DOE/RL-91-50
Revision 4

Environmental Monitoring Plan United States Department of Energy Richland Operations Office

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Pacific Northwest National Laboratory for the
U.S. Department of Energy under Contract DE-AC05-76RL01830

United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

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Preface

This Hanford Site Environmental Monitoring Plan (EMP) was prepared to implement the requirements of DOE Order 450.1, "Environmental Protection Program." DOE Order 450.1 requires that all U.S. Department of Energy (DOE) organizations, and all sites under their purview, assure that site Integrated Environment, Safety, and Health Management Systems (ISMS) include implementation of an Environmental Management System (EMS) (as defined in ISO 14001) that provides for (1) the systematic planning, integrated execution, and evaluation of programs for protecting public health and the environment; (2) pollution prevention; and (3) assuring site compliance with applicable environmental protection requirements. In addition, the Order requires that all DOE organizations conduct environmental monitoring, as appropriate, to support their ISMS and EMS.

The DOE-Richland Operations Office (RL) ISMS (called the Richland Integrated Management System [RIMS]) includes a section specifically addressing components of the Hanford Site's Environmental Monitoring Program. This program is used at the Hanford Site to implement the environmental monitoring requirements specified in DOE Order 450.1.

The RIMS identifies this EMP as the mechanism through which environmental monitoring requirements are implemented at Hanford. This EMP contains the rationale for the required environmental monitoring programs, including the design criteria, sampling locations and schedules, quality assurance requirements, laboratory analytical procedures, and reporting requirements.

This plan is written to comply with all "*should**" statements in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE/EH-0173T) unless noted otherwise in an Exceptions discussion. "*Should**" statements are described in DOE/EH-0173T as flexible guidance and were considered where determined appropriate. DOE/EH-0173T is currently under review by personnel at DOE Headquarters (HQ). Revisions to DOE/EH-0173T may be forthcoming as a result of the review.

Personnel from DOE-RL, the Pacific Northwest National Laboratory (PNNL), and Fluor Hanford, Inc. and its subcontractors contributed to this plan. The Public Safety and Resource Protection Program (PSRPP), managed by PNNL for DOE-RL, coordinated document production.

Both hardcopy and electronic versions of this plan have been produced. The hardcopy version is available for review at the DOE Public Reading Room, located in the Consolidated Information Center in Richland, Washington. The electronic version is available on compact disk (CD). This plan was written to meet the needs of the Hanford Site's DOE offices and their contractors. The content, wording, and format are appropriate to those needs. Questions or concerns about this plan should be directed to Mr. D. C. (Dana) Ward at the DOE Richland Operations Office, P.O. Box 550, Richland, Washington 99352 (dana_c_ward@rl.gov).

Acronyms/Initialisms

Each section in this report is considered to be independent from each other with respect to the use of acronyms/initialisms. Any acronym/initialism used in a table or on a figure is provided thereon. For the convenience of the reader, below is a list of all the acronyms/initialisms used in the entire report.

ADR	anomalous data report
APGEMS	Air Pollutant Graphical Environmental Modeling System
ALARA	as low as reasonably achievable
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	Code of Federal Regulations
CVAA	cold vapor atomic absorption
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DOE	U.S. Department of Transportation
DQO	data quality objective
Ecology	Washington State Department of Ecology
EDE	effective dose equivalent
EMC	Ecological Monitoring and Compliance (Project)
EMP	environmental monitoring plan
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
FDA	U.S. Food and Drug Administration
FEMP	Facility Effluent Monitoring Plan
GENII	Generation II (computer code)
GFAA	graphite-furnace atomic absorption
GPS	global positioning system
HCRP	Hanford Cultural Resources Project
HEIS	Hanford Environmental Information System
HEOP	Hanford Environmental Oversight Project
HMS	Hanford Meteorology Station
HPGe	hyperpure germanium (detector)
HQ	Headquarters (DOE)
ICP-MS	inductively coupled plasma-mass spectrometry
ISMS	Integrated Environment, Safety, and Health Management System
MCSP	Meteorological and Climatological Services Project

NEPA	*National Environmental Policy Act*
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NHPA	*National Historic Preservation Act*
NIST	National Institute of Standards and Technology
NPL	National Priorities List
NTU	nephelometric turbidity unit
PCB	polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory
PSRPP	Public Safety and Resource Protection Program
QA	quality assurance
QC	quality control
RCRA	*Resource Conservation and Recovery Act*
RIMS	Richland Integrated Management System
SBMS	Standards-Based Management System
SESP	Surface Environmental Surveillance Project
SPMU	Special Protection Management Units
TLD	thermoluminescent dosimeter
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, or disposal (unit)
UDAC	Unified Dose Assessment Center
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDOH	Washington State Department of Health

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Hanford Site Environmental Monitoring Plan

Section I. Introduction

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Introduction

Hanford's Environmental Monitoring Program is implemented on two distinct and independent levels, in part due to the large size of the site, the diversity of activities performed onsite, and the number of contractors responsible for the various activities. This structure was established to assure that potential impacts associated with Hanford Site activities are evaluated, and that operations at Hanford are not having a negative impact on human or ecological health or natural and cultural resources.

The first level of the program addresses the operational aspects of environmental protection. Contractors are contractually required to implement the environmental protection requirements stated in DOE Order 450.1. This includes the requirements for major contractors to integrate their Environmental Management Systems into their respective Integrated Environment, Safety, and Health Management System and to perform effluent or environmental monitoring as appropriate at or near active and inactive facilities on the site. The requirements of state and federal laws, regulations, and permits related to facilities are also addressed at this level.

The second level of the program is conducted to assure the protection of site workers, the public, and the environmental resources on and around the site from all operations at Hanford. To accomplish this, the U.S. Department of Energy (DOE) and its contractors must implement the requirements of DOE Orders 450.1 and 5400.5. The activities at this level include groundwater monitoring, site-wide environmental surveillance, meteorological monitoring, natural and cultural resources monitoring, and an assessment of cumulative environmental impact related to Hanford Site activities.

The Richland Integrated Management System (RIMS) describes the site's Environmental Monitoring Program in terms of several environmental monitoring requirements:

- Ensure the early identification of, and appropriate response to, potentially adverse environmental impacts associated with DOE operations. This includes preoperational characterizations and assessments, effluent and emissions monitoring, and environmental surveillance on and off the site.

- Provide the mechanisms and information through which the DOE demonstrates compliance with applicable environmental compliance, public health, and resource protection laws, regulations, and DOE Orders.

- Demonstrate that Hanford Site operations are being conducted so that the protection of the workers and the public is assured.

- Provide assurance that activities at Hanford are conducted in ways that are protective of the air, water, land, and other natural and cultural resources.

- Mandate participation in the site's land use planning activities, human health and ecological risk assessments, and long-term stewardship plans. Environmental monitoring plans (EMPs) and resource management plans assure the consideration of environmental protection requirements throughout each activity's planning, operation, closure, and post-closure life cycle.

- Assure that environmental monitoring sample collection methods, sample analyses, data interpretations, and reporting are consistent across the site, as appropriate, to assure consistency and comparability of the data.

Environmental monitoring activities involve multiple DOE organizations and site contractors that are driven by different missions and regulatory requirements. Monitoring activities are closely aligned with the needs of the environmental cleanup, restoration, and assessment activities ongoing at Hanford. Monitoring and surveillance information is used extensively by numerous projects under the purview of the Hanford Site's DOE offices. Quality assurance is an integral part of all environmental monitoring and surveillance activities to assure that data quality is known and documented and that the data meet DOE and contractor needs.

In addition, environmental monitoring activities are integrated across the site to the extent practicable to avoid the collection of duplicative data. Such integration minimizes duplication of capabilities and resources at Hanford, optimizes operational efficiencies, maximizes the amount of useful information generated, and results in lower costs to the DOE. Monitoring activities are also conducted in a manner that assures the capture, preservation, perpetuation, and use of the institutional knowledge obtained through 50-plus years of monitoring on and near the site.

Environmental Monitoring Program

The primary elements of Hanford's Environmental Monitoring Program include the Effluent Monitoring Program, the Public Safety and Resource Protection Program (PSRPP), the Soil and Groundwater Remediation Project, and the independent oversight activities of the Washington State Department of Health (WDOH). A brief overview of each element is provided in the following paragraphs.

Effluent Monitoring

Effluent monitoring at Hanford is conducted in accordance with reviewed and approved monitoring procedures, and monitoring results are reported in the annual Hanford Site environmental report (e.g., PNNL-16623). Effluent monitoring consists of two components: 1) monitoring of facility effluent and emissions, and 2) environmental monitoring near facilities that have the potential to discharge, or have discharged, stored, or disposed of radioactive and hazardous materials (i.e., near-facility or near-field monitoring).

Facility Effluent Monitoring

Hanford Site contractors perform real-time monitoring of liquid effluent and airborne emissions at each facility to assess the effectiveness of effluent and emissions treatment and control systems, pollution management practices, and to determine facility and Hanford Site compliance with state and federal regulatory requirements. A facility effluent monitoring plan (FEMP) may be prepared and maintained for each existing, new, or modified facility having the potential to 1) release quantities of airborne radioactive materials that could cause a radiation dose in excess of 0.1 millirem per year effective dose equivalent (EDE) to any member of the public; 2) discharge a liquid effluent regulated by 40 CFR 122 and containing sufficient radionuclides to potentially cause an EDE greater than 4.0 millirem per year to any member of the public via the drinking water pathway; or 3) release large quantities of non-radioactive

hazardous materials in amounts exceeding the reportable quantities listed in 40 CFR 302. Each FEMP contains the rationale and design criteria for the effluent monitoring program at the facility, information on the extent and frequency of monitoring and measurements, procedures for analyses of monitoring samples, quality assurance requirements, and program implementation procedures. A discussion of Hanford Site FEMPs is not included in this document because many FEMPs contain information that is currently considered sensitive. Questions or inquiries about Hanford Site FEMPs should be directed to Mr. Tom Ferns, DOE-RL Operations Office, Safety and Engineering Division, Richland, Washington (Thomas_W_Ferns@rl.gov).

Near-Facility Environmental Monitoring

Facility-specific environmental monitoring is conducted to protect workers and the environment adjacent to 1) nuclear facilities; 2) waste storage, treatment, and disposal sites; and 3) remediation sites, in compliance with applicable federal, state, and local environmental regulations and requirements. The objectives of this monitoring are to evaluate:

- Compliance with federal, state, and local environmental radiation protection requirements and guides.
- Performance of radioactive waste confinement systems.
- Concentration trends of radioactive materials in the near-facility environment.

Section II discusses these monitoring activities and contains details about the environmental media sampled, monitoring locations, extent and frequency of monitoring and measurements, procedures for laboratory analyses, quality assurance requirements, and program implementation procedures.

Public Safety and Resource Protection

Environmental surveillance, meteorological services, ecological surveys, and natural and cultural resource protection activities at Hanford are managed through the PSRPP. The PSRPP provides environmental information obtained independent of the site's operating contractors. Program personnel monitor the Hanford environment, provide assurance that the site operates in compliance with applicable environmental regulations, and conduct impact assessments to protect public and worker safety as well as Hanford's significant ecological and cultural resources. This information is necessary for the DOE and site contractors to manage environmental risk at Hanford.

Sections III.A through III.D provide detail on the various components of the PSRPP. In addition to rationale and design criteria, these sections discuss inter-program integration as well as site-wide linkages between PSRPP components and other environmental monitoring, waste site clean-up, environmental restoration, and assessment activities ongoing at Hanford.

The PSRPP is instrumental in assuring that Hanford is in compliance with DOE Orders and environmental and resource protection laws and regulations, including the *Clean Water Act*, *Clean Air Act*, *National Environmental Policy Act* (NEPA), *Endangered Species Act*, *Migratory Bird Treaty Act*, *Bald and Golden Eagle Protection Act*, *National Historic Preservation Act* (NHPA), and the *Native American*

Grave Protection and Repatriation Act. Project personnel are responsible for the preparation, maintenance, and implementation of the following environmental monitoring and resource protection plans for the Hanford Site:

- *Environmental Monitoring Plan* (DOE/RL-91-50).
- *Hanford Site Biological Resources Management Plan* (DOE/RL-96-32).
- *Hanford Site Biological Resources Mitigation Strategy* (DOE/RL-96-88).
- *Ecological Compliance Assessment Management Plan* (DOE/RL-95-11).
- *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington* (DOE/RL-94-150).
- *Threatened and Endangered Species Management Plan: Salmon and Steelhead* (DOE/RL-2000-27).
- *Hanford Cultural Resources Management Plan* (DOE/RL-98-10).

The PSRPP, which is managed and operated as an integrated unit, consists of the following five component projects:

Hanford Environmental Oversight. The Hanford Environmental Oversight Project (HEOP) is responsible for the management of the PSRPP, integration of activities performed within the PSRPP, and coordination of related environmental assessment and resource protection activities across the site. In addition, the HEOP is responsible for PSRPP self-assessments, performance assessments, and design reviews. The HEOP also provides for production coordination of this Hanford Site EMP, consistent with 65 FR 24595 and DOE Order 450.1.

Surface Environmental Surveillance. The Surface Environmental Surveillance Project (SESP) is responsible for site-wide (far field) and offsite environmental surveillance at Hanford. Surface environmental surveillance at the Hanford Site is a multimedia environmental monitoring effort conducted to assess onsite and offsite human health exposures to radionuclides and chemicals and to evaluate the impact of Hanford Site operations on the environment. Onsite surveillance is conducted independent of facility-related environmental monitoring programs to provide an assessment of the effectiveness of effluent controls, monitor for fugitive contaminant releases from cleanup and remediation locations, monitor for releases caused by wildfires or other disturbances from contaminated or potentially contaminated areas, and establish contaminant concentration baselines for use in the event of an unplanned contaminant release. Annual design reviews are performed to assure that project activities are aligned with current site operations and missions and focused on those contaminants with the greatest potential for contributing to offsite doses.

Surface environmental surveillance is closely related to and coordinated with near-facility environmental monitoring (see Section II), groundwater monitoring (see Section IV), and the WDOH's oversight of Hanford environmental programs. In addition, surveillance activities are closely aligned with and support the site's environmental cleanup, restoration, and assessment missions.

SESP personnel are responsible for the preparation of the annual Hanford Site environmental report (e.g., PNNL-16623). The report documents the environmental compliance status of the Hanford Site, environmental conditions on and around the site, and potential onsite and offsite radiological exposures resulting from Hanford operations. The report provides to the public, stakeholders, Tribes, Trustees, and regulatory agencies a historical and current accounting of site operations and their impact on humans and the environment. The report also provides information to the DOE so that it can better manage risk associated with those operations.

Section III.A contains the detailed rationale and design criteria for the SESP, including the media sampled, sampling locations, contaminants of concern, extent and frequency of monitoring and measurements, procedures for laboratory analyses, and quality assurance requirements.

