique because it produced ripe agricultural crops and orchard fruit 2 to 3 weeks ahead of surrounding areas, resulting in higher profits to local farmers. In the early 1900s, dryland wheat and livestock were the primary agricultural commodities in Benton County. As farming increased, water resources other than rainfall were needed to produce higher crop yields. Many irrigation projects began; most were privately and insufficiently funded. Land speculators began constructing large-scale irrigation canals to supply water to thousands of acres in the White Bluffs, Hanford, Fruitvale, Vernita, and Richland areas (Sharpe 1999). However, poor economic conditions associated with the Great Depression of the 1930s created economic hardship for local residents. The hardship continued until the government took over the area under the *First War Powers Act of 1941* (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 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

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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 Before Present (10k B.P.) (Ackerman et al. 1985). These early sites contain lithic assemblages made up of bifaces, scrapers, and microblades similar to those known from Alaskan tool traditions. Sites dating to the earliest occupation of the region often contain assemblages of sea mammal bones. Early components of the Namu site on the central British Columbia coast provide evidence of a 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 7k 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 (Schalk 1988). By about 5k 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 3800 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 such hallmarks 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 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 one were 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, chum, and pink), steelhead and cutthroat trout, and Dolly Varden (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 including 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 way of the 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 at 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 establishing and reinforcing 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; 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).

2.0 Compliance Summary

PNNL is committed to conducting compliant operations in a manner that is sustainable and protects the environment. This section provides a summary of PNNL compliance with applicable federal, state, and local environmental laws and regulations, Executive Orders, as well as DOE Orders, directives, policies, and guidance.

2.1 Sustainability and Environmental Management System

JP Duncan

In December 2012, the DOE-Battelle Prime Contract for the management and operation of PNNL (PNNL Contract; DOE/PNSO 2013) was modified to incorporate applicable requirements from DOE Order 436.1, "Departmental Sustainability," along with its associated performance goals, objectives, and systems. The Order and related Executive Orders and statutes 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….."

Requirements of DOE Order 436.1 include compliance with Executive Orders 13423 and 13514, reporting requirements of the *Emergency Planning and Community Right-to-Know Act of 1986* and the *Pollution Prevention Act of 1990*, and the preparation of a Strategic Sustainability Performance Plan and Site Sustainability Plan. PNNL is required to develop a Site Sustainability Plan, incorporating sustainable acquisition requirements into applicable processes, and to develop an Environmental Management System (EMS) that is certified to, or conforms with, the International Organization for Standardization (ISO) 14001:2004(E) standards. PNNL's ISO 14001 EMS supports DOE's sustainability goals described in the DOE *Strategic Sustainability Performance Plan* (DOE 2011).

A Site Sustainability Plan (e.g., Richards and Judd 2012), identifying PNNL's sustainability projects status and accomplishments 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 (P2) Program activities, accomplishments, and continuous improvement opportunities. Section 3.0 provides additional information concerning PNNL sustainability.

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

Executive Order 13423 of January 24, 2007, 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 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, to include 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 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 objectives and goals as directed by Executive Order 13423; 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, reaffirmed and, in some cases, bolstered the policy and goals established in Executive Order 13423, including increased GHG accounting and reporting. Executive Order 13514 set goals for the reduction of Scope 1, 2, and 3 GHGs;[1] improved water-use efficiency and management; promotion of pollution prevention and waste elimination; advancement of regional and local integrated planning; implementation of sustainable building lifecycle management practices; advancement of sustainable acquisition; and 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.

2.1.4 *Pollution Prevention Act of 1990*

The *Pollution Prevention Act of 1990* requires that pollution be prevented or reduced at the source whenever possible, and that pollution that cannot be avoided be recycled or treated in an environmentally safe manner. PNNL's P2 Program is dedicated to the site's Environmental Stewardship Policy by helping staff members prevent or minimize pollutants (non-hazardous, hazardous, radioactive, etc.) to all media (air, water, and soil). The program looks for opportunities for resource conservation, recycling, energy efficiency, water conservation, and purchasing environmentally preferable products and services. An annual pollution prevention plan is prepared and submitted to the Washington State Department of Ecology in accordance with *Washington Administrative Code* (WAC) 173-307-070. The plan typically

[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.

contains information related to waste generation/reduction, P2 policy/practices, and P2 accomplishments. Further information concerning PNNL's P2 Program is incorporated into data presented in Section 3.0.

2.2 *Energy Independence and Security Act of 2007*

JP Duncan

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; research and development 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 to include solar, geothermal, marine and hydrokinetic, and energy storage; carbon capture and sequestration research; and energy transportation and infrastructure provisions. Conforming to EISA elements, PNNL is actively involved in the Carbon Sequestration Initiative, a program to advance capabilities in geologic sequestration. PNNL also performs EISA evaluations of buildings and has completed whole-building metering for electricity, natural gas, and water. Stormwater management practices are implemented to promote water drainage and reduce runoff. In 2012, a solar water heater was installed in the EMSL facility and a 125-kW photovoltaic array continued operation. In accordance with Secretary Chu's requirements, cool roofs (roofs with thermal resistances of at least R-30) are being implemented; total cool roof area at PNNL in 2012 totaled 679,000 ft^2, or 61 percent.

2.3 *National Environmental Policy Act of 1969*

JA Stegen

The *National Environmental Policy Act of 1969* (NEPA) was enacted to ensure 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 for 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 1,583 NEPA reviews during CY 2012 for research and support activities (1,172 Electronic Prep and Risk System reviews, 335 EMSL user proposals, and 76 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.

Categorical exclusions represent an effective and necessary means for 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 six categorical exclusions were approved by DOE-RL in 2012, 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.

These activities are relevant to PNNL projects conducted in facilities located in the 300 Area of the Hanford Site.

PNSO approved three new sitewide categorical exclusions for PNNL projects in 2012. In March 2012, PNSO approved a categorical exclusion for research activities in the aquatic environment. The categorical exclusion addresses acquiring rights-of-way, easements, and temporary use permits; installing, operating, and removing passive scientific measurement devices; conducting natural resource inventories, data and sample collection, environmental monitoring, and basic and applied research; and conducting surveying and mapping. In June 2012, PNSO approved a categorical exclusion to address transfer, lease, disposition, or acquisition of personal property including, but not limited to, equipment and materials, as well as real property including, but not limited to, land and permanent structures. In August 2012, PNSO approved a categorical exclusion for routine maintenance on the PNNL Campus. The categorical exclusion addresses routine maintenance activities and custodial services for buildings, structures, rights-of-way, infrastructure (including, but not limited to, pathways, roads, and railroads), vehicles, and equipment. The categorical exclusion also addresses localized vegetation and pest control.

In instances where projects clearly were within the definition of a categorical exclusion, but a sitewide categorical exclusion was not applicable, a project- or activity-specific categorical exclusion was prepared. PNSO approved four project-specific categorical exclusions in 2012:

- In January 2012, PNSO approved a project-specific categorical exclusion for conducting a proof-of-principle study to develop a wave glider-based passive acoustic detection system for monitoring whale populations (e.g., presence, distribution, relative abundance) at MSL and in Sequim Bay.
- In February 2012, PNSO approved a project-specific categorical exclusion to use existing manufacturing capabilities in various U.S. locations to build detector subsystem elements for use in upgrading the Belle detector at the KEK Laboratory in Tsukuba, Japan.
- In May 2012, PNSO approved a project-specific categorical exclusion to perform testing of radiation detection equipment using a portable linear accelerator at PNNL. This portable accelerator has a primary beam energy of 6 million electron volts and maximum beam power of less than 25 kW.

- In June 2012, PNSO approved a categorical exclusion to test high-energy radiography systems at PNNL. These systems have a primary beam energy of less than 8.0 million electron volts and an average beam power of less than 300 watts.

NEPA staff reviewed a randomly generated statistical subset of 441 maintenance actions that confirmed that maintenance activities 1) did not involve significant environmental impacts; 2) were limited in scope, cost, and duration; 3) were adequately addressed under existing NEPA reviews; and 4) showed no trends that might indicate the need for a more intensive and directed review.

2.4 Air Quality

JM Barnett

Federal regulations 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. Facilities with potential emissions of radioactive materials at the PNNL Campus are research laboratories at the Physical Sciences Facility, EMSL, the Research Technology Laboratory (RTL), and the Life Sciences Laboratory II. Details regarding ambient air and stack emissions monitoring programs for the PNNL Campus and at MSL are reported annually. Data for 2012 are available in the *Pacific Northwest National Laboratory Site Radionuclide Air Emissions Report for Calendar Year 2012* (Snyder et al. 2013a). Ambient air-monitoring results for MSL are available in the *Sequim Site Radionuclide Air Emissions Report for Calendar Year 2012* (Snyder et al. 2013b). During CY 2012, 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.

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, and 40 CFR 82, as well as the state requirements in WAC 173-400, 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 2011). 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*

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 (i.e., 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 the dose standard.

2.4.3 National Emissions Standards for Hazardous Air Pollutants

Section 112 of the *Clean Air Act* authorized the creation of NESHAP. The "National Emissions Standards for Hazardous Air Pollutants," Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities" (40 CFR 61, Subpart H) established regulations for radioactive air emissions, including standards, monitoring provisions, and annual reporting requirements. The NESHAP cover all pollutants not regulated by the National Ambient Air Quality Standards that are classified as hazardous. PNNL is in compliance with all NESHAP requirements at both the PNNL Campus and MSL.

2.4.4 Radioactive Emissions

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 2012, radioactive emissions from both the PNNL Campus and MSL were well below the federal and state 10-mrem/yr (0.1-mSv/yr) standard.

2.4.5 Air Permits

PNNL has several permits that control airborne emissions from facilities within the PNNL Campus boundary. These include the radioactive air emission license issued by the Washington State Department of Health (RAEL-05), the nonradiological effluent permit for Physical Sciences Facility issued by the BCAA (Order of Approval No. 2007-0013), and the nonradiological effluent permit for EMSL (DEO3NWP-003).

The MSL radioactive materials license (WN-L064) applied to MSL prior to October 1, 2012; it was terminated in May 2013. Revisions of the PNNL operating contract granting DOE exclusive use to MSL research facilities resulted in the Washington State Department of Health issuing a new radioactive air emissions license (RAEL-014), effective October 1, 2012.

2.5 Water Quality and Protection

TW Moon

Federal regulations that apply to water quality at the PNNL Campus and MSL are discussed in this section. This includes drinking water, wastewater, 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 and 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. WA-0020419 to the City of Richland for discharges to the Columbia River from its Publicly Owned Treatment Works. To ensure 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, three industrial wastewater discharge permits regulate the discharge of process wastewater to the City of Richland sanitary sewer system. Industrial wastewater discharge permit #CR-IU005 regulates discharges from EMSL, Permit #CR-IU011 regulates process wastewater discharged from the Physical Sciences Facility, and Permit #CR-IU001 regulates discharges from Richland North facilities, which includes Battelle-owned facilities and the Sigma 5 and 2400 Stevens leased buildings. All waste streams determined to be 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 to Sequim Bay under the authorization of Washington State Department of Ecology NPDES Permit No. WA-0040649. 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 at the upland facility. Drain boxes provide simple oil separation through 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, granular activated carbon adsorbent). The upland area 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 (Richards and Judd 2012).

2.5.3 *Safe Drinking Water Act of 1974*

The *Safe Drinking Water Act of 1974* is the main federal law that ensures the quality of Americans' drinking water. Under the Act, the EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. The *Safe Drinking Water Act of 1974* was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources—rivers, lakes, reservoirs, springs, and groundwater wells.

The Act focuses on all waters actually or potentially designed for drinking use, whether from above-ground or underground sources. The Act authorizes the EPA to establish minimum standards to protect tap water and requires all owners or operators of public water systems to comply with these primary (health-related) standards. State governments, which can be approved to implement these rules for EPA, also encourage attainment of secondary standards.[1] Under the Act, 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. Stormwater is managed as described in Section 2.5.2.

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[1] Secondary standards are set to give public water systems guidance on 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.

2.6 Environmental Restoration and Waste Management

HT Tilden

This section describes PNNL activities 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 (Tri-Party Agreement agencies) to achieve compliance on the Hanford Site with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), and the *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal unit regulations and corrective action provisions. 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* that 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 Internet at the following website: http://www.hanford.gov/?page=81. 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.

PNNL is not part of any Hanford Site CERCLA operable unit or subject to any cleanup action under the Tri-Party Agreement. PNNL maintains administrative controls similar to those at adjacent uncontaminated portions of the Hanford Site 300 Area. PNNL provides information to DOE-RL and its contractors with regard to the facilities it occupies on the Hanford Site in order to prepare 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 *Hanford Site Groundwater Monitoring for 2011* (DOE/RL 2012a).

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" 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.

Under the Tri-Party Agreement (Ecology et al. 1989), waste sites were grouped into "operable units" based on geographic proximity or similarity of waste-disposal history. Two operable units are located near the PNNL Campus and are part of the "Hanford 300 Area" National Priorities List site in accordance with 40 CFR 300, listed on November 3, 1989.

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 interim Record of Decision (EPA 2001) 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. 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 dangerous waste or hazardous substance released.

During CY 2012, no spills or non-permitted discharges that would threaten 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. The central principle of RCRA is its establishment of cradle-to-grave management to track hazardous waste from its generation to 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 under the expired permit until the reissued permit becomes effective, as authorized by WAC 173-303.

With the exception of the 325 Hazardous Waste Treatment Units, PNNL facilities operate under the generator requirements of WAC 173-303. During CY 2012, PNNL facilities followed the generator requirements for waste management and shipped nonradioactive waste to offsite facilities for proper disposal.

RCRA and Washington State Administrative Code (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, major new 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 three times in 2012. One of the inspections revealed minor noncompliances regarding a spent light bulb and an open container of used oil. PNNL promptly resolved issues discovered as part of these inspections.

2.6.5 *Federal Facility Compliance Act of 1992*

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 Reports pursuant to Tri-Party Agreement Milestone M-26.

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 *2011 Hanford Site Polychlorinated Biphenyl Annual Document Log* (DOE/RL 2012b) and the *2011 Hanford Site Polychlorinated Biphenyl Annual Report* (DOE/RL 2012c) describe the PCB waste management and disposal activities occurring on the Hanford Site, including PNNL Campus activities related to PCBs. These documents are provided to EPA annually as required by 40 CFR 761.180. MSL does not generate enough PCB waste to require reporting under 40 CFR 761.180.

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 2012, 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 distributing information about hazardous chemicals present in local facilities. These committees gather information and 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 to support 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).

For purposes of EPCRA, the quantities of chemicals in the Hanford 300 Area facilities that PNNL occupies are combined with those present in PNNL Site facilities. Further, effective October 1, 2012, the quantities of chemicals present in DOE exclusive-use facilities on the PNNL Campus are also included for purposes of calculating reporting thresholds.

As a result of the inclusion of the inventories from all PNNL Campus facilities, PNNL filed a notification under EPCRA Section 302 in October 2012 to report that the combined inventory of sulfuric acid exceeded the reporting threshold of 1,000 pounds. The sulfuric acid is either in a liquid form as a laboratory reagent, or present in lead-acid batteries.

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 26, 2013.[1] 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 reporting threshold at the PNNL Campus. 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 26, 2013[2] for diesel fuel at MSL. Diesel fuel is used to power generators during electrical service interruptions, and reportable lead-acid batteries are used to power forklifts.

These Tier Two reports were preceded by updated Material Safety Data Sheet reports required under EPCRA Section 311 when inventories change significantly.

Neither the PNNL Campus nor MSL was required to submit a Toxic Release Inventory Report for 2012, because all Toxic Release Inventory chemicals are maintained below inventory thresholds.

Table 2.2 provides an overview of PNNL reporting under EPCRA during 2012 and early 2013.

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[1] Tilden HT. February 26, 2013. "EPCRA 312 Report – PNNL Site." [Email to J Beck, Benton County Emergency Services, Richland, Washington, and KR Hubele, Richland Fire Department, Richland, Washington].
[2] Tilden HT. February 26, 2013. "Copy of EPCRA 312 Inventory Report." [Email to JI Wisecup, Clallam County Emergency Services, Port Angeles, Washington, and P Williams, Clallam County Fire District 3, Sequim, Washington].

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 quantity equal to or greater than 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 quantity equal to or greater than 4,500 kg (10,000 lb) or an extremely hazardous substance in quantity equal to or greater than 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 an OSHA hazardous chemical in quantity equal to or greater than 4,500 kg (10,000 lb), or an extremely hazardous substance in quantity equal to or greater than 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, 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 or 4,500 kg (10,000 lb), except for persistent, bio-accumulative, toxic chemicals, which have thresholds of 45 kg (100 lb) or less.	Annually by July 1	EPA; SERC

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

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

Section	Description of Reporting	Reporting Status	Notes
302	Emergency planning notifications	Yes	PNNL Campus reported sulfuric acid in excess of reporting thresholds due to the addition of inventories from DOE exclusive-use facilities.
304	Extremely hazardous substance release notification	Not required	No releases occurred.
311	Material Safety Data Sheet	Yes	Added diesel fuel in excess of reporting thresholds at both the PNNL Campus and MSL.
312	Chemical inventory	Yes	The 2012 Tier Two Emergency and Chemical Inventory reports for both the PNNL Campus and MSL were submitted February 26, 2013.
313	Toxic release inventory	Not required	No emissions greater than reporting threshold requirement.

MSL = PNNL Marine Sciences Laboratory.
PNNL = Pacific Northwest National Laboratory.