Meteorological and Climatological Services. The Meteorological and Climatological Services Project (MCSP), through the operation of the Hanford Meteorology Station (HMS), provides operational meteorological support to the DOE, and site contractors, for site operations, site-wide emergency preparedness, and construction, remediation, environmental restoration, and safety-related activities. The MCSP provides information to organizations on the site that are doing work that could be severely affected by adverse meteorological conditions (thunderstorms, strong winds, dense fog, and snowstorms). The day-to-day meteorological data generated by the MCSP are essential for assuring that work activities are conducted efficiently and under the safest conditions possible. The project also provides timely meteorological data in the event of a suspected or actual release of radioactive or hazardous material to the atmosphere, so that personnel responding to the event can make appropriate and timely decisions. The data are also integral to the site's annual estimates of potential public radiation exposures. Comprehensive climatological data records are maintained for use in a variety of other applications, such as post-accident analysis, dose reconstruction, building design, and environmental impact assessments. The project maintains a long-term meteorological computer database and produces an annual climatological data summary for the Hanford Site environmental report (e.g., PNNL-16623).

Section III.B describes the rationale and design of the MCSP, including the number and location of weather stations, the instruments used, forecasting capabilities, data management efforts, diffusion modeling activities, and emergency response capabilities.

Ecological Monitoring and Compliance. The Ecological Monitoring and Compliance (EMC) Project has multiple objectives that support both activity specific ecological compliance requirements and site-wide requirements to assure the protection of the site's natural resources. EMC project personnel monitor the abundance, vigor, and distribution of plant and animal populations on the Hanford Site and evaluate the cumulative impacts of site operations on these resources. In addition, EMC project personnel perform baseline ecological resource surveys to document the occurrence of protected resources, evaluate and document impacts to protected species and habitats as required by NEPA and the *Endangered Species Act*, facilitate cost effective regulatory compliance, and assure fulfillment of DOE natural resource protection responsibilities.

Section III.C provides additional detail about the types of studies and activities conducted to monitor the status of important resources on and near the site and assure compliance with state and federal resource protection laws.

Cultural Resources. The Hanford Cultural Resources Project (HCRP) performs baseline cultural resources surveys to document the occurrences of protected resources, evaluate and document impacts to protected resources as required by the NHPA, the *American Indian Religious Freedom Act*, and the *Archaeological Resources Protection Act*, facilitate cost-effective regulatory compliance, and assure fulfillment of DOE cultural resources protection responsibilities.

Section III.D provides a detailed description of the HCRP, including requirements, rationale, objectives, and survey design. Additional information is also available within the Cultural Resources section of RIMS.

Groundwater Monitoring

The Soil and Groundwater Remediation Project is responsible for assessing the distribution and movement of existing groundwater contamination (both radiological and chemical) and for identifying and characterizing potential and emerging groundwater contamination problems. Monitoring activities are conducted to comply with requirements of the *Resource Conservation and Recovery Act* (RCRA) and state of Washington regulations, as well as requirements for operational monitoring around retired reactors and chemical-processing facilities, and requirements for environmental surveillance. Groundwater monitoring is also carried out during cleanup investigations under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). Groundwater samples are currently collected from approximately 780 wells, both on and off the site.

Section IV describes the site's groundwater monitoring activities. Groundwater information discussed in this plan includes program design, well locations, sampling frequencies, sampling procedures, analyses performed, data reviews, and rationale for the level of effort devoted to each activity.

Additional information is available in the "Environmental Protection" section of the "Groundwater Protection Management Program" sub-section within RIMS.

Independent Verification of Hanford Site Environmental Monitoring Programs

The WDOH, through a grant from the DOE, conducts an independent verification of the quality of DOE environmental programs at the Hanford Site. The grant provides funds for sample collection and analysis, data compilation and interpretation, and report preparation. In addition, the WDOH participates in periodic collaborative studies with the site environmental monitoring programs to address specific environmental concerns and/or data needs. The WDOH periodically publishes the results of its independent activities in a report (e.g., WDOH 320-039) produced through their Environmental Radiation Program.

Environmental ALARA Program

The as low as reasonably achievable (ALARA) process is used at the Hanford Site to manage and control releases of radioactive material to the environment to levels that are acceptable to the public and regulators, but do not put undue burdens on projects operations and activities. The driving requirements behind the environmental ALARA program are DOE Order 5400.5 and WAC 246-247. DOE Order 5400.5 requires the ALARA process for all activities that result in public doses. WAC 246-247 also mandates the ALARA program as a standard for controlling radioactive air emissions.

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

The ALARA process is applicable to any activity on the Hanford Site that has the potential to expose members of the public or the environment to radiological releases. The primary Hanford Site sources of potential public and environmental radiation exposures are from facility and fugitive air emissions, the processing and transport of radionuclide liquid wastes, and the discharge of groundwater contaminated by past waste disposal practices into the Columbia River.

Typical ALARA program evaluations for radiation protection purposes primarily consider human health. The environmental ALARA process also considers societal, technological, economic, and public policy factors. Some examples of these factors are impacts to sensitive species and habitats, effects on cultural and historic resources, real or perceived restrictions to land use, sociopolitical aspects, and public perception.

Implementation of the environmental ALARA process occurs through Integrated Environment, Safety, and Health Management System (ISMS) core functions and Environmental Management System (EMS) elements. The planning element of the EMS addresses the first three core functions of the ISMS: 1) define the scope of work, 2) analyze the hazards, and 3) develop and implement hazards controls. The ALARA process is simply another requirement blended into the ISMS core functions during job hazards analyses. In general, the ALARA process is analogous to the DOE Order 450.1 definition of an EMS as "a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals." The integration of the ALARA process and the EMS into the ISMS provides a unified strategy for the management of resources, the control and attenuation of risks, and the establishment and achievement of environment, safety, and health goals.

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Hanford Site Environmental Monitoring Plan

Section II. Near-Facility Environmental Monitoring

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Introduction

Near-facility environmental monitoring is an important element of the Effluent and Environmental Monitoring Program managed by Fluor Hanford, Inc., and the River Corridor Closure Project managed by Washington Closure Hanford LLC. This monitoring is directed by Fluor Hanford, Inc. in accordance with U.S. Department of Energy (DOE) Orders 231.1A and 450.1, DOE M 435.1-1, AOP 00-05-06, and quality assurance criteria specified in HNF-EP-0538. Near-facility environmental monitoring consists of both pre-operational monitoring surveys and operational monitoring. Pre-operational monitoring surveys are conducted to obtain environmental baseline information that can be used to design a routine operational environmental monitoring program. Operational monitoring is conducted near active facilities and operations that have the potential to significantly impact the Hanford environment and at inactive contaminated facilities, such as former waste storage and disposal facilities.

Pre-Operational Environmental Survey

Pre-operational characterization, assessment, and site evaluation are required by DOE Order 450.1 and DOE M 435.1-1:

> "Proposed locations for low-level waste facilities shall be evaluated to identify relevant features that should be avoided or must be considered in facility design and analysis."

> "Contractors must ensure the early identification of an appropriate response to, potential adverse environmental impacts associated with DOE operations, including as appropriate, preoperational characterization and assessment; and effluent and surveillance monitoring."

> "Preoperational monitoring of a new disposal site or the expansion of an existing disposal site to determine baseline conditions will be conducted as required by DOE M 435.1-1 as part of the Site Evaluation (DOE M 435.1-1, Section IV.M.(1)). This activity needs to be performed for at least one year prior to construction of a disposal facility. Because much of the environmental data collected by monitoring programs is influenced by seasonal events, one year of data represents an absolute minimum for data collection for new disposal sites. Longer periods of baseline monitoring data collection extending to five or more years provide a better data base. Media selected for monitoring needs to be those most likely to be affected by site development and waste disposal operations. Monitoring locations for all media are selected to provide an uninterrupted stream of data throughout site development, facility operations, facility closure, and post-closure. Preoperational monitoring provides site characterization information, site suitability information, and provides records for public information."

General guidelines for conducting a pre-operational environmental survey can be found in DOE/EH-0173T and DOE/LLW-13Tg.

User Identification

There are five primary users of a pre-operational environmental survey:

1. The planning and construction organization (to demonstrate compliance with DOE Orders 231.1A, 450.1, and 451.1B and DOE M 435.1-1).

2. The facility operating and environmental restoration organizations (to show that containment systems for stored chemicals and waste remain adequate in compliance with DOE Orders 231.1A and 450.1 and DOE M 435.1-1).

3. The program staff (to provide adequate data for determining the need to modify the existing near-facility monitoring objectives and to determine effluent trends and environmental conditions).

4. The Surface Environmental Surveillance Project (managed by Pacific Northwest National Laboratory [PNNL]) to adjust or supplement monitoring locations if needed.

5. Legal counsel (to provide input to plaintiff requests and demonstrate regulatory compliance).

Survey Design

A pre-operational environmental survey is designed to monitor the media specified in DOE/EH-0173T and DOE/LLW-13Tg. To assist in designing this survey, existing documents (e.g., unplanned-release reports, occurrence reports, operational and site environmental reports, historical photographs, environmental impact statements, and preliminary safety analysis reports) are reviewed.

Before initiating pre-operational sampling of any new or modified facility or process, a sampling and analysis plan is prepared and issued. The sampling and analysis plan contains a project description and sampling design rationale and identifies the media to be sampled and analyses to be performed.

Once pre-operational monitoring is completed and analytical data are available, a final pre-operational environmental monitoring report is prepared (e.g., WHC-SD-W058-RPT-001; WHC-SD-WM-TI-778; HNF-2067; HNF-4401; HNF-6150).

Routine Near-Facility Environmental Monitoring

Facility specific environmental monitoring is provided to protect the environment adjacent to nuclear facilities and waste storage, treatment, and disposal sites in compliance with applicable federal, state, and local environmental regulations and requirements.

The objectives of this monitoring are to evaluate:

- Compliance with federal, state, and local environmental radiation protection requirements and guides.

- The performance of radioactive waste confinement systems.
- Concentration trends of radioactive materials in the environment at and adjacent to nuclear facilities, waste disposal sites, and remedial-action activities.

Specifically, near-facility environmental monitoring entails:

- Monitoring inactive, existing, and new low-level waste disposal sites to assess both radiological and non-radiological hazards (DOE Order 435.1 and DOE M 435.1-1).
- Determining the effectiveness of treatments and controls used to reduce effluent and emissions (DOE/EH-0173T).
- Detecting and quantifying unplanned releases (DOE/EH-0173T; 40 CFR 302; WAC 173-303; DOE Order 232.1A).
- Monitoring fugitive emissions (i.e., diffuse sources) from contaminated areas for compliance with national emission standards for hazardous air pollutants (40 CFR 61; DOE/EH-0173T), toxic air emissions (40 CFR 265, Subparts AA and B13), state operating permits (40 CFR 70), and source registration (WAC 246-247).
- Monitoring all surplus facilities before decontaminating or decommissioning (DOE M 435.1-1).
- Monitoring new and existing sites, processes, and facilities to determine potential environmental impacts and releases of contaminants (DOE Order 231.1A; DOE/EH-0173T).
- Monitoring and assessing environmental radioactive contamination and potential exposure to employees and the public (DOE Orders 231.1A, 450.1, and 5400.5).

The primary justifications for near-facility environmental monitoring include:

- Providing regulatory compliance.
- Providing a level of assurance that the effluent and contamination controls for the various facilities and waste sites are effective.
- Monitoring a diversity of operations, activities, and programs managed by several different organizations (accordingly, direction and integration are needed to ensure consistency, technical quality, and cost effectiveness).
- Providing data to assure safe access to a site.
- Assuring the public that the environment is protected.

Near-facility environmental monitoring personnel are responsible for planning, directing, and executing the effective, technically sound monitoring of selected media and for making sure that the regulations and requirements are satisfied. These responsibilities include establishing the basis and scope of the monitoring, developing sampling and surveying schedules, and assuring that schedules and

procedures are followed by the performing organizations. The monitoring personnel serve as primary contacts within and outside of Hanford Site contractors in technical matters pertaining to near-facility environmental monitoring and represent Hanford Site contractors in support of the DOE at meetings with environmental regulators regarding this type of work.

Data obtained as a result of near-facility environmental monitoring activities are used to identify areas of non-compliance with regard to loss of contamination control. Radiological problem reports, occurrence reports, and compliance assessment reports are the formal mechanisms for documenting instances of non-compliance. Formal tracking of non-compliance is also performed. Compliance schedules by the non-compliant organization are then closely tracked to determine their effectiveness. These activities perform the critical function of formally identifying areas of concern regarding unacceptable environmental conditions.

A list of federal, state, and Hanford Site documents regulating environmental monitoring activities is provided in Table II-1.

User Identification

There are six primary users of near-facility environmental monitoring:

1. The planning and construction organization (to demonstrate compliance with DOE Orders 435.1, 450.1, and 451.1B and DOE M 435.1-1).

2. The facility operating contractor (to show that containment systems for stored chemicals and wastes remain adequate in compliance with DOE Orders 435.1 and 450.1 and DOE M 435.1-1).

3. Near-facility environmental monitoring personnel (to provide adequate data for determining the need to modify the existing near-facility monitoring objectives and to determine effluent trends and environmental conditions).

4. PNNL's Surface Environmental Surveillance Project (to adjust or supplement monitoring locations as needed).

5. Legal counsel (to provide input to requests and demonstrate regulatory compliance).

6. Regulatory agencies and the public (to verify compliance with laws and regulations and protection of the environment).

Review

The scope of near-facility environmental monitoring is reviewed by management and staff at least annually to make sure that the work complies with current regulations, that appropriate effluent and emissions are being monitored, and that the monitoring locations are positioned to best determine and quantify potential releases.

Table II-1. Governing Documents for Environmental Monitoring

Document Number	Title
40 CFR 61	National Emission Standards for Hazardous Air Pollutants
40 CFR 70	State Operating Permit Programs
40 CFR 264	Final Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 302	Designation, Reportable Quantities, and Notification
40 CFR 1501	NEPA and Agency Planning
DOE M 450.4-1	Integrated Safety Management System Manual
DOE Order 231.1A	Environmental, Safety, and Health Reporting
DOE Order 232.1A	Occurrence Reporting and Processing of Operations Information
DOE Order 435.1	Radioactive Waste Management
DOE Order 450.1	Environmental Protection Program
DOE Order 451.1B	National Environmental Policy Act Compliance Program
DOE Order 5400.5	Radiation Protection of the Public and the Environment
Chapter 1	General
Paragraph 8	Environmental Monitoring and Surveillance
DOE/EH-0173T	Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance
DOE/LLW-13Tg	Low-Level Waste Management Handbook Series, Environmental Monitoring for Low-Level Waste Disposal Sites
DOE/RL-91-50 (latest revision)	Environmental Monitoring Plan, United States Department of Energy, Richland Operations Office
DTS-OEM-001	Operational Environmental Monitoring
HNF-EP-0538	Near-Facility Environmental Monitoring Program Quality Assurance Project Plan
HNF-PRO-15333	Environmental Protection Processes
HNF-PRO-15334	Effluent and Environmental Monitoring
HNF-PRO-15335	Environmental Permitting and Documentation Preparation
WAC 173-303	Dangerous Waste Regulations
WAC 173-400	General Regulations for Air Pollution Sources
WAC 246-247	Radiation Protection - Air Emissions

Design

Sampling Locations, Sampling Frequencies, Media Sampled, and Parameters Monitored

Media near active/inactive facilities to be sampled include ambient air particulates, soil, and biota. Parameters routinely monitored include, as appropriate, radionuclide concentrations, radiation exposure levels, radiation dose rates, and hazardous constituent concentrations. Sample types, collection and measurement frequencies, and analytes and parameters routinely monitored are summarized in Table II-2.

Table II-2. Sample Types, Collection or Measurement Frequencies, and Analytes and Parameters Routinely Monitored by Near-Facility Environmental Monitoring

Sample Types	Collection or Measurement Frequencies	Analytes/Parameters Monitored
Air	Biweekly	Gross alpha and beta
	Quarterly and/or Semiannual	Strontium, plutonium, uranium, gamma
Soil	Annual	Strontium, plutonium, uranium, gamma
Vegetation	Annual	Strontium, plutonium, uranium, gamma
Animals	Annual	Strontium, plutonium, uranium, gamma
Thermoluminescent dosimeter	Quarterly	External radiation dose
Survey point	Annual	External radiation dose

Monitoring Locations

Information regarding specific sampling locations can be found in HNF-SP-0098. The criteria for establishing monitoring locations for each of the sample types in Table II-2 are as follows:

- Air – downwind and within a few meters of a source. Unless documented site-specific evidence exists to justify otherwise, the sample(s) will be collected in a location free from unusual localized effects or other conditions (i.e., near a large building, vehicular traffic, trees) that could result in artificially high or low concentrations.

- Soil and vegetation – on or near sites and/or facilities with the potential for biological intrusion.

- Animals – on or near sites and/or facilities with the potential for biological intrusion. Animals are sampled opportunistically.

- External dose rate – at or near facilities that may cause elevated dose rates, including active/inactive sites, waste handling facilities, effluent discharge points, and other suspected pathways for radiation exposure.

- Radiation surveys – at inactive waste sites; outdoor radiological control areas; tank farm perimeters and associated diversion boxes, lift stations, and vent stations; perimeters of active or uncovered waste sites (e.g., retention basins, ponds, solid waste burial grounds, ditches); and road and railbed surfaces.

Sampling Frequencies

A routine near-facility environmental monitoring schedule is developed, reviewed, and approved by Fluor Hanford, Inc. and Washington Closure Hanford LLC. The radiation survey frequencies for particular sites are based on site history, radiological conditions, and general maintenance. All sites are surveyed at least once each year. Special surveys may be conducted at more frequent intervals if conditions warrant (e.g., growth of deep-rooted vegetation is noted at a waste site). Sampling and survey frequencies are shown in Table II-2.

Sampling and Measurement Methods

Sampling methods are reviewed to determine equipment efficiency and to comply with current federal (U.S. Environmental Protection Agency) and industry (American National Standards Institute [ANSI-N545-1975]; American Society for Testing and Materials [ASTM 1976]) standards. The following sampling methods are routinely used for near-facility environmental monitoring:

- Ambient air – Air sampling stations collect samples at a height of 2 meters above ground level and use a vacuum pump to pull air through a 47-millimeter-glass-fiber filter at a nominal flow rate of 0.057 cubic meter per minute. A timer and flow-rate meter are used to determine sample time and flow rate, respectively. Filters are collected biweekly to prevent dust loading on the sample filter and impaired flows.

- Soil – Soil sampling equipment may be one of three types: 1) a spade, 2) a core sampler (split spoon) for special soil sampling, or 3) a plug (“cookie cutter”) sampler for routine samples. All equipment is easily decontaminated or is disposable. Samples are placed in a sealable plastic bag or other suitable container and, if necessary, into an appropriate container for shipment.

- Vegetation – Vegetation sampling equipment consists of pruning shears, loppers, saws, a core drill, or a machete. Samples are cut to length, placed in a plastic bag, and, if necessary, into an appropriate container for shipment.

- Animals – Animal samples are usually collected as a result of pest control activities. The animals are checked for radioactive contamination by radiation control staff; those animals found to be contaminated may be retained for analysis. The samples are put in a plastic bag and, if necessary, into an appropriate container for shipment.

- External dose rates – Ambient dose rates are taken by two methods: Harshaw 8807 environmental thermoluminescent dosimeters (TLDs) and micro-rem meters. The TLDs consist of two lithium fluoride (TLD-700) and two calcium fluoride dysprosium (TLD-200) chips sealed in a plastic holder supplied by the PNNL. Three TLDs are placed at each measurement location on a post at 1 meter above the ground. A Bicron micro-rem meter with a tissue equivalent organic scintillator is used to measure relative dose rates.

- Radiation surveys – Radiation survey locations may include road and railbed surfaces, cribs, stabilized burial grounds, covered ponds and ditches, tank farm perimeters, active burial ground perimeters, unplanned release sites, and other radiation areas.

  – Road and rail surveys are performed with a mobile surface contamination monitor or a vehicle equipped with sodium iodide detectors or plastic scintillators. The detector height is adjustable in all cases, and the average survey height is 0.3 meter. When activity is detected, the vehicle is stopped and a thorough survey is made with an Eberline Model BNW-1 portable survey instrument equipped with a P-11 probe to identify the extent of the contamination.

  – Surveys at waste sites and other radiation areas may be conducted with vehicles equipped with radiation detection instruments or with hand-held field instruments. Wherever possible, smear surveys are made on the surface of exposed equipment within a radiation area. Vegetation, animal burrows, and animal feces are also monitored to detect biological transport. Detailed survey practices and procedures are described in DTS-OEM-001, HNF-5173, and HNF-13536.

Parameters Monitored

The parameters to be monitored for each medium vary and may include the following:

- Ambient air – isotopic or total gamma, gross alpha and beta, strontium, plutonium, and uranium at selected locations.

- Soil – isotopic or total gamma, strontium, plutonium, and uranium.

- Vegetation – isotopic or total gamma, strontium, plutonium, and uranium.

- Animals – isotopic or total gamma, strontium, plutonium, and uranium.

- External dose rate – measured in the area where samples are taken to identify any increasing or decreasing trends in radiation that may affect the environment, the workers, or the public.

- Radiation surveys – performed to measure the surface and background radiation in the area in which the measurement is taken.

Samples are typically analyzed for the constituents listed in facility effluent monitoring plans (FEMPs) for the facility of concern. Best professional judgment is used to locate initial sampling sites to monitor the near-facility environment.

Quality Assurance

Quality assurance (QA) may be defined as the actions necessary to ensure the accuracy of a program. The near-facility environmental monitoring QA program consists of procedures and guidelines to demonstrate that environmental monitoring techniques and analyses are performed within established limits of acceptance. Documentation is provided in the *Near-Facility Environmental Monitoring Program Quality Assurance Project Plan* (HNF-EP-0538).

Written operating procedures are an integral part of near-facility environmental monitoring QA. Procedures for field operations are provided in *Operational Environmental Monitoring* (DTS-OEM-001). The following briefly describes the essential components of the near-facility environmental monitoring QA program.

Documentation

Record keeping is a vital part of any environmental monitoring program. Maintenance of environmental data is important from a QA standpoint, from a regulatory standpoint, and for trend analyses and optimization of environmental monitoring procedures. Each phase of near-facility environmental monitoring is documented. This documentation includes environmental sample logbooks, quarterly reports, annual reports, and occurrence reports.

Sample Replication

Replicate sampling and subsequent analyses are the primary means of assessing sample variability. Duplicate samples of air, soil, and vegetation are collected.

Data Analysis

Environmental data are reviewed to determine compliance with applicable federal and company guides. The data are analyzed both graphically and by standard statistical tests to determine trends and impacts on the environment. Newly acquired data are compared with historical data and natural background levels. Routine environmental data are stored on both electronic media (i.e., in a computer environment) and hard-copy printouts.

Analytical Procedures

Three laboratories provide analytical support to the near-facility environmental monitoring program: the PNNL, Waste Sampling and Characterization Facility, and 222-S Analytical Laboratory. Samples are analyzed in accordance with prescribed procedures and quality control guides that meet the requirements of the American National Standards Institute (ANSI-N545-1975), Environmental Measurements Laboratory (EML 1972), American Society for Testing and Materials (ASTM 1976), American Public Health Association (APHA 1980), and U.S. Environmental Protection Agency (EPA 600/4-79-020).

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Hanford Site Environmental Monitoring Plan

Section III.A. Surface Environmental Surveillance

Prepared by: Date:	Concurrence: Date:
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Introduction

This section describes the plan for conducting surface environmental surveillance on and around the Hanford Site. The purpose of this section is to describe how the surveillance and reporting requirements of DOE Orders 5400.5, 450.1, and 231.1A and the guidance of DOE/EH-0173T are to be met for the Hanford Site.

The Surface Environmental Surveillance Project (SESP) conducts environmental monitoring to measure contaminants in environmental media. Project personnel collect samples of air, surface water, sediment, soil, natural vegetation, agricultural products, fish, and wildlife. Samples are analyzed for concentrations of radionuclides attributable to natural sources, worldwide fallout from nuclear weapons testing, and Hanford operations. Data are also collected to monitor several chemicals and metals with both Hanford and non-Hanford sources in Columbia River water and sediment, and in fish and wildlife.

Activities inherent in the operation of the SESP include surveillance design and implementation, procedure development, sample collection, sample analysis, database management, data review and evaluation, chemical exposure assessment, radiological dose assessment, and reporting. Other elements of the project include project management, quality assurance and quality control, staff supervision, training, records management, and equipment maintenance.

Surveillance activities focus on materials that are, have been, or potentially could be released from U.S. Department of Energy (DOE) facilities and work areas on the Hanford Site; however, unplanned releases and releases from non-DOE operations on and near the site are also considered. Surveillance results are provided annually to the DOE; federal, state, and local regulatory agencies; site contractors; environmental groups; regional communities and governments; the public; and Indian Tribes and Nations through the Hanford Site environmental report (e.g., PNNL-16623). In addition, unusual results or trends are reported to the DOE when they occur. Although the scope of the SESP includes chemical surveillance, the primary focus of this surveillance plan is on radiological contaminants.

This section (III.A) of the plan is related to other sections in several respects. The sampling design described is based on radiological and chemical pathway analyses that use data obtained as required by facility effluent monitoring plans and by the near-facility environmental monitoring program described in Section II. The pathway analyses and radiological dose assessments conducted for this plan, and the radiological dose assessments reported in the annual Hanford Site environmental report (e.g., PNNL-16623) use the dispersion data provided by the Meteorological and Climatological Services Project described in Section III.B. The ecological monitoring and compliance assessment studies discussed in Section III.C can be integrated with SESP contaminant monitoring data to assess potential affects of Hanford contaminants on individuals and populations. The pathway analyses and radiological dose assessments conducted for this section include the contribution to dose from the groundwater pathway discussed in Section IV.

The environmental pathways carrying contaminants to people and biota, and the significance of the media and contaminants to total radiological dose, are strongly influenced by environmental settings. The Hanford Site's environmental setting has been summarized in the *Hanford Site National Environmental Policy Act (NEPA) Characterization Report* (PNNL-6415) and is not described here.

Requirements and Objectives of Environmental Surveillance

The general requirements and objectives for environmental surveillance are contained in DOE Orders 450.1 and 5400.5. The broad surveillance objectives are to demonstrate Hanford Site compliance with legal and regulatory environmental requirements, to confirm adherence to DOE environmental protection policies, and to support environmental management decisions. These broad surveillance objectives are embodied in the primary surveillance objectives stated in the DOE Orders and in DOE/EH-0173T:

- Determining the status of the DOE's compliance with applicable environmental quality standards, public exposure limits, and applicable laws and regulations; complying with the requirements of DOE Orders 450.1, 5400.5, and 231.1A; and complying with the environmental commitments made in environmental impact statements, environmental assessments, contractor work plans, state permits, safety analysis reports, or other official DOE documents. Additional objectives that derive from these primary objectives include:
  - Assessing preoperational environmental conditions.
  - Assessing radiological doses to the public and biota from site operations.
  - Assessing radiological doses from other local sources.
  - Reporting environmental alarm levels and potential radiological doses exceeding reporting limits (DOE Order 5400.5, Chapter II, Section 7).
  - Preparing a comprehensive annual (calendar year) site environmental report.
  - Maintaining an environmental monitoring plan (this plan) as part of an Environmental Management System.
- Determining background contaminant levels and site contributions of contaminants in the environment.
- Determining long-term accumulations of site-related contaminants in the environment and documenting concentration trends.
- Determining the effectiveness of treatments and controls for site effluent and emissions.
- Determining the validity and effectiveness of computer models used to predict the concentrations of pollutants in the environment.
- Detecting and quantifying unplanned contaminant releases.
- Identifying and quantifying new or existing environmental quality problems.

DOE/EH-0173T indicates that subsidiary objectives for surveillance should be considered. Subsidiary objectives applicable to the Hanford Site include:

- Obtaining data and maintaining the capability to assess the consequences of accidents or occurrences that release contaminants to the environment.
- Providing public assurance; addressing issues of concern to government officials, regulatory agencies, and stakeholders including the public, local businesses, people or businesses considering relocating to the Hanford area, Hanford Site workers, and local American Indian Tribes.
- Enhancing public understanding of Hanford's impact on the environment through public involvement activities and reporting.
- Providing environmental data and assessments to assist the DOE in environmental management of the site.
- Providing environmental data and assessments to assist contractors in managing construction, cleanup, and remediation activities.

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

Surface Environmental Surveillance Design

Environmental surveillance is designed to meet the objectives listed in the previous section while considering the environmental characteristics of the site and potential and actual releases from site operations. Surveillance activities focus on determining environmental impacts and compliance with public health and environmental standards or protection guides rather than on providing detailed radiological and chemical characterization. Experience gained from environmental surveillance activities and studies conducted at the Hanford Site for more than 50 years is invaluable when planning the surveillance design.

This section discusses the rationale and criteria for Hanford Site environmental surveillance, surveillance design, and the annual surveillance design review process.

Rationale and Design Criteria

The rationale and criteria for Hanford Site environmental surveillance are based on:

- The requirements in DOE Orders 450.1 and 5400.5.
- The requirements in DOE/EH-0173T.

- The results of radiological and chemical pathways analyses.
- Ongoing or anticipated cleanup, remediation, and construction activities.
- Site or activity specific local, state, and federal regulatory requirements.
- Other site commitments.

The minimum objective criteria for determining the content of surveillance projects are contained in Tables 5-1 and 5-2 of DOE/EH-0173T and Table 4 of Section 7 of EPA-520/1-80-012.

Based on current radiological levels and doses, and the above referenced objective criteria alone, periodic surveillance measurements are required a minimum of every 5 years to confirm that doses are below the objective criteria. However, conducting only confirmatory surveillance measurements every 5 years at the site and in the surrounding region would not fully meet some of the primary surveillance objectives (see Requirements and Objectives of Environmental Surveillance on page III.A-2) or satisfy the subsidiary objectives. The rationale and criteria for additional sampling in each medium will be discussed in the sections that follow. First, there are some general considerations that will be factors in decisions about the content of the surveillance design.