2.7 Natural and Cultural Resources

JA Stegen

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 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 – PNNL Campus

JM Becker and MA Chamness

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 2012.

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 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 2012 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 *Hanford Site Biological Resources Management Plan* (DOE/RL 2001).

The *Bald and Golden Eagle Protection Act* prohibits anyone without a permit to disturb, wound, kill, harass, or take bald eagles (*Haliaeetus leucocephalus*) or golden eagles (*Aquila chrysaetos*), alive or dead, including their parts, nests, or eggs. The Act also applies to impacts made around previously used nest sites, if, upon an eagle's return normal breeding, feeding, or sheltering habits are influenced negatively. The PNNL ecological review process provides assurance that a proposed action will not adversely affect bald or golden eagles. Mitigation includes performing work outside of the winter season, staying out of established buffer areas, or entering buffer areas at mid-day, thereby minimizing impacts by avoiding eagle roosting periods.

The *Magnuson-Stevens Fisheries 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, ensure 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 Oceanic and Atmospheric Administration Fisheries on any action that might adversely affect essential fish habitat. The PNNL biological resource review process supports the protection of fishery resources.

The *Rivers and Harbors Act of 1899* is the oldest federal environmental law in the United States. Section 9 of this Act prohibits the construction of any bridge, dam, dike, or causeway over or in navigable waterways without a permit. Administration of Section 9 has been delegated to the United States Coast Guard and the United States Army Corps of Engineers. Section 10 of the Act prohibits the building of any wharfs, piers, jetties, or other structures, or excavation or fill within navigable waters without a permit; authorization is delegated to the U.S. Army Corps of Engineers. PNNL has complied with this Act for past projects; no current projects are applicable.

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 support maintaining compliance with this Act. The program details control mechanisms for nuisance species on aquatic equipment used in infested waters, to prevent incidental introduction into uninfested waters.

Executive Order 11990, "Protection of Wetlands," 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," 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.

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 60 m (200 ft) of floodway-contiguous floodplains. The Act requires that preferred shoreline uses are 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 ensures the policies of the Act are met.

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

Lists that document priority habitats and species of concern in Washington State are maintained by the Washington Department of Fish and Wildlife (WDFW 2008, 2013a) and Washington State Department of Natural Resources (WDNR 2012). Lists that document plant and animal species with federal endangered, threatened, proposed, or candidate status are maintained in 50 CFR 17 (50 CFR 17.11; 50 CFR 17.12). A list that documents migratory birds protected under the *Migratory Bird Treaty Act* is maintained by the U.S. Fish and Wildlife Service (USFWS 2013).

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.

Staff ecologists perform annual pedestrian and visual reconnaissance of biological resources found on undeveloped portions of the PNNL Campus. The primary objective of the field surveys is to determine the occurrence of plant and animal species protected under the federal *Endangered Species Act of 1973*; candidates for such protection; priority habitats and species listed as threatened, endangered, candidate, sensitive, or monitor by the state of Washington; and species protected under the federal *Migratory Bird Treaty Act*. In addition, specific biological resource reviews are conducted prior to implementing any project activities that may disturb such resources.

A baseline biological survey of undeveloped sections of the PNNL Campus was conducted by PNNL ecologists in July 2012, complying with PNSO management plan requirements. Plant communities (Figure 2.1) were classified based on the dominant species of overstory (shrubs) and understory (grasses and forbs). The percent cover of dominant vegetation was visually estimated and recorded. Direct and indirect wildlife observations (e.g., sightings and indicators) were recorded.

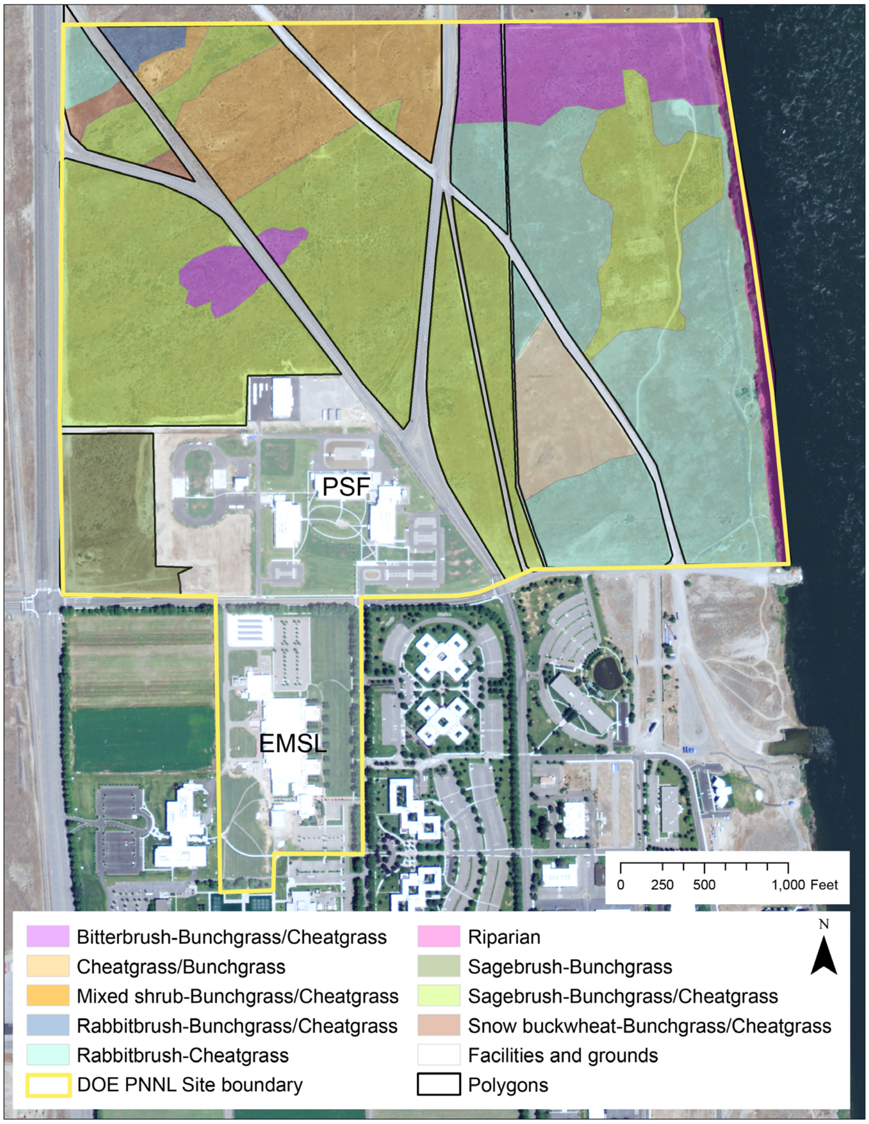

Figure 2.1. Plant Communities Found on the Undeveloped Portions of the PNNL Campus

The uplands and a small section of the riparian corridor along the Columbia River were surveyed in 2012. High water precluded surveys of the remainder of the riparian corridor. Only those species visible from the river bank just above the riparian zone could be noted. The most recent survey of the riparian corridor was completed in 2010 (Chamness et al. 2010). Due to annual variability in wildlife use and detectability, plant species occurrences, survey routes, and observers, the 2012 survey data must be combined with data from previous surveys (Larson and Downs 2009; Chamness et al. 2010; Becker and Chamness 2012) to produce the most complete list of plants and animals known to occur on the PNNL Campus.

No federally or state-listed threatened or endangered plant or animal species was observed in the uplands of the PNNL Campus during the 2012 surveys. However, the sage sparrow (*Amphispiza belli*) was observed, as was evidence of use by black-tailed jackrabbits (*Lepus californicus*). Both are state candidate species. The black-tailed jackrabbit was also recorded in the 2009 and 2010 annual surveys.

Both species are associated with shrub-steppe, and suitable habitat exists for them across much of the upland portion of the PNNL Campus. A list of plant and animal species identified in the areas surveyed in 2012 and their status is provided in Appendix C.

The PNNL Campus borders the Hanford Reach of the Columbia River. Although not part of the surveys described above, the river provides habitat to various aquatic species, the most notable of which include federally listed salmonid species such as the endangered upper Columbia River spring-run Chinook salmon, and threatened upper Columbia River steelhead and bull trout. Steelhead habitat includes juvenile rearing areas, juvenile migration corridors, areas for growth and development to adulthood, adult migration corridors, and spawning areas. Chinook salmon habitat includes juvenile rearing habitat and the juvenile and adult migration corridor. The Hanford Reach is also used as a migration corridor by bull trout (DOE/RL 2000).

Several species of Class B noxious weeds, including diffuse knapweed (*Centaurea diffusa*), rush skeletonweed (*Chondrilla juncea*), yellow starthistle (*Centaurea solstitialis*), and Russian knapweed (*Acroptilon repens*) (WAC 16-750-011; NWCB 2010) were first identified on the PNNL Campus in August 2009 (Larson and Downs 2009). Class B noxious weeds are species designated for control where they are not yet widespread to prevent new infestations (NWCB 2010). Since 2010, PNNL-licensed applicators in coordination with staff ecologists use hand-spraying methods to control populations of these specific weeds while minimizing impacts on other vegetation. A description of the work conducted to control noxious weeds in 2012 is provided in Appendix D.

As stipulated in the PNSO Management Plan (DOE/PNSO 2008), projects involving soil disturbance or work outdoors are routinely evaluated to determine their potential to affect biological resources. Fifteen ecological reviews were conducted for PNNL projects in CY 2012, 11 on the PNNL Campus and 4 in the 300 Area of the Hanford Site. Potential project impacts were evaluated for plant or animal species protected under the *Endangered Species Act of 1973* and candidates for such protection, species listed by the state of Washington as threatened or endangered, Washington State priority habitats, and bird species protected under the *Migratory Bird Treaty Act* and *Bald and Golden Eagle Protection Act*. There were no project impacts that violated related federal or state law, regulation, or conservation priority guidance.

2.7.2 Biological Resources – PNNL Marine Sciences Laboratory Vicinity

JM Becker and MA Chamness

The same federal laws and Executive Orders that provide the framework for protection of biological resources on the PNNL Campus apply to biological resources on Battelle Land–Sequim, which encompasses the MSL facilities and nearby waters. However, additional federal laws provide for protection of marine mammals and coastal resources in the vicinity of MSL.

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 ensure 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 *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, historic, and esthetic 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 Coastal Zone Management Program, adopted in 1976 under purview of the federal *Coastal Zone Management Act of 1972*, is implemented by the Washington State Department of Ecology Shorelands and Environmental Assistance Program. Under the Washington Coastal Zone Management Program, federal activities that affect any land use, water use, or natural resource of the coastal zone must comply with Washington State's *Shoreline Management Act of 1971*, including the associated county Shoreline Master Program where the activity would occur (see descriptions of the *Shoreline Management Act of 1971* and Shoreline Master Program in Section 2.7.1). The PNNL biological resource review process reinforces the policies of the Washington Coastal Zone Management Program.

The first annual survey of biological resources on the upland portions of the Battelle Land–Sequim was conducted in early 2013. The land-cover types and habitats on the site and in the nearshore environment of Sequim Bay are depicted in Figure 2.2. The 2013 survey results will be reported next year (2014).

2.7.3 Cultural Resources

KM Mendez and JA Stegen

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 2012.

The *National Historic Preservation Act of 1966* (16 USC 470) and its amendments establish historic preservation as a national policy and define it as the protection, rehabilitation, restoration, and reconstruction of districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, or engineering. The Act also 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.

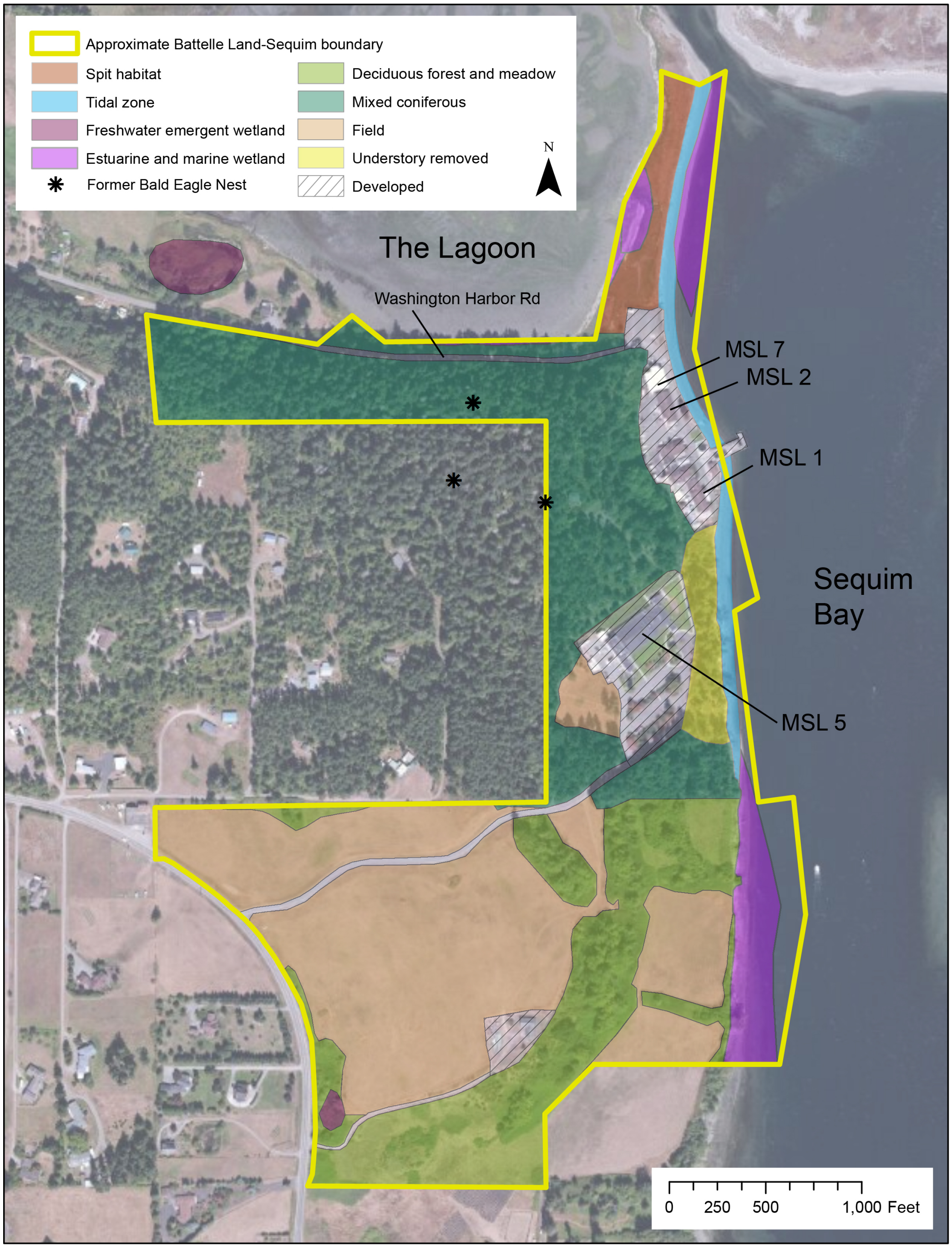

Figure 2.2. Plant Communities Found on Battelle Land–Sequim

The *Antiquities Act of 1906* provided for the protection of historic and prehistoric remains and structures on federal lands. It established a permit system for conducting scientific archaeological investigations and established criminal penalties and fines to manage looting and vandalism of archaeological sites on public lands. By the 1970s, the penalties were no longer commensurate with the severity of the offense, and in 1974 the Act was proclaimed to be unconstitutionally vague by the Ninth Circuit Court of Appeals. 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 removal or excavation, and the penalties for convicted violators. At PNNL, the cultural resource review process supports compliance with the *Archaeological Resources Protection Act of 1979*.

The *Native American Graves Protection and Repatriation Act of 1990* (25 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 *Archaeological and Historic Preservation Act of 1974* (16 USC 469) provides for the preservation of historic 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 historic and archaeological data affected by any federal or federally related land modification activity.

The PNNL Cultural Resources Review Process. Cultural resources reviews are conducted for all federal undertakings to identify their potential to affect cultural resources as part of *National Historic Preservation Act of 1966* Section 106 requirements. The Section 106 review process results in one of three outcomes: 1) No Historic Properties Affected, 2) No Adverse Effect, or 3) an Adverse Effect. Ten Section 106 cultural resource reviews were conducted for PNNL projects in 2012: six on the PNNL Campus and four in the Hanford Site 300 Area. These resulted in the following determinations: one review was categorized as No Potential to Cause Effect, eight reviews as No Historic Properties Affected, and one as No Adverse Effect. In addition to these Section 106 reviews, 12 projects were reviewed by cultural resource staff to ensure that they were covered by previously conducted Section 106 cultural resource reviews. There were no cultural resource reviews at MSL in 2012.

To ensure 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, the trip results are analyzed and reported to local Native American tribes and the Washington State Historic Preservation Office. The cultural resources monitoring trip was conducted on December 11, 2012. Monitoring was conducted by the PNNL cultural resources contractor CH2M HILL, with the participation of PNNL staff and tribal cultural resources staff. Photographs and field notes are 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 is collected during these trips to add to current knowledge of the sites.

As noted during previous PNNL Campus monitoring, portions of landscape fabric were visible in areas at one site, where wind-borne sediments have been removed by aeolian processes. Also noted was an old excavation and associated push pile near the revegetated portions of the site. 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 animal burrow under the northern fence identified during the previous monitoring trip was revisited. It appears that the burrow is still occasionally used by wildlife, but it does not seem to have expanded or caused any impacts on cultural resources. The area of off-road driving identified during the previous monitoring trip was revisited. It appears that no new off-road driving has occurred since the last monitoring trip; the newly established protection measures appear to be working well. Previously unrecorded erosion impacts were identified at a site near the Columbia River. Based on the comparison to photographs taken during previous monitoring trips, there appears to have been approximately 1 m (3.3 ft) of cut bank erosion. Historic debris including metal objects, brick, and bottle glass were observed protruding from the new cut bank face. It appears that the extreme high-water levels of the past year caused the erosion. This area will continue to be monitored on future trips. All observations were considered minor and no additional protective measures were recommended.

2.8 Radiation Protection

GA Stoetzel

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

2.8.1 DOE Order 5400.5, "Radiation Protection of the Public and the Environment"

DOE Order 5400.5 was initially issued in February 1990, and underwent minor revisions in June 1990 (Change [Chg] 1) and January 1993 (Chg 2). It was superseded by DOE Order 458.1 in February 2011. Contractors were given 18 months (until August 31, 2012) to implement the new Order. PNNL was working under the requirements in DOE Order 5400.5 until September 1, 2012, when implementation actions (i.e., procedure revisions and associated training) for DOE Order 458.1 were completed. DOE Order 5400.5 was cancelled by DOE Order 458.1, Chg 3, in January 2013.

The purpose of DOE Order 5400.5 was to establish standards and requirements for the radiological protection of the public and the environment. Relative to guidance, standards, and regulatory requirements existing at the time of its issuance, this Order adopted applicable standards issued by the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurements, incorporated regulatory requirements applicable to DOE operations, and consolidated and upgraded DOE guidance for contaminated property.

DOE Order 5400.5, Chg 2, applied to all DOE elements and contractors performing work for DOE, as provided by law and/or contract, and as implemented by the appropriate contracting officer. Relative to the radiological health and safety of the public, the objectives of DOE Order 5400.5, Chg 2, were to ensure that DOE operations achieved the following:

- Radiation exposures to the public are maintained within established limits.
- Radioactive contamination is controlled through the management of real and personal property.
- Potential exposures to the public are as far below established limits as is reasonably achievable.
- DOE facilities have the capabilities, consistent with the types of operations conducted, to monitor routine and nonroutine releases and to assess doses to the public.

In addition to providing radiological protection to the public, the objective of DOE Order 5400.5 was to provide radiological protection of the environment to the extent practical.

During CY 2012, Chapter II and Chapter IV of DOE Order 5400.5 were implemented, as specified in PNNL's Radiological Control Program Description and associated implementing procedures. No property with detectable residual radioactive material above the surface contamination guidelines derived from DOE Order 5400.5 and supporting guidance documents was released by PNNL during CY 2012. Further detail is available in Section 4.3.

2.8.2 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 with full implementation due by September 1, 2012. During the reporting period of this site environmental report, PNNL was working under the requirements in DOE Order 5400.5 until September 1, 2012, when implementation actions (i.e., procedure revisions and associated training) for DOE O 458.1 were completed.

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 radioactive. Dose constraints to 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 issuance of an annual site environmental report.

In September 2012, PNNL issued revisions to its radiation protection procedures to implement DOE Order 458.1 to include more detailed guidance on 1) the environmental ALARA program, 2) use of process knowledge and historical knowledge when releasing property, 3) preparation and approval of authorized limits requests, and 4) preparation of an annual site environmental report.

2.8.3 DOE Order 435.1, "Radioactive Waste Management"

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

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

- 10 CFR 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 Description 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 "How Do I" workflows and waste management internal procedures.

2.8.4 *Atomic Energy Act of 1954*

The *Atomic Energy Act of 1954* was promulgated to ensure 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 2.8.3], DOE Order 5400.5, Chg 2 [Section 2.8.1]), and DOE Order 458.1 [Section 2.8.2]) 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.

2.9 Major Environmental Issues and Actions

HT Tilden

Releases of radioactive and regulated materials to the environment are reported to DOE and other federal and state agencies as required by law. The specific agencies notified depend on the type, amount, and location of each release event. This section describes releases to the environment that occurred at PNNL during CY 2012.

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 MSL in 2012.

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 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 in 2012. However, the following five unplanned releases from PNNL-occupied buildings to the City of Richland sewer occurred:

- In May 2012, there was an accidental discharge of less than 189 L (50 gal) of a dilute solution of corrosion inhibitor used in a building boiler system. Corrective actions were implemented to prevent future accidental discharges from this and similar systems.
- In August 2012, a few liters of glassware cleaning wash water having a pH of greater than 10 was discharged to the sewer system, exceeding the City of Richland's wastewater criteria. Corrective actions were taken.
- On August 21, 2012, as much as 2,800 L (740 gal) of a dilute solution of corrosion inhibitor were released to the sewer when a coolant loop used to recycle computer heat for heating the building leaked. Corrective actions were implemented to prevent future accidental discharges from this and similar systems.
- In November 2012, a discharge of approximately 1,900–2,300 L (500–600 gal) of coolant from a building heating hot water system (a solution of propylene glycol and water) was discovered to have occurred over the preceding 2 to 3 weeks. Corrective actions were implemented that included modifying the coolant sight-glass to more effectively identify the level of glycol in the system and evaluating all PNNL spaces to identify potential spill pathways to the sewer system.

- In November 2012, a total of 380 L (100 gal) of cleaning solution previously approved for disposal to the sewer was discharged. On December 6, the solution was discovered to have contained molybdenum in excess of the City's discharge limits. A lessons-learned report was shared with staff to emphasize the importance of reviewing project changes that may affect solid and liquid waste streams.

PNNL has taken corrective actions to eliminate accidental discharges and spills to the sewer system, including the inspection of check valves, examination of drains that could receive inadvertent discharges, and evaluating potential engineered controls (e.g., berms) to control spills.

No unplanned releases occurred at MSL in 2012.

2.10 Summary of Permits

HT Tilden

Table 2.3 summarizes air, liquid, and hazardous waste permits for the PNNL Campus and MSL during 2012.

Table 2.3. PNNL Air, Liquid, and Hazardous Waste Permits, 2012

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[a]
		Air Emissions		
Washington State Department of Ecology	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	PNNL-occupied locations on Hanford Site	Radioactive and nonradioactive air emissions	1/1/2012
Washington Department of Health	WN-L027-1[c]	PNNL Campus	Radioactive materials possession and radioactive air emissions	8/31/1992
Washington Department of Health	WN-L064-1[c]	PNNL Marine Sciences Laboratory	Radioactive materials possession and radioactive air emissions	1/31/2015
Benton Clean Air Agency	Order 2007-0013	PNNL Campus	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 98-01[d]	PNNL Campus	Nonradioactive air emissions	None

Table 2.3. (contd)

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[a]
Benton Clean Air Agency	Order 2012-0013	Physical Science Facility	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 2012-0016	PNNL Campus	Nonradioactive air emissions	None
Benton Clean Air Agency	Order RO 2012-0009	Environmental Molecular Sciences Laboratory	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 2007-0006, Rev. 1	Life Sciences Laboratory II	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 06004-00, Rev. 3	Battelle Inhalation Laboratory	Nonradioactive air emissions	None
Olympic Region Clean Air Agency	Order of Approval 08-NOC-621	PNNL Marine Sciences Laboratory, MSL-7	Nonradioactive air emissions	None
Olympic Region Clean Air Agency	Order of Approval 05-NOC-415	PNNL Marine Sciences Laboratory	Nonradioactive air emissions	None
		Liquid Effluents[e]		
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 (new buildings north of Horn Rapids Road)	Liquid effluent discharges to city sewer	12/31/2014
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	2/16/2010
Washington State Department of Ecology	ST-9251	PNNL Campus	Reuse of cooling water for irrigation	6/30/2015
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

Table 2.3. (contd)

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[(a)]
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-Richland Operations Office and/or its contractor(s); PNNL is obligated to comply with these permits through an operating agreement between the DOE-Richland Operations Office and Pacific Northwest Site Office.
(c) These licenses are being processed for termination; radioactive air emissions authorization moved to RAEL-005 and RAEL-014 on October 1, 2012.
(d) Modified to remove the content of Order 2012-0016 on October 1, 2012.
(e) PNNL also conducts activities in leased facilities with wastewater permits issued to the owner. These permits are not listed here, but compliance-related impacts from PNNL activities are included in this report.
PNNL = Pacific Northwest National Laboratory.

3.0 Environmental Management System

J Su-Coker and KL Lowry

PNNL has a mature, robust environmental management system (EMS) that was established in 1996. Since 2002, ISO 14001 certification has been maintained, which includes yearly independent third-party verification of the certification. The EMS is integrated into PNNL's Integrated Safety Management Program, which ensures 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.

Laboratory management conducts assessments to evaluate environmental performance from a programmatic perspective, to determine if there are issues that require attention, and to facilitate the identification and communication of "best management" practices. PNNL management also routinely evaluates progress on key environmental improvement projects.

PNNL's EMS is audited periodically to verify that it is operating as intended and in conformance with the ISO 14001 standards. In 2012, an EMS surveillance audit determined that PNNL 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.


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

Certificate of Registration

This certifies that the Environmental Management System of

Battelle - Pacific Northwest Division

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

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

ISO 14001:2004

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

Certificate Number:	6Z781-EM5
Certificate Issue Date:	03-DEC-2012
Registration Date:	20-OCT-2011
Expiration Date *:	19-OCT-2014

William Niedzwiecki,
President & General Manager,
NSF-ISR, Ltd.

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

In addition, PNNL's 2012 EMS performance data submitted to the Federal Facilities Environmental Stewardship & Compliance Assistance Center (FedCenter) received a "Green" score, for 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).
- Documented operational controls to address significant environmental aspects consistent with objectives and targets were fully implemented.
- Environmental training procedures were established to ensure 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.

PNNL's approach to sustainability is considered holistically against the "triple bottom line" of environmental stewardship, social responsibility, and economic prosperity. The 3 pillars and 12 focus areas create mutually supportive and integrating pieces. Laboratory-wide sustainability performance and accomplishments are provided in an annual Sustainability Report (e.g., PNNL 2013). Further information is available at the PNNL Sustainability website (http://sustainable.pnnl.gov/) and in Section 3.1.

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 ensure regulatory requirements and any concerns of the public or other interested parties are addressed. The 10 most significant aspects identified at PNNL 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 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 chemical requisitioning, and work procedures for chemical 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, research and development 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 ensure they conform to regulations and permits.
- **Physical Interaction with Environment**: Some PNNL projects are performed outdoors in direct contact with the environment. These include facility construction, maintenance, and modifications, as well as occasional R&D activities. Any work proposed to be performed outdoors is reviewed to minimize potential impacts and ensure 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. PNNL also seeks opportunities to further reduce degradation and depletion of environmental resources by purchasing environmentally friendly items (e.g., that contain recycled content).
- **Water Use**: PNNL recognizes the value of water in the eastern Washington environment and has made water conservation a key element of its Site Sustainability Plan (Richards and Judd 2012). PNNL maintains water-use reduction goals and implements actions to reduce water consumption.
- **Fuel Usage**: PNNL is reducing the use of petroleum-based fuels by purchasing new 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 low-speed-electric vehicles for on-campus transportation and has installed solar-powered electric vehicle charging stations across the PNNL Campus. In addition, PNNL was instrumental in obtaining the first bio-fuel service station in Richland, Washington.

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

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

PNNL has also been employing a "ChemAgain" program, involving the redistribution of surplus chemicals, as an effort to reduce PNNL's chemical waste. In fiscal year (FY) 2012, more than 600 chemical containers were redeployed to internal staff. PNNL has also been a practitioner of the "zero waste" principle through diligent planning, recycling, and donating of food scraps to local farmers for animal feed. In FY 2012, all major employee events were zero waste; 100 percent of the waste was recycled or reused at events attended by nearly 1,000 employees.

3.1 Sustainability Goals and Targets

Signed in 2009, Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," 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 sustainability due dates, Executive Order 13514 has set numerical targets for agencies.

PNNL is required to have a Site Sustainability Plan in place, detailing the strategy for achieving these long-term goals, and to provide an annual status. 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. The initial plan was developed in 2010 (Olson et al. 2010) and has been updated annually (Richards et al. 2011; Richards and Judd 2012). The plan includes practical actions to conserve energy, water, and financial resources; improve the comfort and productivity of PNNL staff; and benefit the environment. In FY 2012, PNNL achieved several sustainability milestones, as highlighted below.

Greenhouse Gas Reduction and Comprehensive Greenhouse Gas Inventory. Scope 3 GHG, related to site operations, including business travel, employee commuting, vendor activities, and delivery services, has decreased 6.5 percent compared to FY 2011 (Figure 3.2). In FY 2012, a PNNL-wide telework program was started to reduce GHG from employee commuting. Beyond helping achieve GHG goals by eliminating commuting miles, flexible work arrangements are believed to save staff money and time, reduce stress, increase productivity, and help staff strike a better work/life balance.

Scope 1 and 2 GHG, generated from PNNL operations and activities (Scope 1) or associated with the purchase of energy (Scope 2), decreased 11.4 percent compared to 2011 (Figure 3.3).

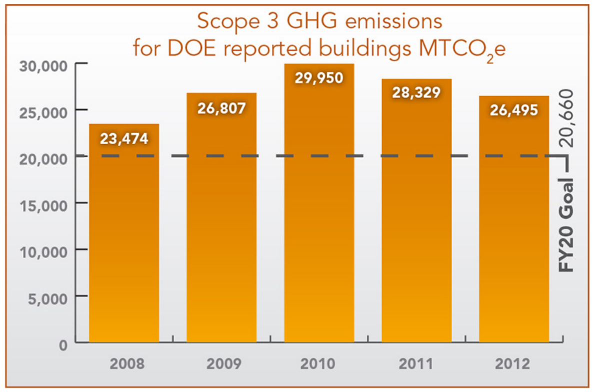

Figure 3.2. Scope 3 Greenhouse Gas Emissions from DOE Buildings on the PNNL Campus, 2008–2012

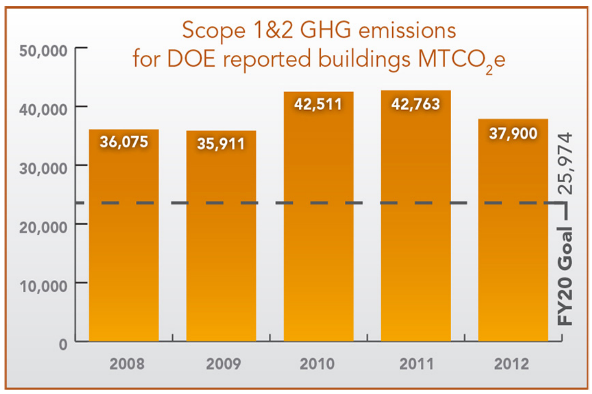

Figure 3.3. Scope 1 and 2 Greenhouse Gas Emissions from DOE Buildings on the PNNL Campus, 2008–2012

High-Performance Sustainable Buildings (HPSBs). PNNL exceeded DOE's goal for 15 percent of existing buildings to meet the five Guiding Principles by 2015: 1) employ integrated design principles for new construction and integrated assessment, operation, and management principles for existing buildings; 2) optimize energy performance; 3) protect and conserve water; 4) enhance indoor environmental quality; and 5) reduce environmental impact of materials. In FY 2012, PNNL certified an additional two buildings and currently 25 percent of its portfolio achieves the HPSB goal (Figure 3.4).

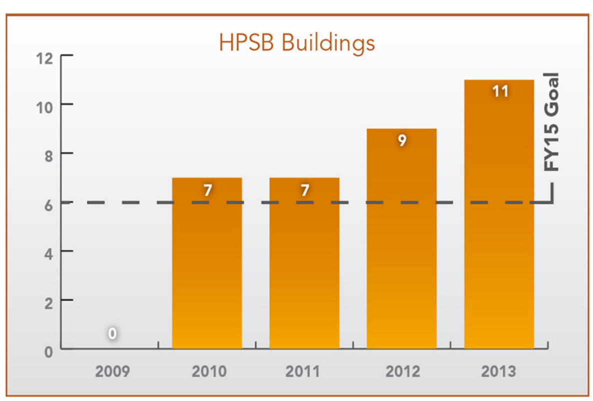

Figure 3.4. High-Performance Sustainable Buildings have Exceeded DOE Goals

Fleet Management: PNNL received a 2012 Sustainability Award from DOE for efforts to right- size the fleet through "putting words into actions." An interdisciplinary team challenged vehicle-use methods and by right-sizing the fleet, PNNL reduced petroleum use by 13 percent in only 1 year (Figure 3.5).