The application of objective criteria from DOE/EH-0173T to the radiological pathway analysis addresses only surveillance for routine releases and does not consider the very large inventory of radioactive materials potentially available for release. Likewise, the onsite inventory of hazardous chemical waste generated during historical operations is believed to be very large.

The need for routine surveillance is reinforced by the recognition that cleanup and remediation actions under the *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement; Ecology et al. 1989) are underway and will continue over the next few decades. These actions, in some cases applying cleanup technologies that have never been used before, may increase the potential for contaminant releases to, and migration within, the environment. The design for routine surveillance includes the establishment of contaminant concentration baselines for assessing the effects of cleanup and remediation actions occurring across the site and for monitoring trends in contaminant concentrations related to those actions.

Design rationale and criteria that apply to most environmental media are summarized in the following paragraphs.

Media Selections

The highest sampling priority is given to media that are directly ingested or inhaled by people. Other media are selected for sampling based on their sensitivity as indicators of loss of materials control, potential use for predicting contaminant accumulations and trends, potential to function as indicators of environmental quality, potential to serve as indicators of biotic impacts, and potential for bioaccumulation in food products (e.g., milk).

Sampling Locations

Background sampling locations (locations reasonably expected to be unaffected by Hanford Site discharges) are established for all media contaminant combinations that are routinely sampled (e.g., PNNL-16369), or would likely be sampled, to assess the environmental impacts of unusual or accidental contaminant releases. Sampling locations near potential onsite contaminant sources are selected to maximize the probability of detecting a loss of containment, and to help assess the magnitude and effects of releases. Sampling stations at the site perimeter (near or just inside the site boundary) are positioned to estimate conditions at the nearest points at which members of the public can be exposed. Exposures at these locations are typically the maximum that any member of the public (not working on the Hanford Site) could receive. Finally, sampling is conducted in nearby communities to obtain data where most of the potential exposures may occur and to provide assurance to the communities that contaminant levels are well below standards established to protect public health and the environment.

Sampling and Analysis Frequencies

Sampling frequencies are based on the need to obtain time representative samples, environmental factors that may impact collection efficiencies, the limitations of the sampling equipment or sampling substrates, and sample availability. Most routine samples are collected biweekly, monthly, or quarterly. However, some are collected semiannually, annually, biennially, or every 3 to 5 years. Most samples are submitted for analysis immediately following collection. Some are retained at the analytical laboratory for several weeks or months and composited with other samples to increase time representativeness and to make it possible to detect contaminants that are present at very low concentrations. The exposure or sample compositing period may be up to 3 months.

Sample Collection and Handling Methods

Sample collection and handling procedures for the SESP are described in PNNL-16744. Steps are incorporated in the sampling procedures to avoid misidentification and cross contamination of the samples being collected. Chain-of-custody procedures are used to assure the integrity of the samples throughout the collection/transport/analysis process and are detailed in the Pacific Northwest National Laboratory's (PNNL's) Standards-Based Management System (SBMS) (PNNL 2007) and PNNL-16744.

Analytical Detection and Precision

The general strategy for obtaining the lowest levels of detection practical is to use standard analytical procedures and to take into consideration practical sampling strategy tradeoffs (e.g., time and location compositing versus discrete samples). Where technically feasible and practical, the minimum objective for a given medium and radiological contaminant combination is to detect a concentration that is equal to or below the concentration that would result in a dose to humans of 1-millirem-per-year effective dose equivalent (EDE) if exposure to that concentration was sustained for 1 year. This dose estimate assumes that the radionuclide is being transported to subsequent compartments of the exposure pathway and that the individual is exposed to all subsequent compartments. For example, the pathway for air assumes not only inhalation but also exposure to airborne materials deposited on the ground and to contaminants from the air taken up in locally grown foods. One millirem is 10% of the public exposure level that must be

reported to the DOE and is 10% of the federal dose limit (40 CFR 61) for the air pathway. Generally, most radionuclide concentrations in environmental samples collected around the Hanford Site result in an annual dose below 1 millirem.

Quality Assurance

Quality assurance (QA) requirements are documented in the PNNL's SBMS (PNNL 2007). QA for the SESP is controlled under the overall project QA and quality control program described in the Quality Assurance and Quality Control section on page III.A-49. As part of the project's QA program, selected sediment, surface water, food and farm products, wildlife, and soil and vegetation samples are provided to the Washington State Department of Health (WDOH) and the U.S. Food and Drug Administration for comparative analyses. Blind-spiked samples provided by the DOE and U.S. Environmental Protection Agency (EPA) are analyzed by the laboratory to evaluate analytical performance on radiological samples. A similar performance evaluation involves the laboratory that analyzes samples for inorganic metals.

Reporting/Alarm Levels

When concentrations of selected radionuclides are entered into the Hanford Environmental Information System (HEIS) database (HEIS 1989), the computer compares them to threshold limits established by the project. Each concentration that does not meet the threshold limits is considered anomalous and the computer generates an anomalous data report (ADR). Project personnel review the ADR to determine the validity of the result and whether additional information is needed from the analytical laboratory. The ADRs are maintained as part of the project record.

Concentrations that require notifications to the DOE have also been established for some radionuclides in some media. For consumable media, the reporting levels are functions of the contaminant concentrations in the edible portions of the medium. For soil, the reporting levels are functions of external exposures to radionuclides other than cesium-137 and strontium-90. Reporting levels for these two radionuclides are nominally equivalent to doses of 10 millirems if the soil concentrations and exposures are sustained for 1 year. The natural variabilities of cesium-137 and strontium-90 concentrations in soil samples make it impractical to report a 1-millirem difference between samples. The 10-millirem reporting level provides an early indication of conditions that might require reporting to DOE Headquarters (HQ) as required by DOE Order 5400.5. All reporting levels provide early indications of conditions that might eventually require reporting to DOE-HQ as required by DOE Order 5400.5.

Concentrations of chemicals in water samples are compared to Washington State ambient water quality criteria (WAC 173-201A). Concentration thresholds that require notification to DOE have not been established for chemical contaminants.

Exposure Pathways and Dose Assessments

Exposure pathway and dose assessments are conducted:

- Annually to assess site compliance with the DOE public exposure limit (DOE Order 5400.5) and the criteria in 40 CFR 61.

- Annually to determine the minimum requirements for environmental surveillance as defined in DOE/EH-0173T.

- At least every 5 years to assess compliance with the DOE interim dose limit for native aquatic organisms (DOE Order 5400.5).

- As necessary when exposure conditions have changed significantly.

Surveillance Design

The SESP historically has focused on monitoring radionuclide concentrations in various media and measuring non-radiological water quality parameters. However, surveillance for non-radiological constituents, including hazardous chemicals, is also conducted. A detailed chemical pathway and exposure analysis for the Hanford Site was completed in 1994 (PNNL-10714). Contaminant related assessments of ecological risk along portions of the Columbia River's Hanford Reach shoreline are currently ongoing. The analyses and results from the assessments help guide the selection of chemicals of concern, appropriate sample media, and appropriate sampling locations.

Each year, a radiological pathway analysis and exposure assessment is performed. The pathway analysis is based on source-term data and on the comprehensive pathway and dose assessment methodology included in the Generation II (GENII) Version 1.485 computer code (PNL-6584) used to estimate radiation doses to the public from Hanford Site operations. Biota dose evaluations are conducted using the DOE Technical Standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002). Implementation tools for the biota dose evaluations include the RESRAD-BIOTA computer code, Version 1.0 (DOE/EH-0676). The results of the pathway analysis and exposure assessment, and the biota dose screening evaluation, serve as the bases for future years' surveillance program designs.

Exposure is defined here as the interaction of an organism with a physical or chemical agent of interest. Thus, exposure can be quantified as the amount of chemical or physical agent available for absorption at the organism's exchange boundaries (i.e., dermal contact, lungs, gut). An exposure pathway is identified based on 1) examination of the types, locations, and sources of contaminants (contaminated soil, raw effluent); 2) principal contaminant release mechanisms; 3) the probable environmental fate and transport (including persistence, partitioning, and intermediate transfer) of contaminants of interest; and 4) the locations and activities of the potentially exposed populations. Environmental processes or mechanisms that could influence the fate and movement of chemical or physical agents through the environment, and the amount of exposure a person might receive at various receptor locations, are listed below.

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

- Transported (e.g., migrate downstream in solution or on suspended sediment, travel through the atmosphere as a gas or associated with airborne particles, or be carried offsite in contaminated wildlife).

- Physically or chemically transformed (e.g., volatilized, photolysized, oxidized, reduced, hydrolysized, or changed through radioactive decay).

- Biologically transformed (e.g., biodegraded, metabolized).
- Accumulated in the receiving media (e.g., sorbed in water, soil, or sediment or stored in organism tissues).

The primary pathways for movement of radionuclides and chemicals from the Hanford Site to biota and to the public are the atmosphere, groundwater, and surface water. The significance of each pathway is determined from measurements and calculations that estimate the amounts of radioactive materials or chemicals transported along each pathway, and by comparing contaminant concentrations, or potential doses, to environmental and public health protection standards or guides. Pathways are also evaluated based on prior studies and observations of radionuclide and chemical movement through the environment and food chains. Calculations based on effluent data show the expected contaminant concentrations off the Hanford Site to be low for all Hanford-produced radionuclides and chemicals and to be frequently below the levels that can be detected by current measurement technologies.

The surveillance design uses a stratified sampling approach to monitor these pathways. Samples are collected, and radionuclide and chemical concentrations are measured in three general surveillance zones that extend from onsite operational areas to the offsite environs.

The first surveillance zone extends from near the Hanford Site's operational areas to the site perimeter. The environmental concentrations of contaminants from facilities and fugitive sources (e.g., non-stack releases from facilities or resuspension of contaminated soils) generally would be the highest and, therefore, most easily detected in this zone. The second surveillance zone consists of a series of perimeter sampling stations positioned near or just inside the site boundary, along State Highway 240, which runs through the site from Richland to the Yakima Barricade, and along the Columbia River. Exposures at these locations are typically the maximum that any member of the public (not working on the Hanford Site) could receive. The third surveillance zone consists of nearby and distant community locations within an 80-kilometer radius of the site's operational areas. Surveillance is conducted in communities to obtain measurements at locations where a large number of people potentially could be exposed to Hanford Site releases and to document that contaminant levels are well below standards established to protect public health and the environment.

Background concentrations are measured at locations distant from Hanford and are compared to concentrations measured onsite and at perimeter and community locations. Background locations are essentially unaffected by site operations but may be affected by other man-made sources of contaminants such as fallout from nuclear weapons testing. A comparison of background concentrations to concentrations measured on or near the site may indicate the impact of site operations.

The amounts of most radioactive materials released from site operations are small. Often it is not possible to distinguish levels resulting from worldwide fallout and natural sources from those associated with Hanford Site releases. Therefore, offsite doses are estimated using the following methods:

- Doses from monitored air emissions and liquid effluent released to the Columbia River are estimated by applying environmental transport and dose calculation computer models to measured effluent monitoring data and selected environmental measurements. Pathway modeling results

are compared to measured results to assess model performance, and the results of the comparison are documented. When measured results exceed model results, the measured results are used to calculate doses.

- Doses from fugitive air emissions (e.g., soil gases or resuspended contaminated soils) are estimated from measured airborne concentrations at site perimeter locations.

- Doses from fugitive liquid releases (e.g., groundwater seeping into the Columbia River) are estimated by evaluating differences in contaminant concentrations measured in the Columbia River upstream and downstream from the Hanford Site.

Annual Design/Review Process

The surveillance design is reviewed and evaluated annually based on the above considerations and an awareness of planned waste management and environmental restoration activities. Periodic re-evaluations may be needed during the year to respond to changing operations or environmental conditions. Key steps in the process include:

- Perform a pathway analysis – The design process starts with a radiological pathway analysis performed for the calendar year just ended. This analysis is based on facility emissions and effluent information (DOE/RL-2006-01; HNF-EP-0527-15) and environmental surveillance results from the previous calendar year. The pathway analysis serves as the basis for the design review.

- Produce the Hanford Site environmental report – The annual environmental report (e.g., PNNL-16623) summarizes the findings of environmental surveillance, effluent monitoring, and cleanup activities conducted during the previous calendar year. A comparison of the previous year's results with pathway analysis conclusions helps to identify changes in environmental conditions that may lead to modifications to the sampling design.

- Project future site activities – Because the pathway analysis and the annual report are retrospective, an activities projection from Hanford Site contractors identifies future activities to be considered in the surveillance design. Resources useful in anticipating future environmental surveillance needs include DOE/RL-96-92, DOE/EM-0327, Ecology et al. (1989), various contractor effluent and operational environmental monitoring plans, results from previous years' monitoring, and periodic technical exchanges between the environmental monitoring, *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) cleanup and risk assessment, and environmental surveillance personnel working for the various site contractors.

- Evaluate surveillance design – The above information is considered in an annual surveillance design evaluation. The design evaluation includes field inspections of sampling and measurement locations to determine whether conditions at the sampling locations continue to meet site selection or sampling design criteria. The evaluation also includes an effort to identify and review new surveillance compliance requirements (e.g., DOE Orders, directives, or other applicable federal or state requirements) and DOE/EH-0173T updates. Plans for future years are discussed with appropriate Hanford Site contractors to make sure that assumptions implicit in the surveillance design about the availability of related monitoring data are valid, and to determine

whether recent data indicate conditions or trends that must be considered in the design. The results of this annual surveillance design evaluation, and any actions taken in response to the evaluation, are documented in the project files and in updates to the project documentation package and the environmental surveillance annual sampling schedule (e.g., PNNL-16369). Plans for the upcoming calendar year are developed and discussed with other contractors to coordinate related activities. Plans are also discussed with representatives from the WDOH to identify those samples to be collected by SESP personnel and provided to the WDOH.

- Submit scope and budget information for upcoming fiscal years – Based on the results of the annual surveillance design evaluation, scope and budget information is prepared for a few upcoming fiscal years. The detail in this scope and budget information is necessarily general in nature; however, it does provide a basis for future planning and future scope and budget development.

- Prepare a project documentation package for the next fiscal year – Specific surveillance objectives, work scope, and budget are provided in the project-specific documentation package written for the upcoming (next) fiscal year. The package sets forth the plans and organization that will be used to conduct, control, and document project activities and represents an agreement between the DOE and the Public Safety and Resource Protection Program (PSRPP) on the objectives, scope, and work to be performed during that fiscal year.

- Obtain scope and budget approval – The scope and budget for the project are reviewed and approved by the DOE. Approval of the scope and budget is documented by a DOE signature on the current fiscal year project-specific documentation package.

- Develop an annual sampling schedule for the upcoming calendar year – An annual sampling schedule (e.g., PNNL-16369) is prepared based on the results of the annual design review process.