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

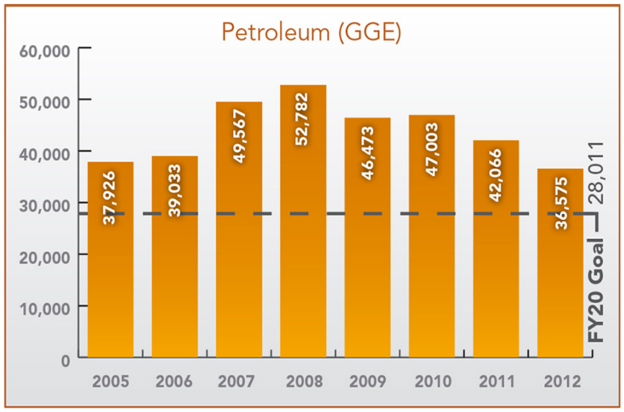

Figure 3.5. Petroleum Fuel Use, 2005–2012

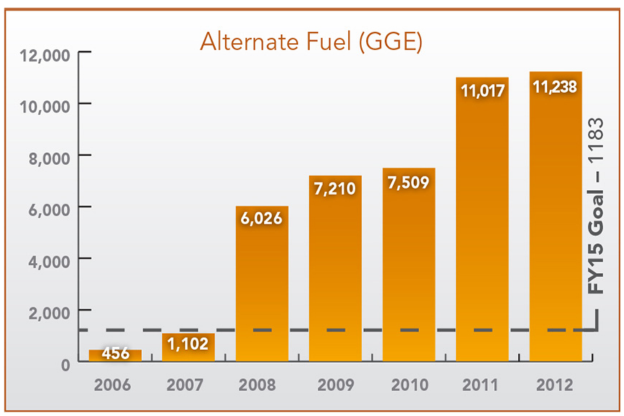

Figure 3.6. Alternative Fuel Use, 2006–2012

Water-Use Efficiency and Management: PNNL has met the water-intensity reduction goal. Implementation of water-saving projects and operational improvements have resulted in an overall reduction of 56.6 percent compared with the 2007 baseline (Figure 3.7).

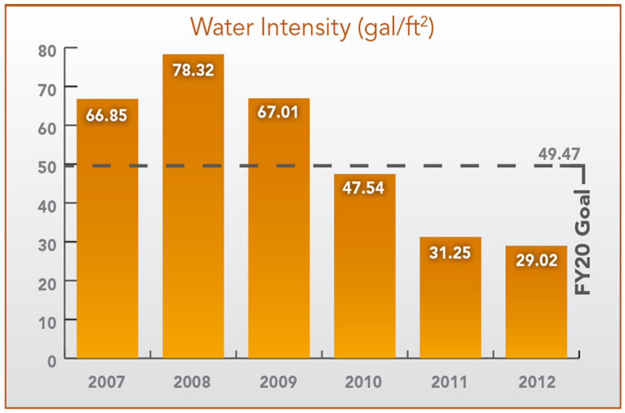

Figure 3.7. Water-Use Intensity, 2007–2012

Pollution Prevention and Waste Reduction: In FY 2012, PNNL achieved the goal of diverting 50 percent of non-hazardous waste from landfill use (Figure 3.8).

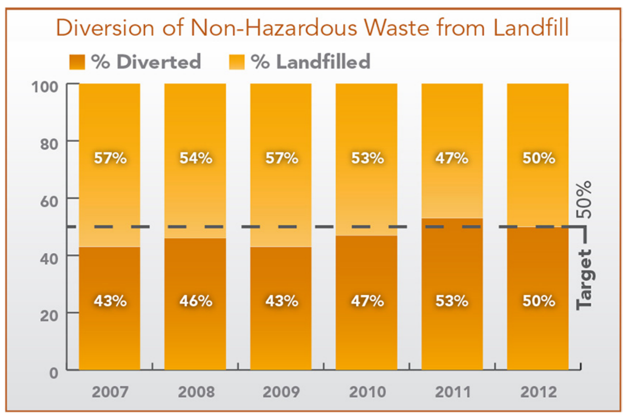

Figure 3.8. Diversion of Non-Hazardous Waste from Landfills, 2007–2012

Data Center Consolidation: By consolidating four server rooms and relocating one data center, PNNL produced significant energy savings and re-purposed the vacated space for additional research activities.

Ozone-Depleting Substances: Executive Order 13423 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. Over the last 10 years, PNNL Class I ozone-depleting substance usage has decreased approximately 30 percent (see Section 5.2).

Table 3.1 summarizes each DOE-SC goal, accompanied by PNNL's performance status, planned actions, and an assessment of the risk of non-attainment.

Table 3.1. U.S. Department of Energy, Office of Science Goals with PNNL's Performance Status and Planned Actions, FY 2012

DOE-SC/ SSPP/ OMB Goal	DOE Goal	Fiscal Year Performance Status	Planned Actions and Contribution	Risk of Non-Attainment
Goal #1 – Greenhouse Gas Reduction and Comprehensive Greenhouse Gas Inventory				
1.1	Energy intensity reduction of 30% by fiscal year (FY) 2015 from 2003 baseline	2003 Baseline: 197,817 Btu/ft^2 2012 Actual: 164,078 Btu/ft^2 2015 Goal: 138,472 Btu/ft^2 Status: 17.1% reduction	Continue implementing Consolidated Energy Data Report projects and operational improvements.	Medium
1.2	7.5% of annual electricity consumption from renewable sources by FY 2013 and thereafter (5% 2010–2012)	2012: 72% of annual electric consumption from onsite generation and renewable energy certificate purchases	Continue operating the 125 kW onsite photovoltaic array and purchasing renewable energy certificates.	Low
1.3	Sulfur hexafluoride (SF_6) reduction	2008 Usage: 207 lb 2012 Usage: 121 lb Status: 42% Reduction	Complete documentation of alternate tracer gases and implement where feasible.	Low
1.4	Metering individual buildings for 90% of electricity (by October 1, 2012); and for 90% of steam, natural gas, and chilled water (by October 1, 2015)	2012: 100% metering of electricity, 100% metering of natural gas	Improve building performance through data analysis from the meters.	Low
1.5	Unless uneconomical, install cool roofs for replacements unless project already has Critical Decision-2 approval; new roofs must have thermal resistance of at least R-30	2012: 61% of Pacific Northwest National Laboratory (PNNL) roof area per Facilities Information Management System are cool roofs	Unless uneconomical, all new roofs will have a thermal resistance of at least R-30 and be solar reflective, consistent with Secretary Chu's DOE requirements.	Low
1.6	Training	PNNL has Certified Energy Managers and a Data Center Energy Practitioner	Continue developing staff skills by providing energy and water training opportunities.	Low
1.7	Net zero energy in new or major renovation facilities	Institutionalizing this long-term goal into our Engineering Standards and Specifications	Leverage new technologies as available to trend toward net zero goal.	Low
1.8	Evaluate 25% of 75% of facility energy use over 4-year cycle	Completed first 4-year Energy Independence and Security Act of 2007 (EISA) cycle of 8 buildings	Execute next cycle of EISA evaluations.	Low
1.9	13% Scope 3 greenhouse gas (GHG) reduction by FY 2020 from a 2008 baseline	2008 Baseline: 23,747 Metric Ton Carbon Dioxide Equivalent ($MTCO_2e$) 2012 Actual: 26,495 $MTCO_2e$ 2020 Goal: 20,660 $MTCO_2e$ Status: 11.6% Increase	Continue promoting telework; install high-end video capabilities in strategic locations to reduce travel; encourage staff bus and carpool promotions and incentives.	Medium

Table 3.1. (contd)

DOE-SC/ SSPP/ OMB Goal	DOE Goal	Fiscal Year Performance Status	Planned Actions and Contribution	Risk of Non-Attainment
1.10	28% Scope 1 & 2 GHG reduction by FY 2020 from a 2008 baseline	2008 Baseline: 36,075 $MTCO_2e$ 2012 Actual: 37,900 $MTCO_2e$ (0 $MTCO_2e$ adjusted for renewable energy certificates) 2020 Goal: 25,974 $MTCO_2e$ Status: Goal achieved (including renewable energy certificates)	Continue renewable energy certificate purchases for near-term GHG reduction goal: implement comprehensive energy conservation plan, including core business hours and aggressive real-time commissioning for future strategy.	Low
	Goal #2 – Buildings, Energy Savings Performance Contract Initiative, Regional and Local Planning			
2.1.a	15% of existing buildings greater than 5,000 ft^2 are compliant with High Performance Sustainable Building (HPSB) Guiding Principles by 2015	25% of PNNL buildings greater than 5,000 ft^2 per Facilities Information Management System are HPSB compliant	Continue trending toward 100% of facilities meeting HPSB.	Low
2.1.b	All new construction, major renovations, and building alterations greater than 5,000 ft^2 must comply with Guiding Principles	Institutionalized Guiding Principles in PNNL Engineering Standards	Achieve Guiding Principles for all new construction greater than 5,000 ft^2.	Low
2.2	Energy Savings Performance Contract (ESPC) Initiative	PNNL has no prospective ESPC or Utility Energy Savings Contract (UESC) projects at this time	Continue reviewing projects to determine viability of this funding mechanism.	Low
2.3	Regional & Local Planning	DOE and City of Richland agreement for long-term Hanford Area utility strategy	Execute utility strategy.	Low
		Goal #3 – Fleet Management		
3.1	10% annual increase in fleet alternative fuel consumption by FY 2015 relative to 2005 baseline	2006 Baseline: 456 gal of gasoline equivalent (Note: 2005 usage not measured) 2012 Actual: 11,238 gal 2020 Goal: 1,183 gal Status: Exceeded Goal	Actively manage alternate fuel use through fleet oversight and staff training; increase percentage of alternative fuel vehicles when available.	Low
3.2	2% annual reduction in fleet petroleum consumption by FY 2020 relative to 2005 baseline	2005 Baseline: 37,926 gal 2012 Actual: 36,575 gal 2020 Goal: 28,011 gal Status: 3.6% Decrease	Continue assessing fleet and right-sizing, along with executing Goal 3.4	Low
3.3	75% of light-duty vehicle purchases must consist of alternative fuel vehicles (AFVs) by 2000 and thereafter	Of total 50 light-duty vehicles in the PNNL fleet, 37 (74%) are AFVs; added 5 E85 AFVs in 2012	Continue working with fleet vendors to replace vehicles with AFV types where available	Low
3.4	Submit *Right-Sizing the Fleet Management Plan* for approval by December 31, 2012. Identify mission critical/non-mission-critical vehicles by December 31, 2012	Drafting requested plan	Execute results of plan	Low

Table 3.1. (contd)

DOE-SC/ SSPP/ OMB Goal	DOE Goal	Fiscal Year Performance Status	Planned Actions and Contribution	Risk of Non-Attainment
Goal #4 – Water-Use Efficiency and Management				
4.1	26% water intensity reduction by FY 2020 from a 2007 baseline	2007 Baseline: 66.88 gal/ft^2 2012 Actual: 29.02 gal/ft^2 2020 Goal: 49.49 gal/ft^2 Status: Exceeded Goal	Continue implementing potable water projects to reduce overall use as feasible.	Low
4.2	20% water consumption reduction of industrial, landscaping, and agricultural water by FY 2020 from 2010 baseline	2010 Baseline: 97,522,000 gal 2012 Actual: 113,593,000 gal 2020 Goal: 78,017,600 gal Status: 16.4% Increase	Continue implementing Landscaping Plan with focus on reducing industrial, landscaping, and agricultural water where possible.	Medium
Goal #5 – Pollution Prevention and Waste Reduction				
5.1	Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris, by 2015	2012: Diverted 50% of non-hazardous solid waste	Continue conducting assessments for waste reducing opportunities.	Low
5.2	Divert at least 50% of construction and demolition materials and debris by FY 2015	2012: Diverted 98% of construction and demolition waste	Continue monitoring construction and demolition recycling performance and raising awareness on waste diversion requirements.	Low
Goal #6 – Sustainable Acquisition				
6.1	Procurements meet sustainability requirements and include sustainable acquisition clause (95% each year)	100% of acquisitions have sustainability requirements and clauses	Continue proactivity with sustainable item procurement.	Low
Goal #7 – Electronic Stewardship and Data Centers				
7.1	All data centers are metered to measure a monthly power utilization effectiveness (PUE; 100% by 2015)	Two of PNNL's three data centers are metered	Complete data center metering before 2015.	Low
7.2	Maximum annual weighted average PUE of 1.4 by 2015	One of PNNL's three data centers is below 1.4 PUE	Implement projects to trend toward goal.	Medium
7.3	Electronic Stewardship: 100% of eligible PCs, laptops, and monitors with power management actively implemented and in use by 2012	100% of eligible equipment is complete	Assure new equipment has power management features.	Low
Goal #8 – Agency Innovation and Government-Wide Support				
8.1	Deployment of research and development (R&D) technologies and support of other governmental agencies	PNNL has piloted multiple R&D technologies and hosted DOE and other national laboratories to showcase our sustainable practices	Continue researcher collaboration to showcase new R&D, plus bench-marking and assisting other agencies in meeting goals.	Low

DOE = U.S. Department of Energy.
DOE-SC = DOE Office of Science.
OMB = Office Management and Budget.
SSPP = Strategic Sustainability Performance Plan.

3.2 Awards and Recognition

In 2012, DOE awarded PNNL a Sustainability Award for efforts toward achieving sustainable operations in the area of fleet management. In all, 18 commercial petroleum vehicles (15 percent) were eliminated from the fleet, and 25 more are slated to be retired by FY 2013-end. By right-sizing the fleet, PNNL reduced its consumption of petroleum-based fuel use more than 20 percent (from its peak in 2008). Currently, 39 of the 54 light-duty vehicles in PNNL's fleet (72 percent) are alternative fuel vehicles. During FY 2011, six alternative fuel vehicles and one hybrid were added. In addition to the sustainability award, PNNL was selected "Best in Class" for the following nominations ("Best In Class" status is prerequisite to competing for the sustainability award): "Decision Tool: Making Informed Sustainability and Economical Decisions" and "Building 331 Landscape Reduction and Parking Lot Improvements."

4.0 Radiological Environmental Monitoring and Dose Assessment

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

4.1 Liquid Radiological Discharges and Doses

TW Moon

Wastewater is discharged from laboratories using radiological materials in the Physical Sciences Facility 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 are above the screening criteria, the wastewater is transported to a waste treatment facility. Wastewater containing radiological materials from all other PNNL Campus and MSL facilities is prohibited from discharge to the receiving sewer or wastewater treatment systems. 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

BG Fritz

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. 2013a, b). Data are summarized in the following sections.

4.2.1 Radiological Discharges and Doses from Air – PNNL Campus

The regulatory standard for a maximum dose to any member of the public is 10 mrem/yr (0.1 mSv/yr) EDE, which applies to radionuclide air emissions, other than radon, from DOE facilities (40 CFR 61, Subpart H). For CY 2012, the PNNL Campus MEI location was 0.55 km (0.34 mi) south-southeast of the Physical Sciences Facility (Snyder et al. 2013a). The dose to the PNNL Campus MEI from routine and nonroutine point-source emissions was 9.2×10^{-6} mrem (9.2×10^{-8} mSv) EDE. The relative contributions of each nuclide to the MEI dose are primarily attributed to gross alpha and gross beta activity (Table 4.1).

For PNNL Campus radionuclide air emissions, Washington State (WAC 246-247-040(1)) has adopted the federal dose standard of 10 mrem/yr (0.1 mSv/yr) EDE found in 40 CFR 61, Subpart H. In addition to the maximum dose attributable to radionuclides emitted from point sources, WAC 246-247-040(6) requires that the dose to the MEI also include doses attributable to fugitive emissions, radon, and nonroutine events. Dose due to routine major and minor point-source emissions is 9.0×10^{-6} mrem (9.0×10^{-8} mSv) EDE. Dose from unmonitored PNNL-licensed sources was 1.0×10^{-7} mrem (1.0×10^{-9} mSv) EDE and dose from radon was 2.0×10^{-6} mrem (2.0×10^{-8} mSv) EDE during 2012. The combined total dose of 1.1×10^{-5} mrem (1.1×10^{-7} mSv) EDE is more than 100,000 times lower than the 10 mrem/yr (0.1 mSv/yr) WAC 246-247 (2011) limit.

Table 4.1. Pacific Northwest National Laboratory Radionuclide and Dose Contributions by Radionuclide, 2012 (Snyder et al. 2013a)

Radionuclide[a]	Releases (Ci)	Dose to MEI (mrem EDE)	Percent of Total EDE
Hydrogen-3 (tritium)	3.1E-06	9.1E-10	<1
Sodium-24[b]	1.3E-08	2.0E-10	<1
Cobalt-60	2.1E-08	1.2E-08	<1
Bromine-82[b]	1.3E-08	3.1E-10	<1
Strontium-89[b]	1.1E-09	4.9E-10	<1
Strontium-90[c]	7.8E-07	2.2E-06	**24**
Yttrium-88[b]	3.8E-10	3.5E-10	<1
Cadmium-109[b]	1.2E-09	9.5E-10	<1
Xenon-133[b]	9.1E-09	5.0E-14	<1
Iodine-129[b]	1.0E-12	2.1E-10	<1
Iodine-131[b]	2.2E-10	2.5E-10	<1
Iodine-132[b]	2.3E-09	5.7E-12	<1
Cesium-137[c]	6.8E-08	9.6E-08	**1**
Barium-140[b]	2.1E-09	4.3E-10	<1
Lead-210[b]	5.4E-10	1.7E-08	<1
Radium-226[b,d]	1.2E-09	5.0E-08	**1**
Thorium-229[b]	9.3E-13	4.5E-10	<1
Thorium-232[b]	1.0E-12	1.7E-10	<1
Uranium-233/234	2.5E-10[e]	4.1E-09	<1
Neptunium-236[b]	9.0E-12	2.0E-10	<1
Neptunium-237[b]	1.0E-12	1.6E-10	<1
Plutonium-238	1.4E-10	7.9E-09	<1
Plutonium-239/240[f]	3.5E-09	3.8E-06	**41**
Plutonium-242[b]	1.0E-12	3.2E-10	<1
Plutonium-244[b]	1.0E-11	3.4E-09	<1
Americium-241[g]	2.7E-10	3.8E-08	<1
Americium-243	6.3E-08	3.0E-06	**32**
Curium-244	8.8E-11	3.1E-09	<1
Σ minor sources[h]	2.1E-08	1.2E-09	<1
Total	**4.1E-06**	**9.2E-06**	**100**[i]

To convert Ci to GBq, multiply Ci by 37.
To convert from mrem to µSv, multiply mrem by 10.
(a) The half-life for each radionuclide can be found in Appendix A, Table A.7.
(b) The release is based on 40 CFR 61, Appendix D, or release records.
(c) Gross beta from Physical Sciences Facility building monitoring is assumed to be strontium-90. Gross beta from RTL-520 monitoring is assumed to be cesium-137. Also, calculated cesium-137 release based on 40 CFR 61, Appendix D and Life Sciences Laboratory II gross beta.
(d) Dose includes progeny isotope radon-222.
(e) Emissions are estimated to be equal to 4×10^{-8} g, assuming emissions are comprised entirely of uranium-234.
(f) Gross alpha activity from Physical Sciences Facility building monitoring and RTL-520 monitoring is assumed to be plutonium-239. Also includes plutonium-239 and plutonium-240 calculated based on 40 CFR 61, Appendix D.
(g) Gross alpha activity from Life Sciences Laboratory II is assigned as americium-241.
(h) Non-significant Pacific Northwest National Laboratory Campus radionuclide emissions from minor emission units and fugitive sources (Snyder et al. 2013a).
(i) Tabulated nuclide-specific values do not add to 100% due to rounding.
CFR = *Code of Federal Regulations*.
EDE = Effective dose equivalent.
MEI = Maximum exposed individual.

The estimated regional population radiation dose (i.e., the collective EDE) from PNNL Campus air emissions in 2012 was calculated using a simplified method that overestimates the population dose. The population consists of approximately 432,000 people residing within an 80-km (50-mi) radius of the Hanford Site 300 Area (Hamilton and Snyder 2011). The close proximity of the Hanford Site 300 Area and rural region within 80 km (50 mi) of the PNNL Campus permits the 300 Area 80-km (50-mi) population estimate to be applicable. Pathways evaluated for population exposure include inhalation, air submersion, ground-shine, and food consumption.

Population exposure to radionuclide air emissions was determined using the MEI dose estimate (9.2×10^{-6} mrem [9.2×10^{-8} mSv]) times the 80-km (50-mi) population (432,117). The 2012 total population dose from radionuclide air emissions estimated in this very conservative manner from nuclides that originate from the PNNL Campus was 4.0×10^{-3} person-rem (4.0×10^{-5} person-Sv) (Snyder et al. 2013a). This represents a decrease when compared to the 2011 estimate of 7.3×10^{-3} person-rem (7.3×10^{-5} person-Sv) and 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 2012d).

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

The PNNL MSL in Sequim transitioned in October 2012 from private operation under Battelle to an exclusive-use contract with PNSO. The operations, which remain unchanged, were regulated previously as a private facility rather than as a DOE radiological air emissions facility.

MSL has two nonpoint source minor emission units associated with the MSL-1 and MSL-5 facilities (see Figure 1.3) that are registered with the state of Washington under Radioactive Air Emissions License (RAEL)–014. These emission units are unchanged from when the site was licensed as a private facility. Radioactive air emissions continue to be well below the criterion for classification as a minor emission unit (i.e., the potential-to-emit [PTE] contribution is less than 0.1 mrem/yr [0.001 mSv/yr] EDE to the MEI).

The MSL-1 and MSL-5 facilities have several locations where radioactive air emissions may originate and exit the building; however, the emission units are characterized as nonpoint sources (WAC 246-247). The associated PTE registrations indicate emissions are primarily particulates with building PTE contributions of less than 5×10^{-4} mrem/yr (5×10^{-6} mSv/yr) EDE. Radiological operations at MSL facilities emit very low levels of radioactive materials (Snyder et al. 2013b). Radioactive material emissions for 2012 were on the order of a few nanocuries (Table 4.2). The 40 CFR 61, Appendix D, method of determining unabated emissions was used.

Table 4.2. 2012 PNNL Marine Sciences Laboratory Inventory and Emissions Estimates (Snyder et al. 2013b)

Nuclide[a]	Emission Type	Site Inventory (Ci)	MSL-1 Release[b] (Ci)	MSL-5 Release[b] (Ci)
Hydrogen-3 (tritium)	Beta/gamma	1.37×10^{-6}	–	1.37×10^{-9}
Carbon-14	Beta/gamma	6.41×10^{-7}	–	6.41×10^{-10}
Potassium-40	Beta/gamma	4.78×10^{-9}	–	4.78×10^{-12}
Iron-55	Beta/gamma	3.45×10^{-11}	–	3.45×10^{-14}
Cobalt-57	Beta/gamma	9.46×10^{-12}	–	9.46×10^{-15}
Cobalt-60	Beta/gamma	1.75×10^{-11}	–	1.75×10^{-14}
Strontium-90	Beta/gamma	8.32×10^{-4}	–	8.32×10^{-13}
Technetium-99	Beta/gamma	1.70×10^{-7}	–	1.70×10^{-13}
Ruthenium-106	Beta/gamma	4.05×10^{-10}	–	4.05×10^{-13}
Antimony-125	Beta/gamma	5.32×10^{-10}	–	5.32×10^{-13}
Iodine-129	Beta/gamma	1.15×10^{-14}	–	1.15×10^{-17}
Cesium-134	Beta/gamma	3.14×10^{-9}	–	3.14×10^{-12}
Cesium-137	Beta/gamma	1.35×10^{-6}	–	3.72×10^{-11}
Europium-152	Beta/gamma	6.18×10^{-11}	–	6.18×10^{-14}
Europium-154	Beta/gamma	1.68×10^{-11}	–	1.68×10^{-14}
Europium-155	Beta/gamma	1.77×10^{-11}	–	1.77×10^{-14}
Lead-210	Alpha	1.28×10^{-10}	–	1.28×10^{-13}
Polonium-208	Alpha	6.96×10^{-7}	–	6.96×10^{-10}
Radium-226	Alpha	2.98×10^{-10}	–	2.98×10^{-13}
Radium-228	Alpha	4.96×10^{-11}	–	4.96×10^{-14}
Thorium-228	Alpha	2.60×10^{-10}	–	2.60×10^{-13}
Thorium-230	Alpha	1.53×10^{-7}	–	1.53×10^{-13}
Thorium-232	Alpha	2.56×10^{-10}	–	2.56×10^{-13}
Uranium-234[c]	Alpha	1.20×10^{-9}	8.33×10^{-13}	3.71×10^{-13}
Uranium-235[d]	Alpha	5.58×10^{-11}	3.81×10^{-14}	1.77×10^{-14}
Uranium-238[e]	Alpha	1.18×10^{-9}	8.28×10^{-13}	3.52×10^{-13}
Plutonium-238	Alpha	8.16×10^{-11}	–	8.16×10^{-14}
Plutonium-239	Alpha	7.48×10^{-9}	–	3.75×10^{-13}
Plutonium-240	Alpha	3.75×10^{-10}	–	3.75×10^{-13}
Americium-241	Alpha	4.34×10^{-10}	–	4.34×10^{-13}
		Total beta/gamma	**0.00×10^{0}**	**2.06×10^{-9}**
		Total alpha	**1.70×10^{-12}**	**6.99×10^{-10}**

To convert Ci to GBq, multiply Ci by 37.
To convert from mrem to µSv, multiply mrem by 10.
(a) The half-life for each radionuclide can be found in Appendix A, Table A.7.
(b) Emissions estimated using 40 CFR 61, Appendix D methods.
(c) To convert uranium-234 inventory or releases to units of grams, divide Ci by 9.5×10^{-3}.
(d) To convert uranium-235 inventory or releases to units of grams, divide Ci by 2.1×10^{-6}.
(e) To convert uranium-238 inventory or releases to units of grams, divide Ci by 3.3×10^{-7}.
MSL = PNNL Marine Sciences Laboratory.

The COMPLY code Version 1.6 (Level 4) was used for estimating dose for comparison to the EPA standard of 10 mrem/yr (0.1 mSv/yr) EDE to any member of the public (40 CFR 61, Subpart H, and WAC 246-247). This code is approved for use for compliance determination (40 CFR 61, Appendix E). The dose standard in 40 CFR 61, Subpart H, applies to radionuclide air emissions other than radon from DOE facilities. Dose is estimated as the product of the emission rate (Ci/yr [37 GBq/yr]) and unit dose factor (mrem/yr [mSv/yr] EDE at the MEI location per Ci/yr [37 GBq/yr] released). 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.

For CY 2012, the MSL MEI location was determined to be 0.19 km (0.12 mi) from the emission point (Snyder et al. 2013b). The dose to the MSL MEI from routine and nonroutine point-source emissions was 9.2×10^{-6} mrem (9.2×10^{-8} mSv) EDE. In 2011, the MEI estimate was 1.2×10^{-9} mrem (1.2×10^{-11} mSv) EDE. Although both the 2012 and 2011 dose estimates are far below the dose standard, the primary reason for the increase in the 2012 dose estimate is that no credit was taken for high-efficiency particulate air filtration in the 2012 emissions estimates, in accordance with requirements of the new DOE-SC radioactive air emissions license (RAEL-014).

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 to 80 km (30 to 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 population 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 population dose of 1.2×10^{-3} person-rem (1.2×10^{-5} person-Sv). Applying this same method to the Victoria metropolitan area would result in an additional 3.3×10^{-3} person-rem (3.3×10^{-5} person–Sv). These extremely overestimated doses are one percent or less of the average annual individual background dose from natural terrestrial and cosmic radiation and inhalation of naturally occurring radon.

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

GA Stoetzel

Principal requirements for the release of DOE property having residual radioactivity are in DOE Order 458.1, Chg 3, "Radiation Protection of the Public and the Environment." These requirements are designed to ensure 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 2012.

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 2012.

Table 4.3. Pre-Approved Surface Activity Guideline Limits

	Allowable Total Residual Surface Contamination Limits (dpm/100 cm^2)		
		Total	
Radionuclides	**Removable**	**Average**	**Maximum**
U-natural, uranium-235, uranium-238, and associated decay products	1,000	5,000	15,000
Transuranic elements, 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
Tritium organic compounds; surfaces contaminated with tritium gas, tritiated water vapor, and metal tritide aerosols	10,000	Not applicable	Not applicable

dpm = disintegrations per minute.

4.3.2 Property Potentially Contaminated in Volume

PNNL uses pre-approved volumetric release limits when releasing small volume research samples and wastewaters 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 2001, 2007). During CY 2012, PNNL released hundreds of liquid research samples with a total volume on the order of 1200 L (317 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

JM Barnett

DOE Order 458.1 (Chg 2) indicates that DOE sites establish procedures and practices to protect biota. PNNL has adopted dose rate limits of 10 mGy/d (1 rad/d) for aquatic animals and terrestrial plants and 1 mGy/d (0.1 rad/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 (see Figure 1.2) 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 (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 Life Sciences Laboratory II and RTL facilities to the PNNL Site (collectively referred to as the PNNL Campus) 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 distant from the PNNL Campus is not conducted.

Routine operations were conducted on the PNNL Campus during CY 2012—there were no unplanned radiological emissions. The resultant external dose rates were less than 7×10^{-4} mGy/d (7×10^{-5} rad/d) for aquatic animals and terrestrial plants and less than 6×10^{-3} mGy/d (6×10^{-4} rad/d) for 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 radionuclide emissions for CY 2012; an assumption that all of the 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.); and the screening-level dose coefficients found in DOE-STD-1153-2002 (DOE 2002; NRC 2006; Snyder et al. 2013a). 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 2012

Nuclide[a,b]	Particulate Emissions[b] (Bq/yr)	Screening Level for 1 rad/d Dose Rate[c] (Gy/yr per Bq/m^3)	Screening Level for 0.1 rad/d Dose Rate[c] (Gy/yr per Bq/kg)	Radionuclide Concentration in 1 m^3 Water[d] (Bq/m^3)	Radionuclide Concentration in 1 m^2 Soil[e] (Bq/kg)	Dose Rate for Aquatic Animals and Terrestrial Plants (mGy/d)	Dose Rate for Riparian and Terrestrial Animals (mGy/d)
Gross α[f,g]	2.3×10^{3}	6.8×10^{-9}	1.4×10^{-5}	2.3×10^{3}	1.0×10^{1}	4.3×10^{-5}	4.0×10^{-4}
Gross β[f,h]	3.1×10^{4}	6.6×10^{-9}	1.3×10^{-5}	3.1×10^{4}	1.4×10^{2}	5.7×10^{-4}	5.0×10^{-3}
Hydrogen-3 (tritium)	1.1×10^{5}	1.4×10^{-11}	2.9×10^{-8}	1.1×10^{5}	5.1×10^{2}	4.4×10^{-6}	4.1×10^{-5}
Sodium-24[h]	4.8×10^{2}	6.6×10^{-9}	1.3×10^{-5}	4.8×10^{2}	2.1×10^{0}	8.7×10^{-6}	7.6×10^{-5}
Cobalt-60	7.8×10^{2}	6.6×10^{-9}	1.3×10^{-5}	7.8×10^{2}	3.5×10^{0}	1.4×10^{-5}	1.2×10^{-4}
Bromine-82[h]	4.8×10^{2}	6.6×10^{-9}	1.3×10^{-5}	4.8×10^{2}	2.1×10^{0}	8.7×10^{-6}	7.6×10^{-5}
Strontium-89[h]	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}
Yttrium-88[h]	1.4×10^{1}	6.6×10^{-9}	1.3×10^{-5}	1.4×10^{1}	6.3×10^{-2}	2.5×10^{-7}	2.2×10^{-6}
Cadmium-109[h]	4.4×10^{1}	6.6×10^{-9}	1.3×10^{-5}	4.4×10^{1}	2.0×10^{-1}	8.0×10^{-7}	7.1×10^{-6}
Xenon-133[h]	3.4×10^{2}	6.6×10^{-9}	1.3×10^{-5}	3.4×10^{2}	1.5×10^{0}	6.1×10^{-6}	5.4×10^{-5}
Iodine-129	3.7×10^{-2}	2.0×10^{-10}	4.0×10^{-7}	3.7×10^{-2}	1.7×10^{-4}	2.0×10^{-11}	1.8×10^{-10}
Iodine-131	8.1×10^{0}	1.4×10^{-9}	2.9×10^{-6}	8.1×10^{0}	3.6×10^{-2}	3.1×10^{-8}	2.9×10^{-7}
Iodine-132[h]	8.5×10^{1}	6.6×10^{-9}	1.3×10^{-5}	8.5×10^{1}	3.8×10^{-1}	1.5×10^{-6}	1.4×10^{-5}
Cesium-137	6.7×10^{0}	2.0×10^{-9}	4.0×10^{-6}	6.7×10^{0}	3.0×10^{-2}	3.6×10^{-8}	3.3×10^{-7}
Barium-140[h]	7.8×10^{1}	6.6×10^{-9}	1.3×10^{-5}	7.8×10^{1}	3.5×10^{-1}	1.4×10^{-6}	1.2×10^{-5}
Lead-210	2.0×10^{1}	1.1×10^{-9}	2.2×10^{-6}	2.0×10^{1}	8.9×10^{-2}	6.0×10^{-8}	5.4×10^{-7}
Radium-226	4.4×10^{1}	6.8×10^{-9}	1.4×10^{-5}	4.4×10^{1}	2.0×10^{-1}	8.3×10^{-7}	7.6×10^{-6}
Thorium-229	3.4×10^{-2}	3.1×10^{-9}	6.2×10^{-6}	3.4×10^{-2}	1.5×10^{-4}	2.9×10^{-10}	2.6×10^{-9}
Thorium-232	3.7×10^{-2}	3.0×10^{-11}	6.1×10^{-8}	3.7×10^{-2}	1.7×10^{-4}	3.0×10^{-12}	2.8×10^{-11}

Table 4.5. (contd)

Nuclide[a,b]	Particulate Emissions[b] (Bq/y)	Screening Level for 1 rad/d Dose Rate[c] (Gy/yr per Bq/m^3)	Screening Level for 0.1 rad/d Dose Rate[c] (Gy/yr per Bq/kg)	Radionuclide Concentration in 1 m^3 Water[d] (Bq/m^3)	Radionuclide Concentration in 1 m^2 Soil[e] (Bq/kg)	Dose Rate for Aquatic Animals and Terrestrial Plants (mGy/d)	Dose Rate for Riparian and Terrestrial Animals (mGy/d)
Uranium-233/234	9.3×10^{0}	3.2×10^{-11}	6.5×10^{-8}	9.3×10^{0}	4.1×10^{-2}	8.1×10^{-10}	7.4×10^{-9}
Neptunium-236[h]	3.3×10^{-1}	6.6×10^{-9}	1.3×10^{-5}	3.3×10^{-1}	1.5×10^{-3}	6.0×10^{-9}	5.3×10^{-8}
Neptunium-237	3.7×10^{-2}	1.3×10^{-9}	2.5×10^{-6}	3.7×10^{-2}	1.7×10^{-4}	1.3×10^{-10}	1.1×10^{-9}
Plutonium-238	5.2×10^{0}	2.5×10^{-11}	5.0×10^{-8}	5.2×10^{0}	2.3×10^{-2}	3.5×10^{-10}	3.2×10^{-9}
Plutonium-239/240	1.3×10^{2}	2.5×10^{-11}	4.9×10^{-8}	1.3×10^{2}	5.8×10^{-1}	8.9×10^{-9}	7.8×10^{-8}
Plutonium-242[g]	3.7×10^{-2}	6.8×10^{-9}	1.4×10^{-5}	3.7×10^{-2}	1.7×10^{-4}	6.9×10^{-10}	6.3×10^{-9}
Plutonium-244[g]	3.7×10^{-1}	6.8×10^{-9}	1.4×10^{-5}	3.7×10^{-1}	1.7×10^{-3}	6.9×10^{-9}	6.3×10^{-8}
Americium-241	1.0×10^{1}	1.4×10^{-10}	2.9×10^{-7}	1.0×10^{1}	4.5×10^{-2}	3.8×10^{-9}	3.5×10^{-8}
Americium-243	2.3×10^{3}	1.3×10^{-9}	2.5×10^{-6}	2.3×10^{3}	1.0×10^{1}	8.3×10^{-6}	7.1×10^{-5}
Curium-244	3.3×10^{0}	2.0×10^{-11}	4.0×10^{-8}	3.3×10^{0}	1.5×10^{-2}	1.8×10^{-10}	1.6×10^{-9}
					Totals	$\mathbf{6.7 \times 10^{-4}}$	$\mathbf{5.9 \times 10^{-3}}$

(a) The half-life for each radionuclide can be found in Appendix A, Table A.7.
(b) Data from Snyder et al. (2013a).
(c) Data from DOE (2002).
(d) Conservative dose rate assumed to be from 1 m^3 (35 ft^3) of contaminated water.
(e) Conservative dose rate 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.) (NRC 2006).
(f) Maximum of the bi-weekly or semi-annual average measurement (Snyder et al. 2013a).
(g) Radium-226 dose rate factor used as conservative alpha surrogate.
(h) Cobalt-60 dose rate factor used as conservative beta surrogate.