Air Surveillance

Small amounts of radioactive particles and gases continue to be released to the atmosphere from the Hanford Site. Point sources (stacks and vents) release materials during routine operations. Cleanup and remediation activities and wind-blown dust are also potential sources of contaminants. Once released into the environment, these materials are diluted to low concentrations as they are transported to locations where people may be directly exposed to radionuclides through inhalation and immersion, or indirectly exposed through deposition of contaminants onto farm crops, native vegetation, and surface soil.

Each year, a radiological pathway analysis and exposure assessment is performed. Recent pathway analyses have indicated that the annual dose to a maximally exposed individual from Hanford Site operations is typically less than 0.1 mrem. The air pathway is a major contributor to this dose.

Operations in the former operating areas (100, 200, 300, and 400 Areas) have the potential to accidentally release radioactive contaminants to the atmosphere. Air samplers operating continuously on and around the site would provide data that could be used to help estimate doses following an unplanned release of contaminants.

Objectives

The objectives of air surveillance include:

- Obtaining air concentration measurements at locations of actual and potential public residence to verify that doses to the public from DOE operations remain low relative to standards.
- Providing early detection of potential increases in public and worker exposures, and contamination of the environment, through measurements of actual and potential emissions to the air from facilities and areas with surface contamination and buried waste.
- Providing surveillance data for areas near waste units scheduled for treatment and/or restoration to help assess the integrated effects of individual site actions and actions conducted over time.
- Obtaining measurements at the site perimeter and in nearby communities to provide assurance to the public that the degree of contamination from DOE operations is known.
- Sampling air onsite and offsite continuously to assess the environmental effects and radiological doses from unusual releases.
- Providing data to evaluate and improve the computer models used to predict and assess public dose compliance and environmental contamination.

Plan Rationale and Criteria

The criteria for air sampling consist of those identified in DOE/EH-0173T and in the site's radioactive air emissions license (number FF-01). The locations, media, sampling frequencies, samples that are temporally and spatially composited, analyses, and analysis frequencies to meet Hanford Site air surveillance objectives and criteria are given in an annual sampling schedule (e.g., PNNL-16369). The calendar year 2007 sampling locations are provided in Figure III.A-1. Sampling locations may change annually. The rationale and any additional specific criteria for these selections are discussed below.

Media Selection

Air is sampled according to the primary form in which the radionuclides occur. Most of the radionuclides of interest occur in particulate form at the site. Past measurements indicate that some radionuclides occur predominantly as gases (e.g., tritium, iodine).

Analyte Selections

The radionuclides identified as being routinely collected and analyzed for are those that 1) are released in measurable quantities from Hanford facilities, 2) have the potential to be released under

plausible abnormal conditions, 3) are calculated to contribute more than 10% of the maximally exposed individual dose, or 4) are of special public or agency interest.

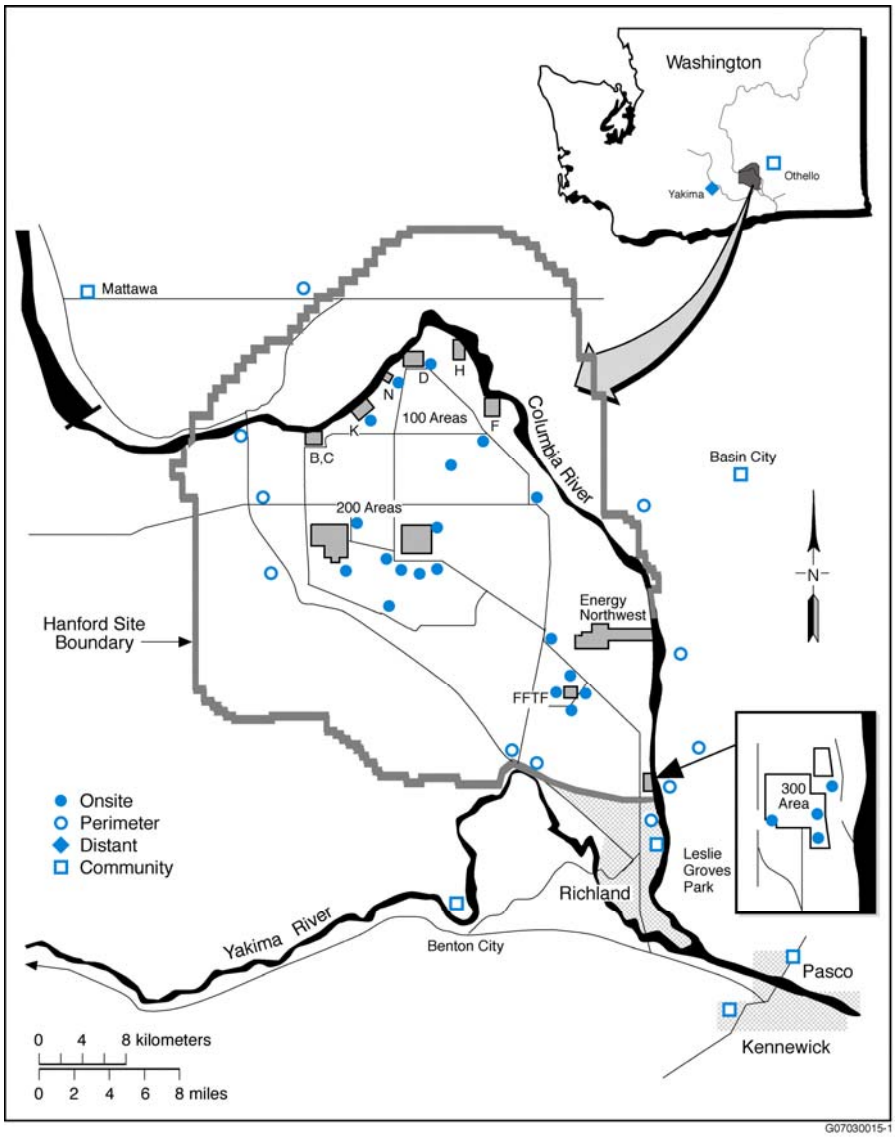

Figure III.A-1. Air Sampling Locations in 2007

Sampling Methods

Air samples are collected in ways that avoid loss of sample mass, cross contamination, or misidentification. Exchanging whole sample collection media containers, rather than handling the collection media in the field accomplishes this as does labeling and sealing or storing each sample so that sample integrity as it is collected in the field is maintained. Airflow control for all radiological samples is maintained with mechanical flow controllers. Sampler plumbing is designed to minimize fluctuations in flow throughout the sampling period. This is important for assuring the collection of a sample representative of the entire sampling interval (i.e., results are not biased toward one portion of the interval).

Air samples analyzed for gross beta, gross alpha, strontium-90, plutonium isotopes, uranium isotopes, and gamma emitters are collected by continuously drawing air through high-efficiency glass-fiber filters. The filters have a sampling efficiency of at least 99% for 0.3-micrometer-diameter particles at the flow rate being used (~2.5 cubic meters per hour). Flow rates for particle filters are checked and readjusted (if needed) at the end of the sampling period and sample volumes are measured with in-line dry-gas meters.

When samples are collected for iodine-129 analysis, they are collected on petroleum-based (low-background) charcoal cartridges. Iodine cartridges are preceded in the sampling train by a disposable glass fiber filter to remove particles. The collection efficiency of the cartridges has been verified at a flow rate of 2.5 cubic meters per hour. The cartridges have a 2.5-centimeter bed depth and have a nominal exposure period of 28 days.

Samples for tritium analysis are collected on silica gel. Air flow rates (0.011 cubic meter per hour), sampling volumes, and exposure periods (nominally 28 days) are such that the gel is not likely to be saturated during the sampling period, minimizing the likelihood of sample loss due to breakthrough. Silica gel saturation is monitored using a color-change indicator in the gel, which is also useful in diagnosing problems in the sampling system (i.e., leaks). Flow rates for adsorbent samples are measured at the beginning and end of each sampling period using a device with a documented accuracy of ±20%. Sample volumes are calculated by the laboratory using the average of the initial and final flow rate measurements, and the hours of exposure.

Sampling and Analysis Frequencies

Air sampling locations are visited every other week. Experience indicates that air-particulate glass-fiber filters must be collected at this frequency to avoid occasional excess particulate buildup on the filters. Following collection, each particulate sample is analyzed for gross beta to provide an early indication of any unplanned contaminant release that may require expedited analysis of samples and/or additional or special sampling. For the same reason, some particulate samples are also analyzed for gross alpha. Biweekly filter samples from a single location or from multiple locations are composited for quarterly analysis (gamma emitters, uranium isotopes, plutonium isotopes, strontium-90) to track trends that are not likely to be detectable by the gross activity measurements. Radiochemical analyses of filters are performed quarterly to provide data to estimate or bound the human annual dose standards.

Tritium silica gel columns are collected approximately every 4 weeks. This is an operationally practical sampling period for these samplers and has been observed to be short enough to preclude significant breakthrough of the silica gel sampler and loss of sample (PNNL-10690).

When iodine-129 in air is monitored, the charcoal cartridges are collected every 4 weeks. These monthly samples are composited and analyzed quarterly. In 2006, the instrument used for this assay failed irreparably and a replacement instrument is not currently available. Project staff are working to identify another instrument or laboratory that is capable of performing this ultra-trace measurement.

Sampling Locations

Samplers are located to obtain measurements representative of open areas (i.e., away from trees, large structures). This approach is expected to provide better comparability of data between sampling locations. Samplers are generally placed outside of building wake zones, away from vegetation and in

generally flat terrain. Sampling inlets are located 2 meters above the ground to provide measurements representative of radionuclide concentrations inhaled by humans.

Site-Wide. Air samplers are primarily located around the operational areas to maximize the amount of radiological material collected. The current sampling locations were determined based on several factors, including access, power availability, and atmospheric dispersion modeling results. Some samplers around the 200 Areas were installed to increase the likelihood of detecting an unusual occurrence. The potential for diffuse emissions from underground waste storage tanks and re-suspension and dispersion of contaminated soil makes it necessary to locate multiple samplers around these areas.

Air samplers are located with the goal of providing measurements representative of the integrated effects of the areas being monitored, a goal that may require a tradeoff with the goal of measuring the maximum effects.

Perimeter. Sampling stations are located at the perimeter of the site to measure the concentrations of radionuclides at locations accessible by members of the public.

Offsite. Offsite air samplers are located: 1) near the historical locations of the maximally exposed individual to attempt to verify such exposures; 2) in the nearest downwind communities (Tri-Cities) to determine the maximum population exposures; and 3) in a few selected distant communities.

One background location that is more than 20 kilometers upwind from the site is sampled routinely. Samples from this background location are analyzed for all the radionuclides identified in the Analyte Selections section on page III.A-11. Sampling locations used in calendar year 2007 are shown in Figure III.A-1. Information on individual sampling locations can be found in the annual Hanford Site environmental surveillance sampling schedule (e.g., PNNL-16369).

Surface Water Surveillance

The Columbia River flows through the northern portion of the Hanford Site and forms part of the site's eastern boundary. The Hanford Reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula (the impoundment created by McNary Dam). Priest Rapids Dam is the nearest dam upstream of the site and McNary Dam is the nearest dam downstream.

The Columbia River has been developed extensively for hydroelectric power, flood control, navigation, irrigation, and industrial water supplies. The river is used as a source of drinking water at onsite facilities as well as at communities located downstream of the site. In addition, the river and its shoreline are used for a variety of recreational activities, including hunting, fishing, boating, water skiing, wind surfing, picnicking, and swimming. The Hanford Reach of the Columbia River and some of the surrounding lands are part of the Hanford Reach National Monument (65 FR 37253).

In addition to the Columbia River, other surface waters exist at or near the Hanford Site. These include West Lake, Rattlesnake Springs, and two intermittently flowing streams (Dry and Cold Creeks), as well as other small springs on the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit of the Hanford Reach National Monument. Riverbank springs (i.e., groundwater discharge) occur along the Hanford

shoreline of the Columbia River as well. Other surface waters include the Fast Flux Test Facility process water ponds and offsite irrigation systems that use Columbia River water obtained immediately downstream of the Hanford Site.

Pollutants resulting from past and current operations at the Hanford Site, both radiological and chemical, are known to enter the Columbia River. In addition to EPA-permitted direct discharges of liquid effluent from onsite facilities, contaminants from past waste disposal practices seep into the river through riverbank springs and subsurface groundwater discharges. Hence, the surface water pathway (Columbia River) has consistently been one of the primary contributors to the potential dose received by the public as a result of operations at the Hanford Site. Therefore, periodic sampling of surface waters, including the Columbia River, is conducted as part of Hanford Site surface water surveillance. Such sampling also provides a means to verify the effectiveness of the Hanford Site's facility-related effluent control and effluent monitoring systems. Unplanned releases, long-term contaminant trends, and changes in environmental conditions that may be related to contaminants may also be detected by routinely sampling these media.

It is important to know the types and amounts of contaminants entering the Columbia River along the Hanford Reach shoreline. Periodic sampling of known riverbank springs provides this information and helps monitor the contaminants identified in groundwater samples collected from wells located near the springs. Shoreline surveillance sampling includes the collection of water and sediment from flowing riverbank springs.

In 2003, the Washington State Department of Ecology (Ecology) submitted revised surface-water quality standards to the EPA for approval (WAC 173-201A). Under the submitted standards, the Class A (Excellent) designated uses criteria will be replaced with separate designations for aquatic life uses, recreational uses, water supply uses, and miscellaneous uses. For the Columbia River downstream from Grand Coulee Dam, the aquatic life designation will be "salmon and trout spawning, non-core rearing, and migration," which provides for the protection of spawning, non-core rearing, and migration of salmon and trout and other associated aquatic life. The recreational uses designation for the Columbia River down stream from Grand Coulee Dam will be "primary contact," which provides for activities that may involve complete submersion by the participant. The entire Columbia River will be designated for all water supply and miscellaneous uses by the state of Washington.

The Columbia River and the potential impact of Hanford Site operations on the quality of river water and sediment have received significant public scrutiny during recent years. Surface water surveillance activities initiated in the past to address public concerns and to provide public reassurance will be continued.

Objectives

The objectives of surface water surveillance include:

- Assessing the impact of Hanford Site operations on Columbia River water quality.
- Identifying significant changes in contaminant concentrations (radiological and chemical) in surface water.

- Verifying the adequacy of effluent monitoring and controls.
- Characterizing contaminants in the surface water environment.
- Determining the status of the site's compliance with applicable water quality standards.
- Providing reassurance to the public that risks associated with the use of the Columbia River are low and are being evaluated on a continuous basis.

Plan Rationale and Criteria

The basis for the design of the surface water surveillance program is discussed in DOE/EH-0173T. In addition, other environmental monitoring guides and references were considered in the development of the Hanford Site's surface water surveillance program. Similarly, references and guidance specific to water quality monitoring and water sample collection were used in developing sampling protocols.

Media Selections

Contaminants are known to enter the Columbia River as a result of past and current operations at the Hanford Site. Consumption of water or biota from the Columbia River or foodstuffs produced on land irrigated with Columbia River water could expose the public to these contaminants. Additionally, direct exposures from water recreation could occur. The Columbia River is routinely monitored to measure the potential exposures from these pathways.

Riverbank spring water (groundwater discharge) containing contaminants enters the river along the Hanford Reach shoreline. The springs are monitored periodically to document the locations and levels of contaminants entering the river. Such monitoring also confirms the findings of the Soil and Groundwater Remediation Project relative to the extent of the contaminated groundwater plumes at the Hanford Site.

Onsite ponds, while not directly accessible to the public, are used by migratory waterfowl and wildlife. Onsite ponds are monitored to determine the potential for wildlife exposures from this pathway and to verify existing effluent controls at selected facilities.

Offsite irrigation water, withdrawn from the Columbia River downstream of the Hanford Site may be affected by site operations. Consumption of food irrigated with water withdrawn from the Columbia River downstream of the site was identified as a pathway contributing to the potential dose to the hypothetical maximally exposed individual in 2006 (PNNL-16623). Periodic monitoring provides reassurance to the public that irrigation water quality is not affected by Hanford Site operations.

The following provides a description of the monitoring activities specific to each medium identified above.

Columbia River

Analyte Selections. Columbia River water samples are analyzed for those constituents that, as determined by pathway analyses, represent a significant fraction of the potential public dose from the water pathway. In addition, contaminants of public concern are monitored. In general, analyses are conducted

for those contaminants known or suspected to be present in the river water as a result of past or current Hanford Site operations. Most constituents that have been documented to be consistently below measurable levels have been removed from the sampling schedule.

Radionuclides monitored in water samples can include gross alpha, gross beta, selected gamma emitters (gamma scan), tritium, isotopic uranium, strontium-90, technetium-99, iodine-129, plutonium-238, and plutonium-239/240. Gross alpha and gross beta measurements provide a general indication of radioactive contamination. Gamma scans provide the ability to monitor for numerous specific gamma-emitting radionuclides, including cobalt-60, ruthenium-106, antimony-125, cesium-137, and europium-152 and europium-154, as well as others. Radionuclides of interest are selected based on their importance in verifying the effectiveness of effluent control and monitoring systems, and in determining site compliance with applicable water quality standards.

Chemical contaminants analyzed for in selected SESP Columbia River water samples include volatile organic compounds, metals, and anions. In addition, Columbia River water quality parameters are monitored by the U.S. Geological Survey (USGS) (under a subcontract with PNNL) at both an upstream and downstream location, The parameters monitored include temperature, pH, turbidity, conductivity, hardness, and alkalinity measurements, and concentrations of dissolved oxygen, suspended solids, dissolved solids, phosphorus, chromium, iron, and nitrate.

Sampling Methods. The sample types, collection methods, sample sizes, and sampling and analysis frequencies are discussed in the following paragraphs. The selection of sampling methods and equipment depends on the potential for fluctuations in contaminant concentrations, variability in the effluent release into the receiving water, potential for significant environmental or human impact, and characteristics of the contaminant of interest. Water samples collected in the field are stored at the laboratory in a manner that preserves sample integrity for the required analytical method. Examples of preservation methods include refrigeration, amber bottles for light-sensitive materials, and the addition of acid preservatives.

Two types of automatic water sampling systems are used to collect samples of Columbia River water for radiological analyses: 1) a cumulative system that collects a fixed volume of water at set intervals at each location during each sampling period and 2) a system that continuously collects waterborne radionuclides from the river on a series of filters and a mixed-bed ion-exchange resin column. Flow-proportional sampling is desirable; however, because of the large size of the Columbia River, such a system is not practical. Manual composites (grab samples) are collected in those cases where the use of automatic units is not feasible and to cover periods of equipment downtime. The requirements of the analytical method to be used and the required levels of analytical sensitivity determine sample size.

Cumulative sampling systems are operated at Priest Rapids Dam and the Richland pump house and consist of timer activated units that periodically collect water from a continuously flowing sub-stream of Columbia River water into a 10-liter container. The sampling sequence includes a pre- and post-subsample air purge to avoid cross contamination between the individual sample aliquots. The cycle is repeated throughout a 1-week-sampling period such that approximately 55 milliliters of water are collected every hour. The water is collected from the 10-liter container every week and the weekly samples from each location are composited over a 4-week period, resulting in a total sample size of approximately 40 liters. Analyses are performed on these samples according to an established schedule (e.g., PNNL-16369).

Continuous sampling systems are located at Priest Rapids Dam and the Richland pump house. A special, continuously flowing system is used to separate radionuclides from the river water before analysis. A large volume of water is required to allow the extremely small concentrations of these radionuclides to be detected. River water is pumped through the collection system at a rate of approximately 50 milliliters per minute, resulting in a total volume sampled of approximately 1,000 liters during each 2-week-sampling period. Suspended particles are removed on a series of filters. Soluble radionuclides, except tritium, are collected on a mixed-bed ion-exchange resin column. The filters and ion-exchange resin are changed every 2 weeks, composited by location, and analyzed on a quarterly basis according to an established schedule (e.g., PNNL-16369).

Grab samples of Columbia River water are collected quarterly or annually along cross sections at transect and near-shore sites for analyses of various radiological and non-radiological water quality parameters. Special care is taken to obtain water from a flowing portion of the river, avoiding stagnant backwater areas. Surface debris and bottom sediment are also avoided during sampling by collecting the samples from approximately mid-depth. Following collection, samples are delivered to an analytical laboratory. Samples are collected according to an established sampling schedule (e.g., PNNL-16369).

Water quality measurements are taken at the Vernita Bridge and at Richland by the USGS (under subcontract with PNNL) three times per year. Columbia River flow-rate measurements at the Priest Rapids Dam gauging station, near the upstream boundary of the site, are also provided by the USGS.

Sampling Locations. Routine Columbia River water sample collection locations in 2007 are identified in Figure III.A-2. Samples are collected upstream of Hanford Site facilities at Priest Rapids Dam and near the Vernita Bridge to provide background data from locations unaffected by site operations. Samples are collected downstream of Hanford Site facilities at the Richland pump house to identify any increase in contaminant concentrations caused by site operations. This location provides an upper estimate of the amount of radioactive material in the water supply of the potentially affected population group(s).

Priest Rapids Dam is located approximately 8-kilometers upstream of the site boundary and 20 kilometers upstream of the 100-B Area. The water sampler at Priest Rapids Dam is positioned approximately midstream within the dam and collects water from the reservoir behind the dam. The Vernita Bridge sampling location is approximately 6-kilometers upstream of the 100-B Area.

The Richland pump house is located approximately 4-kilometers downstream of the site boundary and approximately 5.5-kilometers downstream of the effluent discharge farthest downstream. It is operated by the city of Richland and is the first downstream point of river water withdrawal for a public drinking water supply. The SESP water sampling station is on the city of Richland's drinking water supply intake structure on the Benton County shoreline. The structure's water intake is located approximately 9 meters into the river. Historical environmental monitoring reports indicate this to be the drinking water supply having the maximum radionuclide concentrations downstream of the Hanford Site (BNWL-90; BNWL-316; BNWL-439; BNWL-983; BNWL-1341; BNWL-1505; BNWL-1669; HW-80991). Past sampling along transects near this location indicated that concentrations of gross beta activity and tritium are slightly elevated near the Benton County shoreline (HW-69369; PNL-8531). In 2006, water samples collected at the Richland pump house had statistically elevated concentrations of tritium compared to samples collected at Priest Rapids Dam, located upstream of the Hanford Site (PNNL-16623).

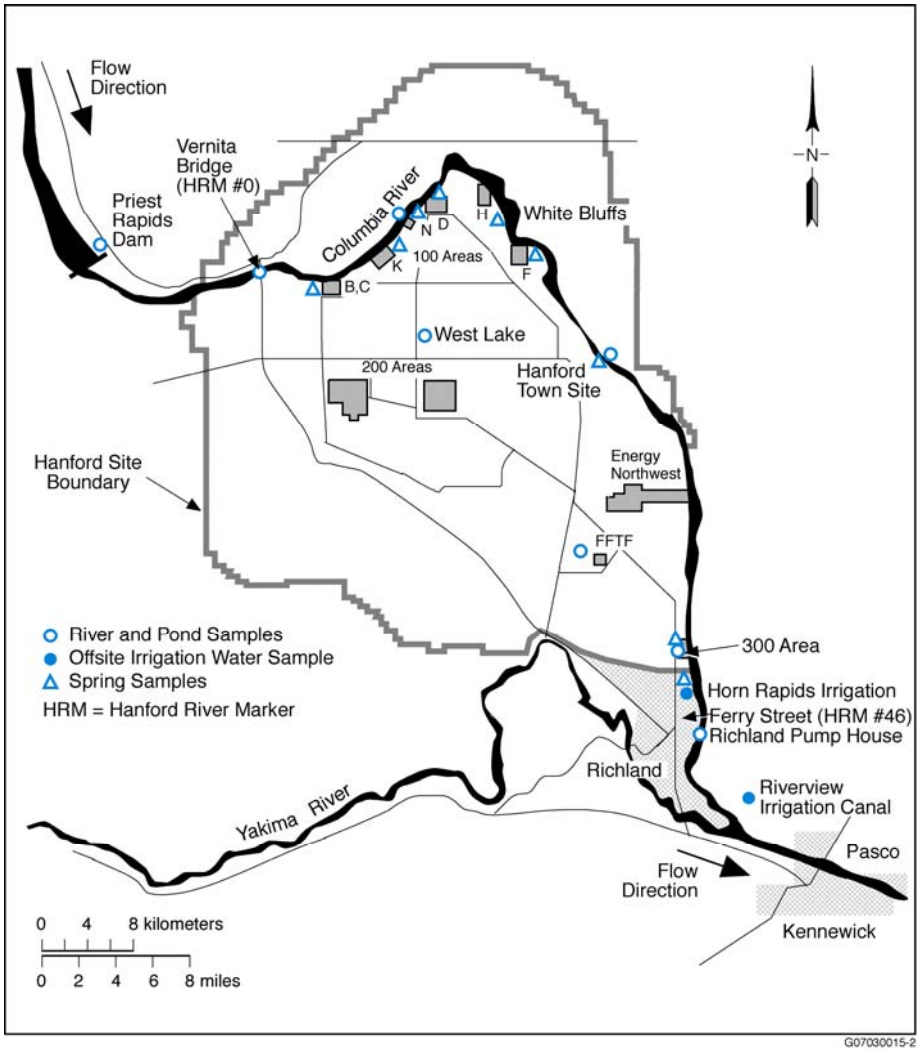

Figure III.A-2. Surface Water Sampling Locations in 2007

Transect and near-shore sampling is conducted near the Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and Richland pump house. Transect sampling is performed to determine the distribution of contaminants across the river at these locations. Near-shore and transect sampling are used to determine the localized zone of influence near known discharges of contaminated groundwater via riverbank springs. The representativeness of the single-point-intake sampling system located at the Richland pump house is also evaluated using results of the transect sampling. Samples are collected at approximately mid-depth at several points (up to 6) along a transect line (across the river). Transect sampling will identify those contaminants that are measurable in the river and which may be influenced by proximity to the contaminated groundwater plume. Near-shore samples (up to 5 stations centered around the transect-sampling location) are collected at approximately mid-depth near the Hanford shoreline. Near-shore samples provide information on the concentrations of contaminants where the groundwater plumes interact with the Columbia River.

Riverbank Springs

Analyte Selections. Water samples collected at these locations are analyzed for constituents known or suspected to be present in the local groundwater. The primary radionuclides of interest include tritium, uranium, strontium-90, technetium-99, and iodine-129. Chemical contaminants of interest include metals (primarily chromium), volatile organic compounds, and anions.

Sampling Methods. Samples are typically collected using a hand or peristaltic pump directly in an improved discharge zone to avoid agitation of the sediment. The sampling zone of the riverbank spring is improved by scooping sediment from the discharge area to form a small pool, and allowing any sediment in the pool water to settle before the sampling pump is used. Riverbank spring samples are handled and transported in a manner similar to the river water samples discussed above.

Sampling Frequency. Samples are collected annually.

Sampling Locations. Routine riverbank spring sampling locations are shown in Figure III.A-2. Samples are collected along the shoreline of the 100-B/C Area, 100-K Area, 100-N Area, 100-D Area, 100-H Area, 100-F Area, downstream of the Hanford town site, and at the 300 Area. Groundwater enters the Columbia River at these locations, with some contaminant concentrations significantly higher than background concentrations.

Onsite Ponds

Analyte Selections. Unfiltered aliquots of the samples are analyzed for gross alpha and gross beta activities, gamma-emitting radionuclides, and tritium at the Fast Flux Test Facility pond, and tritium at West Lake according to an established schedule (e.g., PNNL-16369). In addition, sediment samples are also collected at West Lake (see Pond Sediment Surveillance on page III.A-24).

Sampling Methods. Grab samples are collected from each pond. Care is taken to avoid surface debris and resuspension and inadvertent collection of bottom sediments.

Sampling Frequency. Samples are collected quarterly.

Sampling Locations. Two onsite ponds (Figure III.A-2), located near operating areas, are routinely sampled. West Lake, located north of the 200-East Area, is recharged from groundwater (ARH-CD-775). This lake has not received direct effluent discharges from site facilities, and radionuclide concentrations are influenced by the local groundwater. The Fast Flux Test Facility pond, located near the 400 Area, is used for the disposal of water from various facilities in the 400 Area.

Offsite Irrigation Water

Analyte Selections. Irrigation water samples are analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, and uranium isotopes according to an established schedule (e.g., PNNL-16369). Tritium and uranium were identified as primary contributors to the calculated hypothetical dose to the public via the river water pathway in 2006 (PNNL-16623).

Sampling Methods. Grab samples of irrigation water are collected.

Sampling and Analysis Frequencies. Samples are collected three times during the irrigation season.

Sampling Locations. Samples are collected from two irrigation water supplies that obtain water from the Columbia River downstream of the Hanford Site (Figure III.A-2).

Columbia River Sediment Surveillance

As a result of Hanford Site operations, large quantities of radioactive materials and chemicals were discharged to the Columbia River. On release to the river, most contaminants were dispersed rapidly. Some were sorbed onto inorganic particles and detritus, incorporated into aquatic biota, or deposited on the riverbed as sediment. Fluctuations in the river-flow rate as a result of the operation of hydroelectric dams, annual spring freshets, and occasional floods have resulted in the resuspension, relocation, and redeposition of the contaminated sediment.

Since the shutdown of the eight single-pass-cooling reactors, the radionuclide burden in the river surface sediment has been decreasing as a result of radioactive decay and the subsequent deposition of uncontaminated material on top of the contaminated sediment. However, discharges of some radionuclides and chemicals to the Columbia River still occur through the seepage of contaminated groundwater into the river.

The accumulation of radioactive materials and chemicals in sediment can potentially lead to contaminant exposures to humans and river and shoreline biota. Human exposure can occur through ingestion of aquatic species exposed to contaminated sediment, through ingestion of river water containing re-suspended contaminants, or as an external radiation source irradiating people who are fishing, wading, sunbathing, or participating in other recreational activities associated with the river and shoreline. Currently, public exposures to contaminants in Columbia River sediment are well below the levels at which routine surveillance of the sediments is required (DOE/EH-0173T). However, periodic sampling is necessary to confirm the low levels and to assure that no significant changes have occurred over time that may increase the potential exposure to the public through this pathway.