4.4.2 Radiation Protection of Biota – PNNL Marine Sciences Laboratory

Environmental media pathways were evaluated during the development of MSL 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 no environmental monitoring would be required due to the low probability of potential air emissions and the absence of radiological emissions via liquid pathways or directly to land areas. 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 2012—there were no unplanned radiological emissions. The external dose rates for operations in CY 2012 were less than 2×10^{-6} mGy/d (2×10^{-7} rad/d) for aquatic animals and terrestrial plants and less than 2×10^{-5} mGy/d (2×10^{-6} rad/d) for riparian and terrestrial animals (Table 4.6). These conservative dose rates are well below MSL dose rate limits and are based on the reported total gross alpha and total gross beta radionuclide emissions for CY 2012; an assumption that all of the 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.); and the screening-level dose coefficients found in DOE-STD-1153-2002 (DOE 2002; NRC 2006; Snyder et al. 2013b). The resulting water and soil concentrations are very conservative and used for basic screening and simplicity of calculation for comparison to the adopted biota dose rate limits.

4.5 Unplanned Radiological Releases

No radiological releases to the environment exceeded permitted limits at the PNNL Campus or MSL in 2012.

4.6 Environmental Radiological Monitoring – PNNL Campus

BG Fritz

A particulate air-sampling 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 surveillance was conducted in 2011. The air surveillance monitoring locations were reevaluated in 2012 (Barnett et al. 2012a) based on two factors: the expanded footprint of DOE-permitted radiological operations locations (i.e., the addition of Life Sciences Laboratory II and RTL facilities) and the re-location of the PNL-1 and PNL-2 monitoring stations to their permanent locations. The initial locations of PNL-1 and PNL-2 were sufficient, but not ideal, because siting was partially driven by access to electrical infrastructure. Solar panels are used to operate the permanent equipment at the PNL-1 and PNL-2 locations.

Table 4.6. Screening-Level Dose Rates for the PNNL Marine Sciences Laboratory, Calendar Year 2012

Nuclide[a,b]	Particulate Emissions[b] (Bq/yr)	Screening Level for 1 rad/d Dose Rate[c] (Gy/yr per Bq/m^3)	Screening Level for 0.1 rad/d Dose Rate[c] (Gy/yr per Bq/kg)	Radionuclide Concentration in 1 m^3 Water[d] (Bq/m^3)	Radionuclide Concentration in 1 m^2 Soil[e] (Bq/kg)	Dose Rate for Aquatic Animals and Terrestrial Plants (mGy/d)	Dose Rate for Riparian and Terrestrial Animals (mGy/d)
gross α[f]	2.6×10^{1}	6.8×10^{-9}	1.4×10^{-5}	2.6×10^{1}	1.2×10^{-1}	4.8×10^{-7}	4.4×10^{-6}
gross β[g]	7.6×10^{1}	6.6×10^{-9}	1.3×10^{-5}	7.6×10^{1}	3.4×10^{-1}	1.4×10^{-6}	1.2×10^{-5}
					Totals	$\mathbf{1.9 \times 10^{-6}}$	$\mathbf{1.7 \times 10^{-5}}$

(a) The half-life for each radionuclide can be found in Appendix A, Table A.7.
(b) Data from Snyder et al. (2013b).
(c) Data from DOE (2002).
(d) Conservative dose rate assumed to be from 1 m^3 (35 ft^3) of contaminated water.
(e) Conservative dose rate 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.) (NRC 2006).
(f) Radium-226 dose rate factor used as conservative total gross alpha surrogate.
(g) Cobalt-60 dose rate factor used as conservative total gross beta surrogate.

Figure 4.1. Air-Sampling Stations for the PNNL Campus (Snyder et al. 2013a)

During the first six months of 2012, environmental radiological air surveillance continued to be performed at the three original sampling stations: PNL-1, PNL-2, and PNL-3. In June 2012, two original air-monitoring stations, PNL-1 and PNL-2, were discontinued and removed. Simultaneously, two new solar-powered air-monitoring stations were established on the PNNL Campus at the preferred locations. The solar-powered stations were positioned to cover the same area as the discontinued stations and continue to be called PNL-1 and PNL-2. At the same time, a fourth air-sampling station, PNL-4, was added to the sampling network, southwest of the Battelle baseball field. PNL-4 provides ambient monitoring for the southern extent of the PNNL Campus (Barnett et al. 2012a) and only represents the second half of 2012, when the RTL facilities were brought under the DOE license. Since the PNL-1 and PNL-2 locations moved mid-year, atmospheric modeling (CAP88-PC Version 3) was used to calculate an adjustment factor to approximate the PNL-1 and PNL-2 particulate air concentrations to model each station's results, as if the air was monitored at the final PNL-1 and PNL-2 positions. The adjustment factors were based on full 2012 meteorology. The adjustment factor for PNL-1 was 2.6 and the adjustment factor for PNL-2 was 1.6. Table 4.7 includes only the PNL-1 and PNL-2 adjusted results.

Table 4.7. Summary of 2012 Air-Sampling Results for PNNL

Nuclide[a]	Location	No. of Samples	No. of Detections	Average ± 2 SD (pCi/m^3)[b]
Gross Alpha	PNL-1	25	24	$1.0 \times 10^{-3} \pm 6.3 \times 10^{-4}$
	PNL-2	25	22	$8.4 \times 10^{-4} \pm 6.3 \times 10^{-4}$
	PNL-3	24	17	$6.3 \times 10^{-4} \pm 6.9 \times 10^{-4}$
	PNL-4	13	13	$6.7 \times 10^{-4} \pm 3.1 \times 10^{-4}$
	Yakima	26	23	$6.2 \times 10^{-4} \pm 8.2 \times 10^{-4}$
Gross Beta	PNL-1	25	25	$2.8 \times 10^{-2} \pm 1.8 \times 10^{-2}$
	PNL-2	25	25	$2.2 \times 10^{-2} \pm 1.5 \times 10^{-2}$
	PNL-3	24	24	$1.6 \times 10^{-2} \pm 1.1 \times 10^{-2}$
	PNL-4	13	13	$1.9 \times 10^{-2} \pm 1.1 \times 10^{-2}$
	Yakima	26	26	$1.4 \times 10^{-2} \pm 1.2 \times 10^{-2}$
Cobalt-60	PNL-1	3	0	$4.7 \times 10^{-4} \pm 4.7 \times 10^{-4}$
	PNL-2	3	0	$1.0 \times 10^{-4} \pm 2.7 \times 10-4$
	PNL-3	3	0	$2.3 \times 10^{-4} \pm 2.2 \times 10^{-4}$
	PNL-4	1[c]	0	$3.9 \times 10^{-4} \pm 3.8 \times 10^{-4}$
	Yakima	4	0	$7.9 \times 10^{-5} \pm 4.6 \times 10^{-4}$
Uranium-233/234[d]	PNL-1	2	2	$8.0 \times 10^{-5} \pm 2.7 \times 10^{-5}$
	PNL-2	2	2	$6.6 \times 10^{-5} \pm 1.7 \times 10^{-5}$
	PNL-3	2	2	$4.1 \times 10^{-5} \pm 1.2 \times 10^{-5}$
	PNL-4	1[c]	1	$4.6 \times 10^{-5} \pm 1.0 \times 10^{-5}$
	Yakima[d]	4[d]	0[d]	$3.8 \times 10^{-5} \pm 6.5 \times 10^{-5}$
Plutonium 238	PNL-1	2	0	$1.7 \times 10^{-6} \pm 4.1 \times 10^{-6}$
	PNL-2	2	0	$-1.8 \times 10^{-8} \pm 2.6 \times 10^{-6}$
	PNL-3	2	0	$4.2 \times 10^{-7} \pm 8.0 \times 10^{-8}$
	PNL-4	1[c]	0	$-5.5 \times 10^{-7} \pm 1.7 \times 10^{-6}$
	Yakima	4	0	$-1.1 \times 10^{-6} \pm 7.0 \times 10^{-6}$

Table 4.7. (contd)

Nuclide[(a)]	Location	No. of Samples	No. of Detections	Average ± 2 SD (pCi/m^3)[(b)]
Plutonium 239/240	PNL-1	2	1	$6.1 \times 10^{-6} \pm 5.1 \times 10^{-6}$
	PNL-2	2	1	$2.5 \times 10^{-6} \pm 3.2 \times 10^{-6}$
	PNL-3	2	1	$3.5 \times 10^{-6} \pm 2.2 \times 10^{-6}$
	PNL-4	1[(c)]	0	$-4.8 \times 10^{-7} \pm 2.3 \times 10^{-6}$
	Yakima	4	0	$3.0 \times 10^{-7} \pm 3.3 \times 10^{-6}$
Americium-241[(e)]	PNL-1	2	0	$1.1 \times 10^{-6} \pm 4.8 \times 10^{-6}$
	PNL-2	2	0	$1.8 \times 10^{-6} \pm 6.9 \times 10^{-6}$
	PNL-3	2	0	$-1.5 \times 10^{-6} \pm 1.4 \times 10^{-5}$
	PNL-4	1[(c)]	0	$1.8 \times 10^{-6} \pm 4.9 \times 10^{-6}$
	Yakima	0	0	NA
Americium-243	PNL-1	2	0	$1.5 \times 10^{-6} \pm 1.2 \times 10^{-5}$
	PNL-2	2	0	$2.4 \times 10^{-6} \pm 5.8 \times 10^{-6}$
	PNL-3	2	0	$-4.0 \times 10^{-6} \pm 1.2 \times 10^{-5}$
	PNL-4	1[(c)]	0	$1.0 \times 10^{-6} \pm 5.4 \times 10^{-6}$
	Yakima	0	0	NA
Curium-243/244	PNL-1	2	0	$-1.0 \times 10^{-6} \pm 6.4 \times 10^{-6}$
	PNL-2	2	0	$-1.4 \times 10^{-6} \pm 5.0 \times 10^{-6}$
	PNL-3	2	0	$-7.9 \times 10^{-7} \pm 2.6 \times 10^{-6}$
	PNL-4	1[(c)]	0	$-1.0 \times 10^{-6} \pm 3.0 \times 10^{-6}$
	Yakima	0	0	NA

(a) The half-life for each radionuclide can be found in Appendix A, Table A.7.
(b) January−June 2012 PNL-1 and PNL-2 ran as 120 V near the Hanford Site 300 Area. Second half of 2012, both stations transitioned to solar (24 V) and moved to permanent locations; the adjustment factor applies to first half of 2012 and was determined by using modeling program CAP88-PC Version 3.
(c) Single result ± total propagated analytical error.
(d) Hanford Site Monitoring Data from the Yakima location reported as uranium-234, not uranium-233/234.
(e) Americium-241 values reported are for the analyses done by the more sensitive alpha spectroscopy method.
NA = Not analyzed.
SD = Standard deviation.
To convert pCi/m^3 to Bq/m^3, multiply pCi by 0.037.

In addition to collecting PNNL Campus emissions, these samplers can collect radioactive particulates released from other nearby sources. During 2012, the Hanford Site 300 Area contributed most of the non-PNNL particulates detected from offsite facilities. 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,[1] 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

[1] Uranium-234 is a naturally occurring radionuclide. It is co-reported with uranium-233 by the analytical laboratory because the emission peaks overlap.

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.

In 2012, 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 analyses, none of the background samples collected detectable amounts of activity, making meaningful comparisons difficult. Only uranium-233/234 and plutonium-239/240 were measured on PNNL network samples at detectable concentrations. However, the non-detectable concentrations at the background site are not an indication that concentrations on the PNNL Campus are higher. By compositing on a bi-annual basis, the PNNL samples have a lower detection limit than the background samples, which are composited quarterly (collected in Yakima by the Hanford Site monitoring program).

4.7 Environmental Radiological Monitoring – PNNL Marine Sciences Laboratory

JP Duncan

Emissions at MSL are very low, the radionuclide inventory is relatively small, and radiological impact estimates are well below regulatory limits, even when highly over-estimating assumptions are applied (Barnett et al. 2012b). The emissions at MSL have historically met requirements for dose limit compliance based on estimates 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 well below the minor emissions unit limit of 0.1 mrem/yr [0.001 mSv/yr; Barnett et al. 2012b]).

A particulate air-sampling network has not been established at MSL.

4.8 Future Radiological Monitoring

BG Fritz

No changes to the radiological monitoring programs are anticipated for 2013.

5.0 Environmental Nonradiological Program Information

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

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 Plan (Ballinger and Beus 2012). 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

TW Moon, EA Raney, and MY Ballinger

The PNNL Campus operates under three industrial wastewater discharge permits that regulate the discharge of process wastewater to the City of Richland sanitary sewer system. Permit #CR-IU005 regulates the wastewater discharges from EMSL, Permit #CR-IU011 regulates wastewater discharges from the Physical Sciences Facility, and Permit #CR-IU001 regulates wastewater discharged from facilities in Richland North. 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 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. WA-0040649. This permit identifies effluent limitations and monitoring requirements for this facility. Monitoring data required by the NPDES permit is given in Table 5.1 for the last 3 months of 2012 corresponding to the time period of PNSO oversight for operations of MSL. 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 for samples taken from October through December of 2012.

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 7.5, conductivity of 161 µS/cm, and total dissolved solids of 78 mg/L).

Table 5.1. PNNL Marine Sciences Laboratory NPDES Monitoring Results for Outfall 008,[(a)] October–December 2012

Parameter	Quantity Found Below Method Reporting Limit	Method Reporting Limit	Maximum Value
Maximum Flow (gpd)	NA	NA	58,500
Bromoform (μg/L)	3	1	<1
Chlorine, Total Residual (μg/L)	3	50	<50
Nitrate as Nitrogen (μg/L)	0	9	426
Antimony (μg/L)	2	10[(b)]	<10
Arsenic (μg/L)	2	5	<5
Beryllium (μg/L)	2	5	<5
Cadmium (μg/L)	2	5	<5
Chromium (μg/L)	2	5	<5
Copper (μg/L)	3	10[(b)]	<10
Lead (μg/L)	3	2[(b)]	<2
Mercury (μg/L)	2	0.2	<0.2
Nickel (μg/L)	2	20	<20
Selenium (μg/L)	2	20[(b)]	<20
Silver (μg/L)	2	10	<10
Thallium (μg/L)	2	5[(b)]	<5
Zinc (μg/L)	3	10[(b)]	<10
pH[(c)]	1	NA	7.8

(a) There were no regulated discharges from Outfall 007 in this time period.
(b) The highest Method Reporting Limit reported for all months is listed.
(c) pH limits of 6–9 standard units were specified in the current permit effective December 1, 2012.
gpd = Gallons per day.

5.2 Air Effluent

BG Fritz

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 ensured by complying with regulatory standards for equipment and permit conditions. This typically involves activities including using clean fuels and monitoring fuel use, 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 ensure 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%.