Objectives

The objectives of sediment surveillance include:

- Verifying that doses caused by Hanford Site operations through this pathway remain low, by means of periodic river system evaluations, sampling, and analysis.
- Providing an indication of changes in environmental conditions that have the potential to increase public exposures.
- Providing assurance to the public that site surveillance activities are credible and that the radiological conditions and potential exposure pathways are understood and receive the appropriate attention.

Plan Rationale and Criteria

The basis for sampling sediment from surface water locations is discussed in DOE/EH-0173T. In addition, other environmental monitoring guides and references have been considered in the development of the sediment sampling plan. The locations, sampling frequencies, and analyses performed routinely on Columbia River sediment samples are established annually (e.g., PNNL-16369). Additional rationale and specific criteria are described in the following paragraphs.

Media Selections

Routine sediment sampling is necessary to meet site-specific surveillance requirements (DOE/EH-0173T). It is important to know where a contaminant enters the Columbia River along the Hanford Reach and its fate after entering the river. Because the sources of Hanford-produced contaminants are predominantly shoreline springs (i.e., contaminated groundwater), the sampling of river sediment helps identify specific contaminants and the amount of each contaminant that has entered the river from the Hanford Site, as well as from sources upriver of the Hanford Site. Routine sampling of the sediment also provides the public a degree of assurance that their concerns about contaminant levels in the river are being considered and addressed appropriately.

Analyte Selections

Sediment samples are analyzed for contaminants of concern known or suspected to be present as a result of past or current operations at the Hanford Site. Effluent discharge reports are reviewed to identify contaminants of concern currently entering the river. Groundwater monitoring reports (e.g., PNNL-16346) identify those contaminants near the river and potentially entering the river that must be considered in the sampling plan. Historical reports documenting past releases or sediment contaminant concentrations are reviewed to determine contaminants of concern as a result of past operations.

Sediment samples are analyzed for gamma-emitting radionuclides (gamma scan), strontium-90, and uranium and plutonium isotopes according to an established schedule (e.g., PNNL-16369). Such analyses are consistent with past and current releases and historical data relative to contaminants in the sediments. In addition, sediment samples may be analyzed for metals and total organic carbon.

Sampling Methods

Because of the depth and swiftness of the river at some of the sediment sampling locations, samples are collected using a dredge-type mechanical sampler deployed from a boat. In some cases, primarily in the shallow water sloughs along the Hanford Reach, the dredge is deployed by someone wading to better control the sample depth. Sediment sampling at riverbank spring locations is typically not done when the sampling location is underwater. Samples at riverbank springs are collected with a hand-held ladle.

Sampling and Analysis Frequencies

Sampling and analysis of Columbia River sediments are conducted on an annual basis. Sampling occurs after the spring freshet to provide a consistent and more easily interpreted information base. The spring freshet may redistribute some of the contaminated sediments, particularly the sediment deposited in sloughs.

Core samples, to determine the fate and buildup of contaminants in river sediment over time, may be collected periodically, commensurate with findings of past core-sampling activities and in consideration of future activities that may resuspend and redistribute contaminants.

Sampling Locations

Samples of Columbia River sediment are collected at the locations shown in Figure III.A-3. Samples are collected upstream of the Hanford Site (beyond the influence of Hanford Site liquid effluent and groundwater discharges) behind Priest Rapids Dam. Samples are collected downstream of the Hanford Site at Richland and behind McNary Dam (the nearest downstream impoundment). Samples (typically two per location) are collected behind each of the dams at approximately equal distances along a sampling transect. This provides additional information relative to the distribution of contaminants in the sediments across the river. Sediment samples are collected (one sample per location) along the Benton County shoreline of the Hanford Reach, at locations near the discharges (past and current), in areas where material is known to be deposited, and in areas commonly used by the public. These locations include

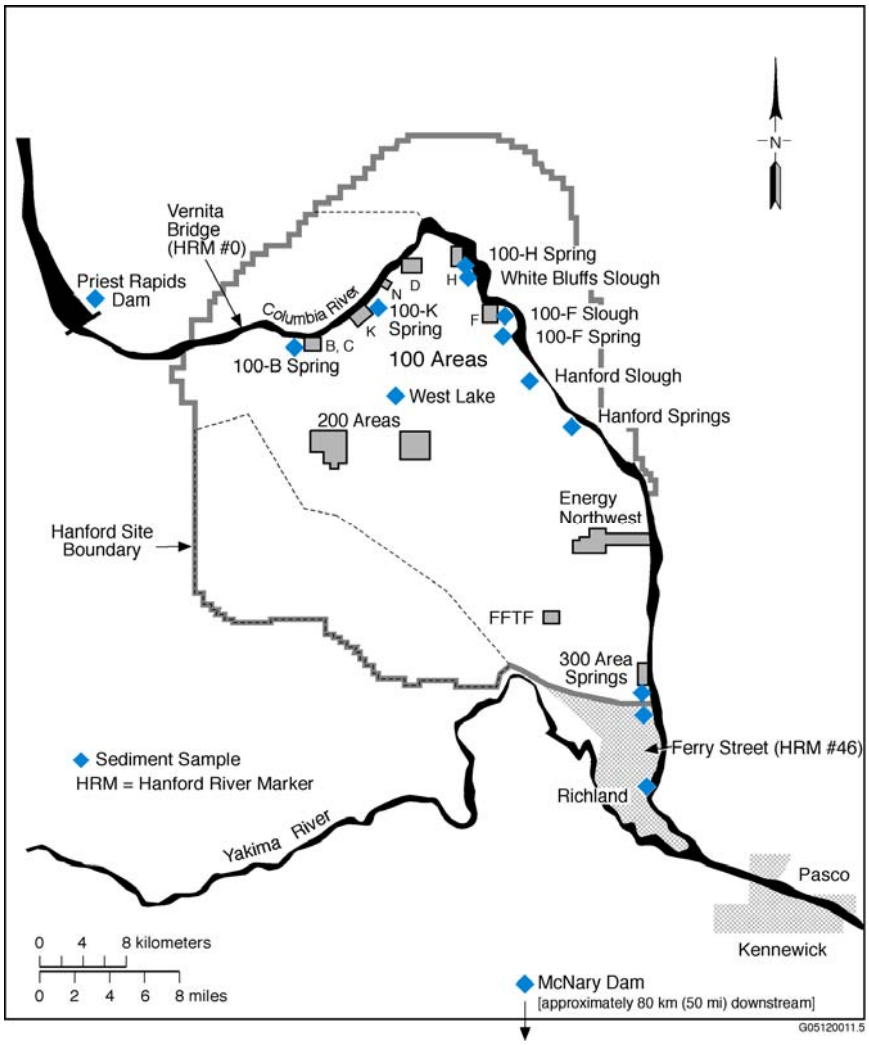

Figure III.A-3. Sediment Sampling Locations in 2007

riverbank springs at the 100 Areas, Hanford town site, 300 Area, White Bluffs slough, 100-F slough, Hanford slough, and a shoreline beach near the Richland pump house.

In addition to the routine sediment sampling, core samples are collected periodically from the upstream and downstream impoundments to determine the distribution and fate of the contaminants present as a result of past Hanford Site operations. The frequency of this sampling depends on the findings of past sampling activities and anticipated activities with the potential to affect the river and/or the sediment in the McNary Dam impoundment.

Pond Sediment Surveillance

West Lake has not received direct effluent discharges from Hanford Site facilities, but it is influenced by precipitation and changing water-table elevations that are related to discharges of water to the ground in the 200 Areas. The pond has a small amount of standing water in the winter and is nearly dry in the summer.

Plan Rationale and Criteria

West Lake is not accessible to the public but may be used by migratory waterfowl and other wildlife, creating a potential pathway for the dispersion of contaminants.

Media Selection

Sediment is collected at West Lake because high suspended-sediment-loading makes water analyses difficult for some radionuclides; therefore, the surveillance of these radionuclides has been shifted from water to sediment.

Analyte Selection

West Lake sediment samples are analyzed for gross alpha, gross beta, gamma emitters, strontium-90, technetium-99, and uranium isotopes.

Sampling Methods

Samples are scooped or spooned from the surface sediment beneath the pond water.

Sampling Frequency

Samples are collected and analyzed semiannually.

Food and Farm Products Surveillance

Agricultural products are major contributors to the economy of the Columbia Basin, where the Hanford Site is located. Large tracts of arable land surround the site, and surveillance of agricultural products (including dairy products) produced on this land is an important element of surface environmental surveillance. Radioactivity of Hanford Site origin can reach agricultural areas by three pathways: atmospheric transport and deposition of facility and fugitive emissions, irrigation with Columbia River water potentially contaminated with Hanford effluent, and uptake of contaminants from historical operations that remain in the environment. A variety of food and farm product samples are collected around the site each year and analyzed to monitor the potential deposition and uptake of recently released contaminants and the uptake of materials that may persist in the soil from historical contributions.

Samples of food and farm products are collected from distant locations that have not been exposed to Hanford contaminants so that background levels can be determined. The background levels are compared to levels measured in samples collected on and near the site so that the amounts of Hanford-related radionuclides in the samples can be estimated.

Objectives

The objectives of food and farm product surveillance include:

- Verifying that radiological doses related to the food and farm product exposure pathways remain low and quantifiable as required by DOE/EH-0173T.
- Providing assurance to producers and consumers of agricultural products grown near the Hanford Site that the degree of contamination caused by site operations and cleanup activities is known and documented in publicly available reports (e.g., the annual Hanford Site environmental report).
- Providing baseline data to quantify contaminant level changes due to fugitive or accidental releases of Hanford Site radiological materials.
- Monitoring the potential impact of using irrigation water withdrawn from the Columbia River downstream of the site.

Plan Rationale and Criteria

Pathway analyses indicate that emissions and effluent of Hanford origin can reach agricultural products through atmospheric deposition at downwind locations and by the application of irrigation water withdrawn from the Columbia River downstream from the Hanford Site. Specific agricultural pathways target a variety of local, representative products identified in DOE/EH-0173T and emphasize the concern for public assurance.

Current levels of Hanford-produced radionuclides in food and farm products are at or below analytical detection limits. Assurance that regional agricultural products are not contaminated is

important to the public, the region's agribusinesses, and the DOE. Therefore, periodic sampling must be done in a manner and frequency to maintain that assurance.

Sampling procedures are designed to make sure that sample collections are done safely and consistently and meet the objectives of the monitoring programs that use the data. Sampling and data quality objectives are continuously reviewed, and scheduling changes or media substitutions are made as needed to address those objectives.

Media Selections

Selections of specific media are based on their significance to human and ecological dose. The food and farm product media that are routinely monitored include:

- Milk – Whole raw milk is collected from dairies downwind of the Hanford Site, near the site perimeter, and at a control location generally upwind and distant from the site.
- Farm produce – Fruits (apples, grapes, cherries, tomatoes), vegetables (potatoes), and leafy vegetables are collected as they become available at locations around the site perimeter. Specific crops are collected by area and not all areas yield the same types of produce.
- Alfalfa – Samples of fresh alfalfa are collected from one upwind control location and three locations adjacent to the Hanford Site perimeter.
- Wine – Red and white wines produced from grapes harvested during the collection year at vineyards located around the site are collected and analyzed.

Analyte Selections

Food and farm product samples are routinely analyzed for radionuclides that: 1) are found in Hanford Site effluent and emissions; 2) contribute to doses associated with various potential exposure pathways; and 3) are of concern to the public and to agribusiness. The radionuclides routinely monitored in most samples include strontium-90 and gamma emitters (including cesium-137). Some samples are also analyzed for tritium (milk, wine, tomatoes). These contaminants can be transferred to humans and other biota via various consumption pathways. Onsite cleanup and remediation activities may require analyses for specific contaminants in some products. These contaminants will be identified on a case-by-case basis as cleanup and remediation work progresses.

Until recently, milk samples were also analyzed for iodine-129. However, the unique instrument used for this assay failed irreparably in 2006 and a replacement instrument or laboratory for this ultra-trace measurement is not currently available. The need for this analysis will be reassessed when a new measurement capability becomes available.

Sampling Methods

Food and farm products are collected either from the field or from the grower in adequate amounts to meet analytical detection limits. Global positioning system coordinates are obtained whenever possible for all farm product samples, except for milk, which is routinely collected at the same locations. Perishable

agricultural samples, such as milk, are kept on ice or refrigerated following collection (see PNNL-16744). Fruits and vegetables are packaged in plastic bags. Stored samples are refrigerated or frozen as needed to minimize spoilage.

Sampling and Analysis Frequencies

Food and farm products are collected during the harvest season and are analyzed following collection. Samples of some products are collected annually from locations that have the greatest potential for exposure to Hanford effluent and emissions. Specific products are sampled in alternating years or on a 3-year cycle as indicated in an annual sampling schedule (e.g., PNNL-16369). Milk samples are collected and analyzed quarterly for some contaminants and semiannually for others.

Sampling Locations

Routine food and farm product samples are collected offsite at locations that are likely to have the highest concentrations of Hanford Site contaminants (i.e. locations downwind or downstream of site facilities) (see DOE/EH-0173T). Background samples are collected at locations upwind or upstream of, or distant from, the Hanford Site.

Food and farm products are sampled from established sampling areas around the Hanford Site. The areas sampled in 2007 are shown in Figure III.A-4. Areas to the east of the site are considered downwind

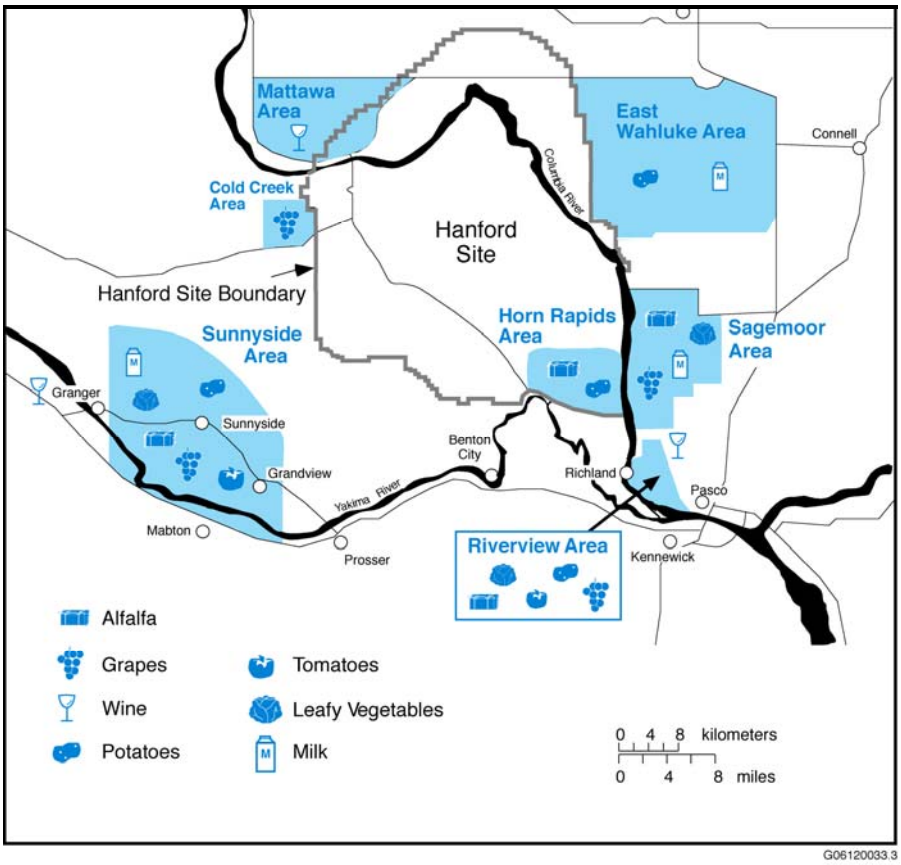

Figure III.A-4. Food and Farm Products Sampling Locations in Calendar Year 2007

locations. Areas to the west of the site are considered upwind or distant. The Riverview and Horn Rapids sampling areas are agricultural areas located downstream of the Hanford Site that use Hanford Reach water for irrigation.