Table 5.2. PNNL Campus Nonradiological Atmospheric Emissions for 2012 Reported in Accordance with the Global Reporting Initiative (GRI) Standards

GRI Indicator	Indicator Title	2012 Emissions	Units
EN16	Total direct and indirect greenhouse gas emissions	44,560	Metric tonnes of carbon dioxide equivalent
EN17	Other relevant indirect greenhouse gas emissions	26,827	Metric tonnes of carbon dioxide equivalent
EN19	Ozone-depleting substance R12	0.015	Metric tonnes
	Ozone-depleting substance R22	0.00073	Metric tonnes
	Ozone-depleting substance R123	0.0014	Metric tonnes
	Ozone-depleting substance 403B	0.0000	Metric tonnes
	Ozone-depleting substance 414B	0.0000	Metric tonnes
	Emissions of ozone-depleting substances in CFC-11 Equivalent	0.0174	Metric tonnes
E20	Nitrogen oxides	3,417	kg
	Sulfur dioxide	34	kg
	Volatile organic compounds	862	kg
	Hazardous air pollutants	98	kg
	Particulate matter	492	kg
	Carbon monoxide	7075	kg

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

5.3 Soil Monitoring

TW Moon, EA Raney, and MY Ballinger

Water from the Richland Research Complex cooling ponds supplements irrigation system water on the PNNL Campus. During the summer months, a blue dye is added to the cooling ponds to prohibit algae growth. The application of water from the cooling ponds to agricultural land on the campus is considered an industrial application. PNNL staff sample and analyze the surrounding soils as required by Washington State Department of Ecology state waste discharge permit #ST-9251. In 2012, 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, 2012[(a)]

Parameter	Minimum Value	Maximum Value
Depth (in.)	12	24
Moisture (%)	9.56	13.95
Exchangeable sodium (%)	1.44	1.88
Cation-exchange capacity (meq/100 g)	7.2	9.6
Organic matter (%)	0.77	1.63
Total Kjeldahl nitrogen (mg/kg)	482	949
Nitrate as nitrogen (mg/kg)	1.1	3.4
Ammonia as nitrogen (mg/kg)	4.5	9.0
Total phosphorus (mg/kg)	657	783
Conductivity 1:1 (mmhos/cm)	0.11	0.20
Sodium (meq/100 g)	0.13	0.16
Calcium (meq/100 g)	5.43	6.48
Magnesium (meq/100 g)	1.4	1.7
Potassium (mg/kg)	65	165
Sulfate (mg/kg)	9	13
pH 1:1	6.8	7.2
Redoximorphic features	Absent	Absent

(a) A total of seven samples from four locations were analyzed in 2012.

6.0 Groundwater Protection Program

TW Moon, EA Raney, and MY Ballinger

Groundwater under the PNNL Campus is monitored routinely through seven groundwater monitoring wells. The Hanford Site groundwater monitoring report (DOE/RL 2012a) indicates that five contaminants (uranium, tritium, trichloroethylene, cis-1,2-dichloroethene [a degradation product of trichloroethylene], and nitrate) are found at levels that exceed drinking water standards in parts of the Hanford 300-FF-5 Operable Unit. Under the PNNL Campus, the contaminants either were not detectable or were present in concentrations well below drinking water standards, with the exception of nitrate, which exceeded drinking water standards (Figure 6.1). The nitrate plume underlying the PNNL Campus and much of north Richland originates from offsite agricultural and industrial activities and is not identified as a contaminant of concern for the 300-FF-5 Operable Unit.

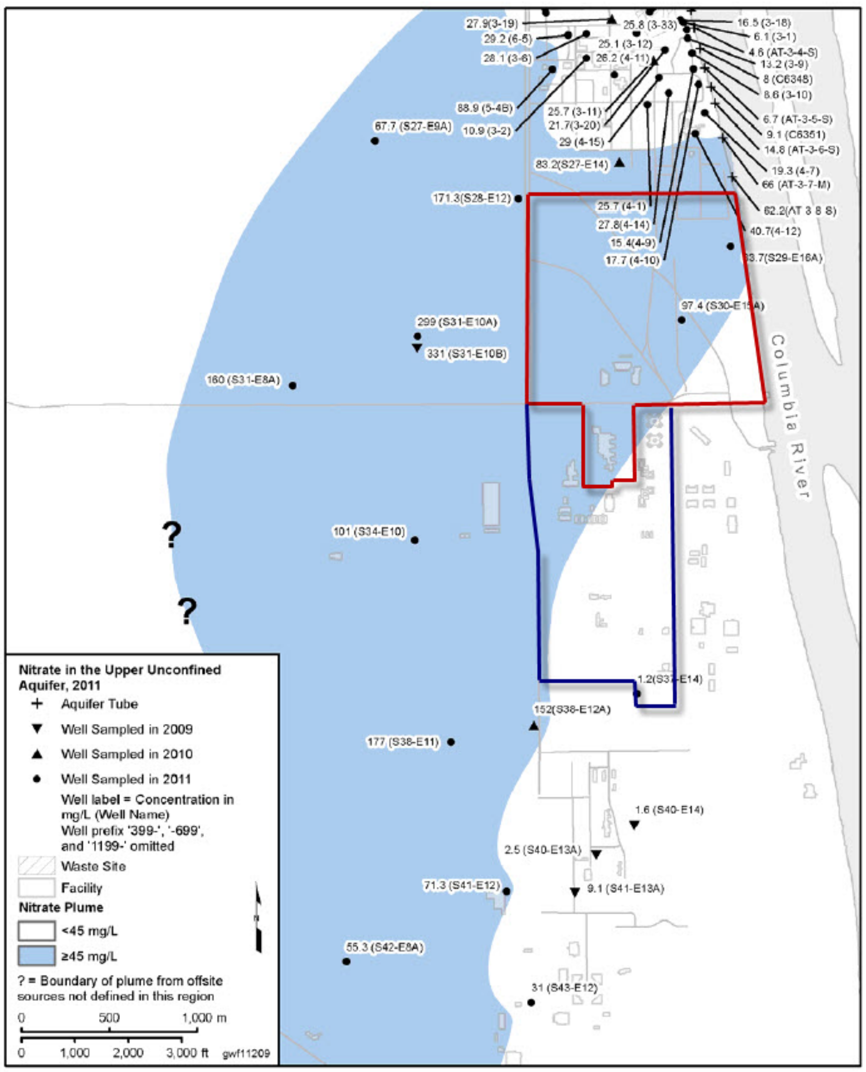

Figure 6.1. Nitrate Plume Beneath Portions of the PNNL Campus (modified from DOE/RL 2013)

In 2010, construction of the Biological Sciences Facility/Computational Sciences Facility (BSF/CSF) was completed. This 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 production 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 a 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 down-gradient from the injection site in addition to the production and injection wells. Three of the monitoring wells located on the PNNL Site were already components of the Hanford Site monitoring network. 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 2012. PNNL is in compliance with all sampling and monitoring requirements of the discharge permit and results show no concern with respect to the ground-source heat pump water affecting movement of the contaminant plumes. No other groundwater sampling at either the PNNL Campus or MSL is required for environmental compliance.

Table 6.1. Biological Science Facility/Computational Sciences Facility Ground-Source Heat Pump Monitoring Results, 2012

Parameter	Number of Samples Analyzed	Quantity Found Below Detection Limit	Detection Limit	Minimum Value	Maximum Value
Injection Wells					
Flow (gpd)	NA	NA	NA	0	1301
Temperature (ºC)	NA	NA	NA	0[(a)]	29.2
pH (pH units)	4	NA	NA	7.6	7.8
Dissolved oxygen (mg/L)	4	NA	NA	8.4	8.8
Conductivity (µS/cm)	4	NA	NA	816	843
Turbidity (NTU)	2	0	0.04	0.06	0.08
Total dissolved solids (mg/L)	2	0	10	454	522
Nitrate-nitrite (mg/L)	2	0	0.09	24.9	26.6
Uranium (µg/L)	2	0	0.0005	6.81	8.24
Tritium (pCi/L)	2	2	1,000	ND	ND
Trichloroethylene (µg/L)	2	2	0.072	ND	ND
Monitoring Wells Down-Gradient of the Injection Wells					
Temperature (ºC)	NA	NA	NA	15.9	18.3
pH (pH units)	28	NA	NA	6.6	7.4
Dissolved oxygen (mg/L)	28	NA	NA	5.7	9.7
Conductivity (µS/cm)	28	NA	NA	508	841
Turbidity (NTU)	14	0	0.04	0.08	2.84
Total dissolved solids (mg/L)	14	0	10	299	504
Nitrate-nitrite (mg/L)	14	0	0.09	7.18	24.6
Uranium (µg/L)	14	0	0.0005	2.61	6.12
Tritium (pCi/L)	14	14	1,000	ND	ND
Trichloroethylene (µg/L)	14	14	0.072	ND	ND

(a) Corresponds with minimum flow of zero indicating no pollutant impact from injection occurring at this time.
gpd = Gallons per day.
NA = Not applicable.
ND = Non-detectable.
NTU = Nephelometric turbidity unit.

7.0 Quality Assurance

MY Ballinger

Environmental sampling and monitoring activities were performed under PNNL's Environmental Management and Operations (M&O) Program. These activities included sampling of wastewater, radiological air emissions, and ambient air and were subject to the PNNL quality assurance program, which implements the requirements of DOE Order 414.1D, "Quality Assurance." Sampling is conducted by the Effluent Management Group under quality assurance plans that describe the specific quality assurance elements that apply to each activity. The quality assurance plans address requirements in DOE Order 414.1D and EPA QA/G-5 (EPA 2002). The plans were approved by the PNNL quality assurance organization that monitors compliance with the plan. Work performed through contracts or statements of work, such as sample analyses, must meet the same quality assurance requirements. Potential suppliers of calibrated equipment and services were audited before service contracts were approved and awarded, or 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, with quality assurance requirements integrated into the Effluent Management Quality Assurance Plan (Ballinger and Beus 2012). The quality assurance plan contains and references specific quality assurance 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. Quality assurance requirements for these activities were incorporated into the Effluent Management Quality Assurance Plan (Ballinger and Beus 2012) 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 radioactive air emissions license, and compliance is demonstrated through calculated emissions with no sampling or monitoring required. Wastewater sampling and monitoring is performed to comply with the NPDES permit for MSL. Quality assurance requirements are specified in a quality assurance plan specific to effluent monitoring at the site. This plan is in the process of being integrated into the Effluent Management Quality Assurance Plan (Ballinger and Beus 2012).

7.1 Sample Collection Quality Assurance

Samples were collected by personnel trained to conduct sampling according to approved and documented procedures. Some samples are required to be analyzed 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 demonstrate compliance with method requirements. Sampling protocols include use of appropriate sampling methods and equipment, a defined sampling frequency, specified sampling locations, and protocols for sample handling, 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. Quality assurance 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 matrix spikes, surrogates, and laboratory control samples/blank samples to assess accuracy.

All wastewater samples are analyzed using EPA-approved methods, which include duplicate samples, trip blanks, matrix spikes, and laboratory control samples, and each analytical 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.

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 2012: 1) radiological air emission samples were analyzed by the PNNL Radiochemical Sciences and Engineering Group; 2) ambient air samples were analyzed for radioactivity by General Engineering Laboratories, 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 due to the 15-min sample hold time. Analyses were performed according to a documented statement of work or contract, which described the activities necessary to ensure that the analysis results were of high and verifiable quality. These activities included calibrating and performance testing of analytical equipment; implementing a quality assurance program; maintaining analytical and support equipment and facilities; handling, protecting, and analyzing samples; checking data traceability, validity, and quality; recording all analytical data; and communicating and reporting to the Effluent Management Group.

In 2012, the Radiochemical Sciences and Engineering Group and General Engineering Laboratories 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) intercomparison program, which provides an evaluation of laboratory performance. The MAPEP provided standard samples of environmental media (e.g., air filters, soil, vegetation, and water) 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 ±30 percent of a reference value. In 2012, General Engineering Laboratories participated in two MAPEP studies (MAPEP 26 and 27 [2012]), and 89 percent of the results were within acceptable control limits; the Radiochemical Sciences and Engineering Group participated in one of the studies (MAPEP 27), and 93 percent of results were within acceptable control limits. The General Engineering Laboratories are also audited annually by the U.S. Department of Energy Consolidated Audit Program, which provides added confidence in the data reported by the laboratory.

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 Radiochemical Sciences and Engineering Group 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 General Engineering Laboratories (Table 7.1). The QC samples from both laboratories indicated that the sample batches had no measurable contamination from sample preparation activities, and no issues were identified in the sample preparation process.

Table 7.1. Summary of Quality Control Results Used for Air Filter Analyses, 2012

Quality Control Sample Type	Analytes	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-233234, U-235, U-238	36	79%[(a)]
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	4	100%[(b)]
Matrix spike samples	Am-241, Am-243, Cm-243/244, Pu-238, Pu-239/240, U-233/234, U-235, U-238	2	100%[(c)]
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	9	100%[(d)]
Pacific Northwest National Laboratory Radiochemical Sciences and Engineering Group:			
Laboratory blanks	Gross alpha, gross beta, Am-241, Am-243, Cm-243/244, Pu-238, Pu-239/240, U-233	2	100%[(a)]
Matrix spike samples	Gross alpha, gross beta, Pu-241, Sr-90	2	100%

(a) 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 the MDA was below reporting limits for all gross beta analyses.
(b) The relative percent difference between the sample and duplicate result is less than 25%, or the duplicate error ratio is less than 3.
(c) Control limit ±25%.
(d) Percentage of results within control limits for spiked analytes and either below MDA or below reporting limits for unspiked analytes.

ALS Environmental and an in-house laboratory at MSL analyzed all wastewater samples from the PNNL Campus and MSL during 2012. 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 quality assurance plan, perform periodic proficiency testing, and be periodically inspected by the Washington State Department of Ecology to ensure that it is operating within regulatory and quality assurance requirements. Both laboratories are also accredited through the National Environmental Laboratory Accreditation Program. 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). Quality assurance and QC requirements in the contract with PNNL include the measurement or assessment of accuracy, precision, reliability, representativeness, completeness, and comparability. These measurements are reviewed for each analytical data package to verify that 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. As mentioned in Section 7.1, 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

Quality assurance is integrated into data management processes and calculations through documents such as the quality assurance plans, a data management plan, and procedures. Parameters for dose calculations are documented as a component of the PNNL environmental monitoring plan (Snyder at 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.

8.0 References

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Appendix A

Helpful Information

Appendix A

Helpful Information

The following information is provided to assist the reader in understanding this report. Included here is information about scientific notation, units of measure, 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 Measure

The primary units of measure 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	fCi	fCi	pCi	pCi	nCi	nCi	μCi	μCi	mCi	mCi	Ci	Ci	kCi
27	1	27	1	27	1	27	1	27	1	27	1	27	1
1	37	1	37	1	37	1	37	1	37	1	37	1	37
μBq	μBq	mBq	mBq	Bq	Bq	kBq	kBq	MBq	MBq	GBq	GBq	TBq	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 received from 1 day's exposure to natural background radiation. An acute (short-term) dose to the whole body of 100 rem (1 sievert) would likely cause temporary radiation sickness in some exposed individuals. An acute dose of over 500 rem (5 sievert) would soon result in death in approximately 50% of those exposed. Exposure to lower amounts of radiation (10 mrem [100 μSv] or less) produces no immediate observable effects, but long-term (delayed) effects are possible. The average person in the United States receives an annual dose from exposure to naturally produced radiation of approximately 300 mrem (3 mSv). Medical and dental x-rays and air travel add to this total. 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.

Table A.5. Conversions for Radiological Dose Units

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

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.

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)

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

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
^{3}H	tritium	12.35 yr	^{140}Ba	barium-140	12.75 d
^{7}Be	beryllium-7	53.3 d	^{152}Eu	europium-152	13.33 yr
^{14}C	carbon-14	5,730 yr	^{154}Eu	europium-154	8.8 yr
^{24}Na	sodium-24	14.96 h	^{155}Eu	europium-155	4.96 yr
^{40}K	potassium-40	1.28×10^{9} yr	^{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.

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.8. Elemental and Chemical Constituent Nomenclature

Symbol	Constituent	Symbol	Constituent
Ag	silver	K	potassium
Al	aluminum	LiF	lithium fluoride
As	arsenic	Mg	magnesium
B	boron	Mn	manganese
Ba	barium	Mo	molybdenum
Be	beryllium	NH_3	ammonia
Br	bromine	NH_4^+	ammonium
C	carbon	N	nitrogen
Ca	calcium	Na	sodium
CaF_2	calcium fluoride	Ni	nickel
CCl_4	carbon tetrachloride	NO_2^-	nitrite
Cd	cadmium	NO_3^-	nitrate
$CHCl_3$	trichloromethane	Pb	lead
Cl^-	chloride	PO_4^{-3}	phosphate
CN^-	cyanide	P	phosphorus
Cr^{+6}	chromium (hexavalent)	Sb	antimony
Cr	chromium (total)	Se	selenium
CO_3^{-2}	carbonate	Si	silicon
Co	cobalt	Sr	strontium
Cu	copper	$SO\text{-}_4^{-2}$	sulfate
F^-	fluoride	Ti	titanium
Fe	iron	Tl	thallium
HCO_3^-	bicarbonate	V	vanadium
Hg	mercury		

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.

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% 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.

A.8 Reference

EPA 402-R-99-01. 1999. "Cancer Risk Coefficients for Environmental Exposure to Radionuclides." Appendix G in *Federal Guidance Report 13*, KF Eckerman, RW Leggett, CB Nelson, JS Puskin, and ACB Richardson, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C.

Appendix B

Glossary

Appendix B

Glossary

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

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.

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: $1\ \text{Ci} = 3.7 \times 10^{10}\ \text{Bq}$.

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 effective dose equivalent – Sum of the *total effective dose equivalents* for individuals composing a defined population. Such 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 *effluent* 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/hr]).

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.

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 – Smallest amount or concentration of a chemical or radioactive material that can be reliably detected in a sample.

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

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

monitoring – As defined in DOE Order 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 total effective dose equivalent*. 1 person-Sv = 100 person-rem.

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.

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

quality control – Comprises all those 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 at 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.

References

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40 CFR 1508.4. 2012. "Categorical Exclusion." *Code of Federal Regulations*, U.S. Department of Energy, Washington, D.C. Accessed August 13, 2013, at http://www.gpo.gov/fdsys/pkg/CFR-2012-title40-vol34/pdf/CFR-2012-title40-vol34-sec1508-4.pdf.

DOE Order 5400.5. Chg 2. 1993. "Radiation Protection of the Public and the Environment." U.S. Department of Energy, Washington, D.C.

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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 2012

Species Name	Common Name	State Status	Federal Status	Noxious Weed Class
Achillea millefolium	yarrow			
Achnatherum hymenoides	Indian ricegrass			
Acroptilon repens	Turkestan knapweed			B
Agoseris heterophylla	annual mountain dandelion			
Agropyron cristatum	crested wheatgrass			
Ailanthus altissima	tree-of-heaven			C
Ambrosia acanthicarpa	bur ragweed			
Amsinckia lycopsoides	fiddleneck			
Artemisia dracunculus	taragon			
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			C
Centaurea diffusa	tumble knapweed			B
Centaurea solstitialis	yellow starthistle			B
Chamaesyce serpyllifolia	thymeleaf spurge			
Chenopodium album	lamb's quarters			
Chenopodium leptophyllum	slimleaf goosefoot			
Chenopodium rubrum	red goosefoot			
Chondrilla juncea	rush skeletonweed			B
Chrysothamnus viscidiflorus	green rabbitbrush			
Cichorium intybus	chicory			
Clematis ligusticifolia	western virginsbower			
Comandra umbellata ssp. pallida	bastard toadflax			
Convolvulus arvensis	field bindweed			C
Conyza canadensis	horseweed			
Coreopsis tinctoria var. atkinsoniana	Columbia tickseed			
Crepis atribarba ssp. originalis	slender hawksbeard			
Cryptantha circumscissa	matted cryptantha			
Cryptantha flaccida	weak-stemmed cryptantha			
Dalea ornata	western prairieclover			
Elymus elymoides ssp. elymoides	bottlebrush grass			
Elymus lanceolatus ssp. lanceolatus	thickspike wheatgrass			
Epilobium brachycarpum	tall willowherb			
Ericameria nauseosa ssp. nauseosa var. speciosa	gray rabbitbrush			
Epilobium brachycarpum	tall willowherb			
Ericameria nauseosa ssp. nauseosa var. speciosa	gray rabbitbrush			
Eriogonum niveum	snow buckwheat			

Table C.1. (contd)

Species Name	Common Name	State Status	Federal Status	Noxious Weed Class
Erodium cicutarium	storksbill			
Hesperostipa comata	needle-and-thread grass			
Holosteum umbellatum	jagged chickweed			
Hymenopappus filifolius	Columbia cutleaf			
Hypericum perforatum	Klamath weed			C
Lactuca serriola	prickly lettuce			
Lagophylla ramosissima	rabbitleaf			
Leymus cinereus	giant wildrye			
Machaeranthera canescens	hoary aster			
Malus pumila	apple			
Medicago sativa	alfalfa			
Morus alba	white mulberry			
Oenothera pallida	pale evening primrose			
Opuntia polyacantha	starvation pricklypear			
Phacelia hastata	whiteleaf scorpionweed			
Phlox longifolia	longleaf phlox			
Plantago lanceolata	English plantain			
Plantago patagonica	Indian wheat			
Poa bulbosa	bulbous bluegrass			
Poa secunda	Sandberg's bluegrass			
Prunus virginiana var. melanocarpa	chokecherry			
Pseudoroegneria spicata	bluebunch wheatgrass			
Psoralidium lanceolatum	dune scurfpea			
Pteryxia terebinthina var. terebinthina	turpentine springparsley			
Purshia tridentata	bitterbrush			
Robinia pseudoacacia	black locust			
Rosa woodsii var. ultramontana	Woods' rose			
Salsola tragus	Russian thistle			
Sisymbrium altissimum	Jim Hill's tumblemustard			
Sphaeralcea munroana	Munro's globemallow			
Sporobolus cryptandrus	sand dropseed			
Stephanomeria paniculata	stiff wirelettuce			
Tragopogon dubius	yellow salsify			
Tribulus terrestris	puncture vine			B
Ulmus pumila	Siberian elm			
Verbascum thapsus	common mullein			

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 2012

Species Name	Common Name	State Status	Federal Status
Amphispiza belli	sage sparrow	SC	
Branta canadensis	Canada goose		
Bubo virginianus	great horned owl		
Calidris mauri	western sandpiper		
Callipepla californica	California quail		
Carpodacus mexicanus	house finch		
Chondestes grammacus	lark sparrow		
Eremophila alpestris	horned lark		
Icterus galbula	Bullock's oriole		
Melospiza melodia	song sparrow		
Passerella iliaca	fox sparrow		
Phasianus colchicus	ring-necked pheasant		
Pica pica	black-billed magpie		
Sturnella neglecta	western meadowlark		
Turdus migratorius	American robin		
Tyrannus tyrannus	eastern kingbird		
Tyrannus verticalis	western kingbird		
Zenaida macroura	mourning dove		

SC = State candidate.

Table C.3. Mammal Species Observed on the PNNL Campus in 2012

Species Name	Common Name	State Status	Federal Status
Canis latrans	coyote		
Castor canadensis	beaver		
Odocoileus hemionus	mule deer		
small mammal	unknown/unidentified small mammal		
Sylvilagus nutalli	mountain cottontail		
Thomomys talpoides	northern pocket gopher		

Appendix D

Mapping and Control of Noxious Weeds on the PNNL Campus in 2012

Appendix D

Mapping and Control of Noxious Weeds on the PNNL Campus in 2012

Several species of Class B noxious weeds, including diffuse knapweed (*Centaurea diffusa*), rush skeletonweed (*Chondrilla juncea*), yellow starthistle (*Centaurea solstitialis*), and Russian knapweed (*Acroptilon repens*) were identified on the Pacific Northwest National Laboratory (PNNL) Campus in August 2009 (Larson and Downs 2009) and mapped in more detail in 2010 and 2011 (Chamness et al. 2010; Becker and Chamness 2012). Class B noxious weeds are species designated for control where they are not yet widespread to prevent new infestations. Tree-of-heaven (*Ailanthus altissima*) was added to the Class C noxious weed list in 2012. A small clump of this species was observed near the river in 2012. Benton County does not yet require control of tree-of-heaven but strongly recommends it.

Hand-spraying herbicides to control noxious weeds minimizes impacts on non-targeted species and cultural resources and is the preferred herbicide application method. PNNL staff (with current Washington State applicator licenses) sprayed the herbicide Milestone (along with a water conditioner, drift control and sticking agents, and blue dye for visibility) using backpack sprayers. The Milestone label restricts use to temperatures below 80°F and wind speeds less than 4.5 m/s (10 mph). Hand-spraying the weeds has been reasonably effective in killing targeted plants.

PNNL staff have hand-sprayed herbicides each year since 2010, primarily targeting individual rush skeletonweed plants in areas where they are most abundant. Individual yellow starthistle and diffuse knapweed plants were also sprayed when encountered. Spraying of diffuse knapweed was stopped in 2012 when seed-eating weevils were identified on some of the plants. These weevils (*Larinus minutus*) only eat the seeds of diffuse knapweed, and have been introduced across the western United States to control diffuse knapweed. They have apparently migrated onto the PNNL Campus. Leaving the diffuse knapweed untreated provides habitat for the weevils, allowing them to reproduce and multiply, providing further control of these plants.

The use of biocontrols for Russian knapweed was explored in 2012. Staff at the U.S. Department of Agriculture Animal and Plant Health Inspection Service indicated biocontrols for Russian knapweed are not yet available. Consequently, six test plots were set up within the largest patch of Russian knapweed to test application of Milestone in the late spring when the plants are blooming as a control method (Figure D.1). Three Russian knapweed plots were selected randomly for hand-spray application. In spring 2013, these plots will be compared to the adjacent areas that were not sprayed to determine usefulness of spring applications.

Rush skeletonweed spreads by seed (each mature plant may produce between 1,500 and 20,000 seeds), by buds along the roots and on the root crown, and from root fragments in the soil (NWCB 2010a). Numerous small rush skeletonweed plants were observed in the vicinity of larger plants sprayed the previous year, requiring more than 1 year of treatment in several areas. These small plants are likely either sprouts from the roots of plants treated in previous years or had grown from seed. Consequently, rush skeletonweed can require multiple herbicide applications over several years to kill the plant and its roots. In contrast, yellow starthistle reproduces only by seed (NWCB 2010b), but its seed may remain viable in the soil for several years, requiring additional surveys and treatment.

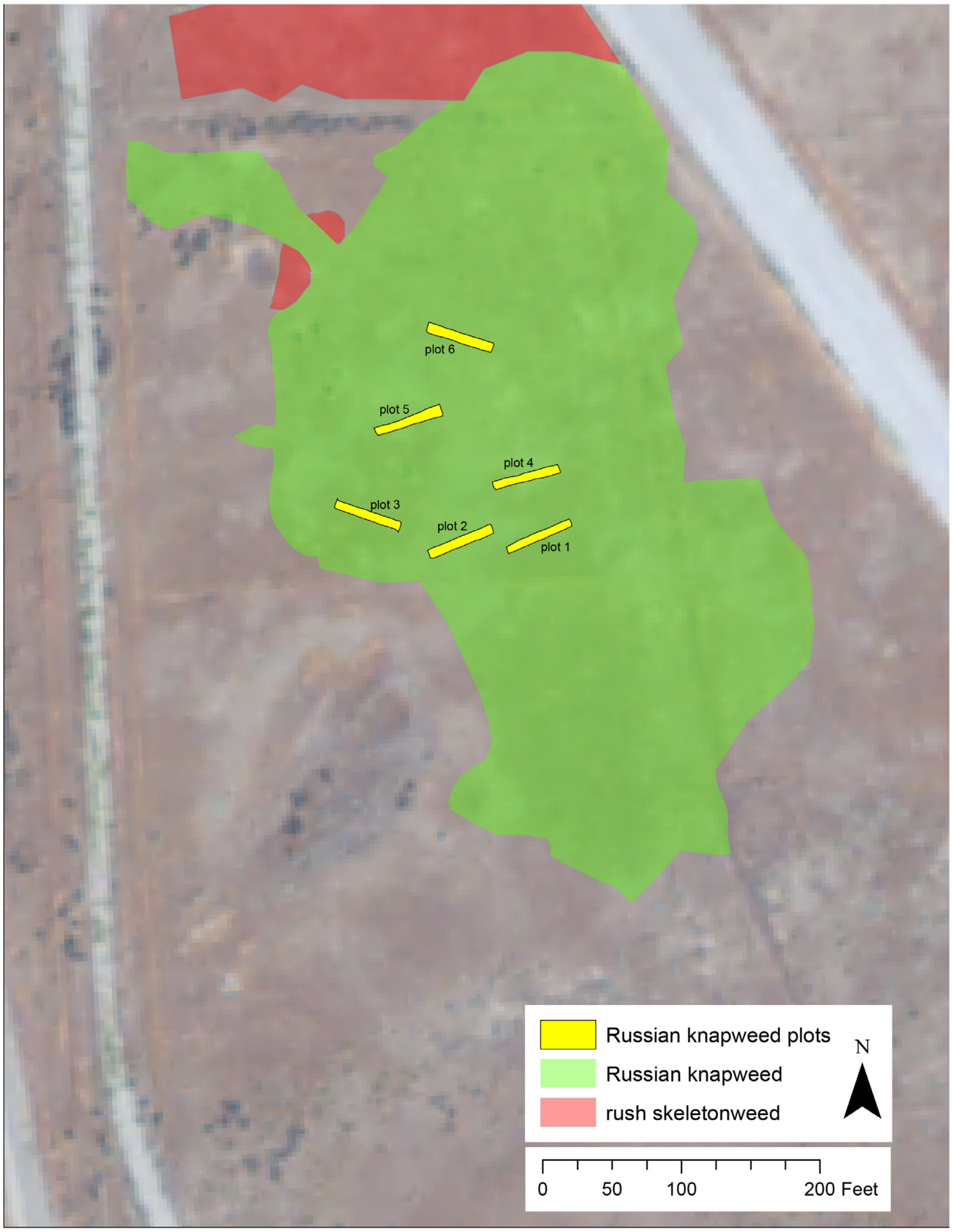

Figure D.1. Test Plots for Techniques to Control Russian Knapweed

Spraying in 2012 focused on the eastern third of the area north of Horn Rapids Road and east of George Washington Way (Figure D.2) where concentrated populations of the target weeds occur. Figure D.2 shows these areas of higher density weed populations; however, numerous small patches containing only a few weeds are not shown on the map. Spraying occurred on May 1, 8, 16, and 30 and

June 12 and 20, 2012. These were days when staff were available and weather conditions were appropriate. Rush skeletonweed becomes less susceptible to herbicides once daily temperatures are consistently above 80°F.

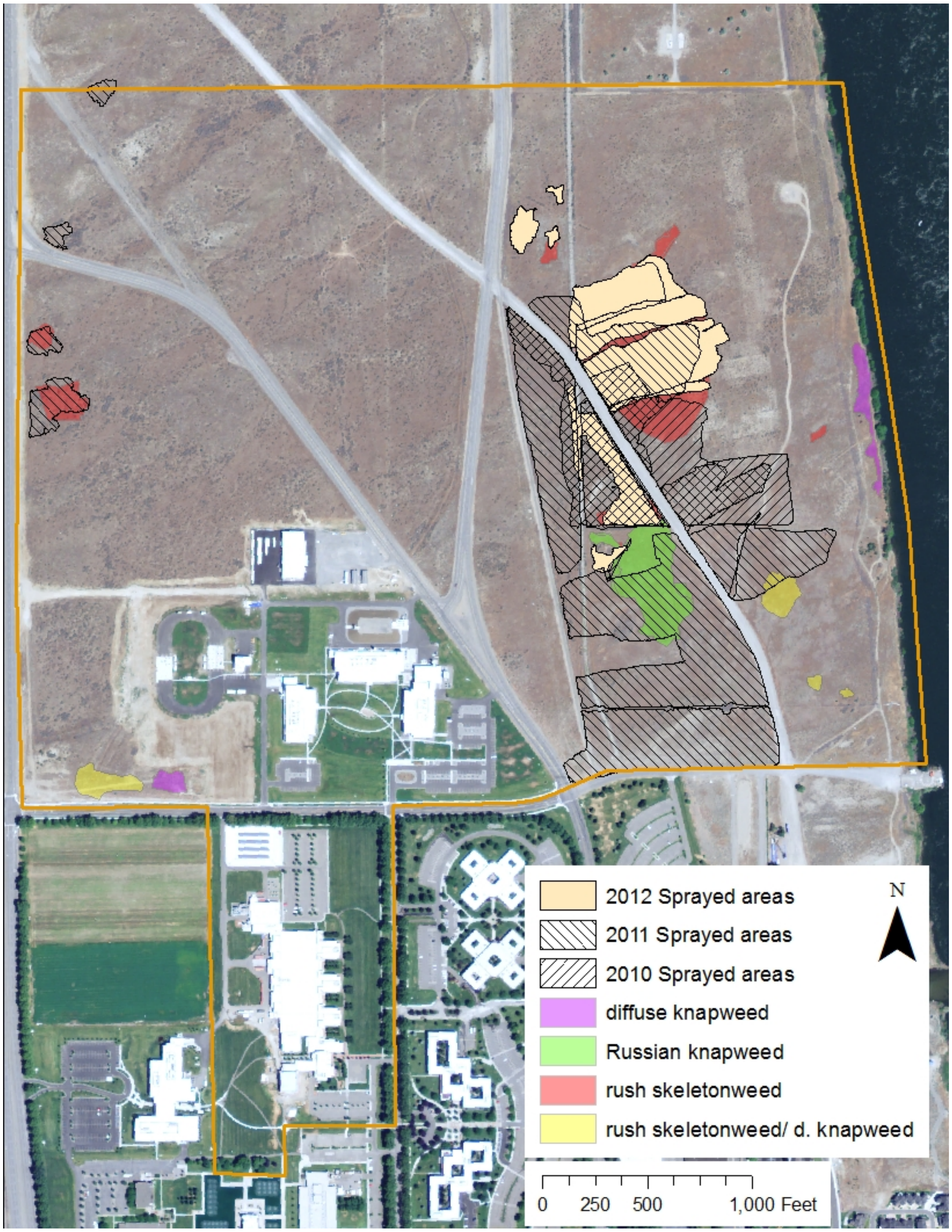

Figure D.2. Areas Treated for Noxious Weeds from 2010 Through 2012

Approximately 4.9 ha (12 ac) were hand-sprayed in 2012 (tan areas in Figure D.2). A little over half of this area was previously sprayed in 2011 and/or in 2010. In general, areas that had been previously sprayed had noticeably fewer rush skeletonweed plants than untreated weedy areas. The northeastern portion of the area sprayed in 2012 had never been treated before and contained relatively large patches of very small, young rush skeletonweed plants. Spraying these areas consumed a disproportionately large amount of time for the area covered. The increase in the number of small, young rush skeletonweed plants found this year in areas thought to have a relatively sparse population may indicate rapid spread of this weed.

Noxious weed control activities on the PNNL Campus, particularly those near the river, will be coordinated with cultural and ecological resource staff, relevant state and federal agencies, and representatives of interested Native American tribes. Recommendations for 2013 include the following:

- Research the use of biocontrols along with herbicides to control rush skeletonweed and if feasible apply the biocontrols on the PNNL Campus.
- Compare the number of Russian knapweed plants in sprayed and untreated plots. If the herbicide appears to be successful, apply herbicide in the spring.
- Apply herbicide to the small population of tree-of-heaven, possibly several times throughout the growing season using herbicides such as Garlon 3A, Garlon 4, Tordon, or glyphosate.
- Begin to reseed areas that have not been sprayed for at least a year using native grass and shrub seed. Increasing native plant density can provide competition to weeds.

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