Fish and Wildlife Surveillance

Fish and wildlife, on and off the Hanford Site, are valued natural and recreational resources. Fish from the Hanford Reach of the Columbia River may be caught and consumed by anglers, and wildlife residing onsite (elk, deer, rabbits, upland game birds, and waterfowl) may move offsite and be harvested by the public for consumption. Fish may be exposed to radiological and chemical contaminants present in Hanford Site groundwater entering the Columbia River via shoreline springs. Wildlife onsite could be exposed to contaminants at waste storage sites, at former waste disposal locations, in contaminated areas, and in Columbia River shoreline springs water. Unplanned contaminant releases and releases from cleanup activities could also lead to contamination of edible wildlife tissues. It is important, therefore, that consumable fish and wildlife on and near the site be sampled to document levels of potential contaminants. The collection of certain species with small home ranges that live near operating and cleanup areas on the site assists in verifying the effectiveness of onsite contaminant controls.

Samples of fish and wildlife are collected from distant locations that have not been exposed to Hanford contaminants so that background levels can be determined. The background levels are compared to levels measured in samples collected on and near the site so that the amounts of Hanford-related radionuclides in the samples can be estimated.

Objectives

The objectives of fish and wildlife surveillance include:

- Verifying that radiological doses to humans related to fish and wildlife exposure pathways remain low and quantifiable as required by DOE/EH-0173T.
- Providing assurance to consumers of fish and wildlife collected near the Hanford Site that the degree of contamination caused by site operations and cleanup activities is known and documented in publicly available reports (e.g., the annual Hanford Site environmental report).
- Monitoring the accumulation and inventory of long-lived radionuclides and trace metals in fish and wildlife tissues.
- Evaluating radionuclide concentrations and associated doses to key wildlife near onsite operational areas to determine the degree of risk to biological resources.

Plan Rationale and Criteria

Fish and wildlife species monitored on and around the Hanford Site are selected for sampling based on their likelihood of exposure to contaminants, potential for accumulating contaminants, and potential for moving off the site and being consumed by hunters or fishers. Consideration is also given to species that may be consumed by ethnic groups.

Sampling procedures are designed to assure that sample collections are done safely and consistently and meet the objectives of the monitoring programs that use the data. The species of fish and wildlife selected for sampling are found in sufficient abundance that sampling will not affect population stability. Sampling and data quality objectives are continuously reviewed, and scheduling changes or media substitutions are made as needed to address those objectives.

Media Selections

Selections of specific biota are based on their significance to human and ecological dose. The biota that are routinely monitored include:

- Aquatic biota – Whitefish have historically been sampled because of their value to recreational fishing and their propensity to accumulate radionuclides; however, carp, suckers, and bass are also sampled. For human dose assessment purposes, two sample types are obtained: edible muscle and offal, i.e., the eviscerated remnants including the head, skin, fins, and bones. Liver samples may also be collected to assess accumulation of trace metals. A number of species other than food fish may be sampled because they may best represent potential ecological sentinels on the Hanford Site. These species include sculpins, clams, crayfish, and microinvertebrates.

- Terrestrial biota – Routinely collected species include elk, deer, rabbits, geese, and upland game birds (usually pheasant or quail, but may include chukar). Muscle, bone, and sometime liver samples are collected. A number of other organisms may also be collected because they best represent potential ecological sentinels on the Hanford Site. These organisms include invertebrates, small mammals, amphibians, and birds.

Analyte Selections

Fish and wildlife samples are analyzed for 1) radionuclides and, in some cases chemicals, that are found in Hanford Site effluent and emissions, 2) radionuclides that contribute to doses associated with various potential human and biota exposure pathways, and 3) radionuclides and chemicals that are of concern to the DOE, public, American Indian Tribes, activist groups, environmental organizations, public officials, and regulatory agencies. Fish and wildlife samples are analyzed for strontium-90, which accumulates in bones, and gamma emitters, specifically cesium-137, which accumulate in muscle tissues. Some fish samples are analyzed for uranium; selected deer, elk, and rabbit samples may be analyzed for plutonium. Radionuclide concentrations in wildlife during the past 10 years have indicated little need to conduct routine analyses for other radionuclides. Livers from most organisms are analyzed for metals, and some fish and goose livers are analyzed for mercury. Onsite cleanup and remediation activities and special studies may require analyses for specific contaminants in some samples. These contaminants will be identified on a case-by-case basis.

Sampling or Measurement Methods

Wildlife samples are collected from animals killed by traffic or by trapping or hunting. Fish are obtained using rod and reel, electroshocking, or seine nets. Tissue, bone, and organ samples are removed from collected animals either in the field or in the laboratory. Special care is taken to assure that samples are not contaminated with skin, hair, or materials from the gastrointestinal tract. Tissue samples must also be kept free of dirt because contaminant levels in the soil can impact concentration measurements in the tissues. Samples are usually double bagged in plastic and stored samples are refrigerated or frozen. Most metals analyses are done by inductive coupled plasma mass spectrometry. Cold vapor atomic absorption (CVAA) spectrometry is used for mercury analyses.

Sampling and Analysis Frequencies

Fish and wildlife are collected annually from Hanford Reach locations; however, each species is only collected in alternating years (biennially) or every third year (triennially). Background samples are collected for specific species periodically. Wildlife populations undergo natural fluctuations and routinely scheduled species are not always abundant or easily collected. When this occurs, the sampling and data quality objectives are reviewed and scheduling changes or species substitutions are considered. The current level of sampling is consistent with meeting DOE concerns for public assurance about contamination levels in fish and game in the region, emphasis on cleanup activities on the site, and recent concerns about contaminants in the Columbia River.

Sampling Locations

Routine fish and wildlife samples are collected offsite at locations that are likely to have the highest concentrations of Hanford Site contaminants (i.e. locations downwind or downstream of site facilities) (see DOE/EH-0173T). Onsite sampling locations are selected to provide close-in monitoring of operational, cleanup, and remediation areas with the potential to release radioactive materials, and potentially contaminated Columbia River shoreline locations. Background samples are collected at locations upwind or upstream of, or distant from, the Hanford Site.

Samples of fish are collected from the Columbia River near or downstream of locations where contaminated water is known to enter the river. Wildlife is sampled from locations that provide the highest potential for exposure to Hanford Site contaminants (e.g., the 100-N Area shoreline springs, 200 Areas former waste disposal sites). The locations sampled in 2007 are shown on Figure III.A-5.

Background samples are collected from areas expected to receive approximately the same contribution of fallout radioactivity as the Hanford Site. For fish, background organisms are distant upstream Columbia River residents that have a low probability of moving upstream from the Hanford Reach and passing over upstream dams. Background sites for game species are also distant from the site, have a Hanford-like climate, and are generally upwind of Hanford operations (e.g., Boardman, Oregon, for rabbits).

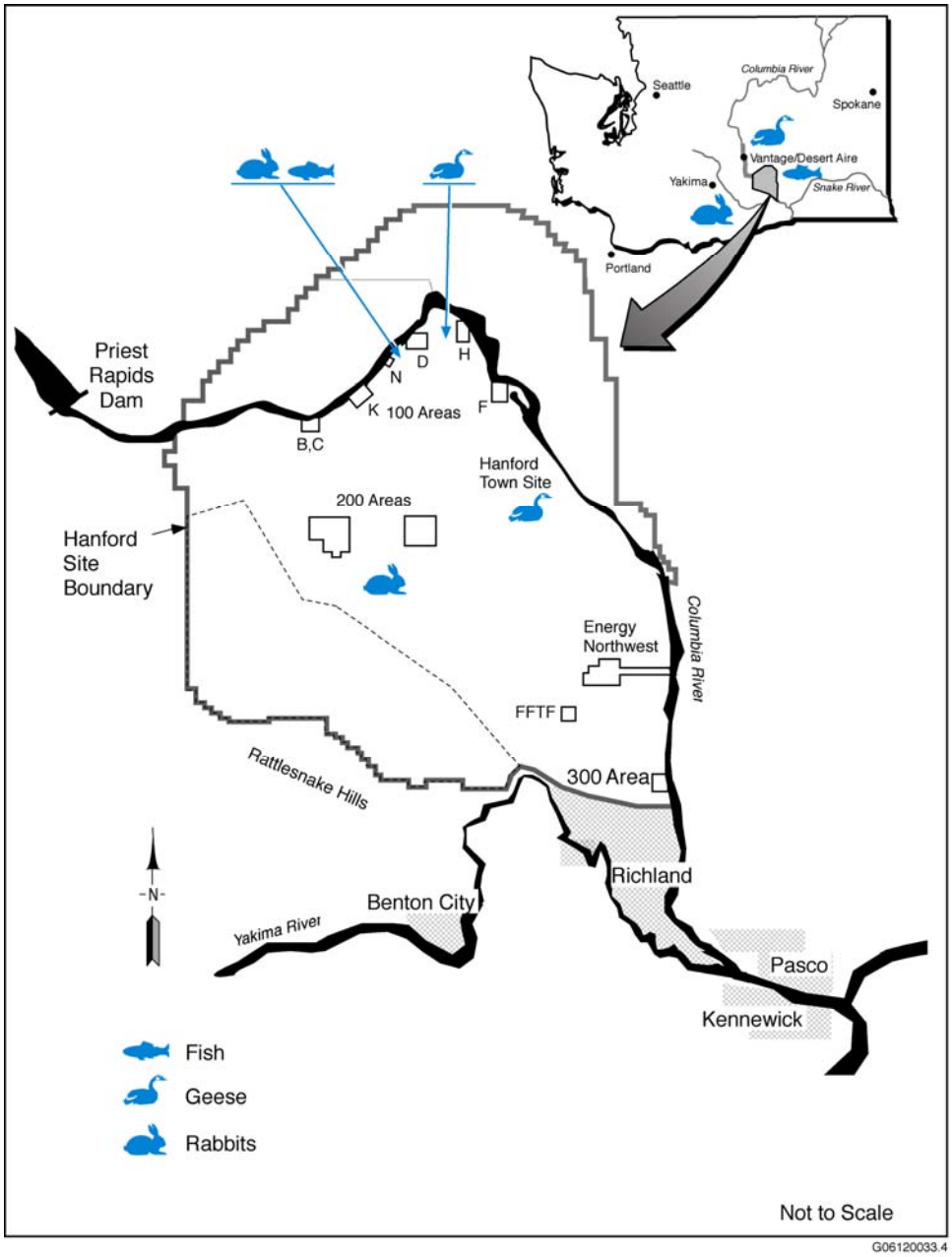

Figure III.A-5. Wildlife Sampling Locations in 2007

Soil and Vegetation Surveillance

Surveillance of soil and native vegetation is designed to monitor atmospheric deposition of contaminants at offsite locations not influenced by agriculture and at onsite locations adjacent to potential sources of environmental radioactivity. Atmospheric data and computer models indicate that Hanford Site emissions can be dispersed in the environment on and off the site and deposited onto the land, where there

is then the potential for accumulation. Soil and vegetation on portions of the Columbia River shoreline bordering the Hanford Site are monitored because they may be exposed to contaminants present in Hanford Site groundwater and shoreline springs. Soil and vegetation at publicly accessible areas near and downwind of the site must be monitored to provide assurance to the DOE and the public that these media are not significantly contaminated by particulate and gaseous emissions from Hanford. Samples of soil and vegetation are also collected from distant locations to help determine background levels.

Objectives

The objectives of soil and vegetation surveillance include:

- Verifying that radiological doses related to the soil and vegetation exposure pathways remain low and quantifiable as required by DOE/EH-0173T.
- Providing assurance to people living near the Hanford Site that the degree of contamination caused by site operations and cleanup activities is known and documented in publicly available reports (e.g., the annual Hanford Site environmental report).
- Providing baseline data to quantify contaminant level changes due to fugitive or accidental releases of Hanford Site radiological materials.
- Monitoring the buildup and inventory of long-lived radionuclides onsite and offsite from the deposition of airborne releases.

Plan Rationale and Criteria

Routine soil and vegetation sampling supports air monitoring efforts to document fugitive radioactive emissions that settle on the ground. Additionally, special sampling is conducted as needed for site cleanup and decommissioning activities, and to facilitate the transfer of DOE Hanford Site property to other federal, state, or local agencies.

Environmental concentrations of routinely monitored radionuclides in soil and vegetation have generally fallen below detection limits. Soil and vegetation monitoring is conducted at locations on the site with the potential for elevated concentrations, at downwind locations around the perimeter of the site, and at an upwind location distant from the site. Special onsite sampling may focus on soil and vegetation along the Hanford Reach shoreline where contaminated groundwater enters the river, on aquatic vegetation in the river where groundwater seepage occurs, and on soil and vegetation at selected cleanup and remediation sites.

Soil and vegetation sampling procedures are designed to ensure that sample collections are done safely and consistently and meet the objectives of the monitoring programs that use the data. Sampling and data quality objectives are continuously reviewed and scheduling changes or media substitutions are made as needed to address those objectives.

Media Selections

Native vegetation samples consist of the current year's growth (leaves and limbs) collected from shrub species in proportion to their estimated abundance at the sampling site. Surface soil samples are collected to a depth of 2.5 centimeters.

Analyte Selections

Soil and vegetation samples are analyzed for radionuclides that are found in Hanford Site effluent and emissions, for radionuclides that contribute to doses associated with various potential exposure pathways, and for radionuclides and chemicals that are of concern to the DOE, public, American Indian Tribes, activist groups, environmental organizations, public officials, and regulatory agencies. Soil samples are routinely analyzed for the radionuclides common to Hanford Site operations: gamma emitters, strontium-90, uranium isotopes, plutonium isotopes, and, for selected samples, americium-241. Vegetation samples are analyzed for gamma emitters, uranium isotopes, strontium-90, and plutonium isotopes. These radionuclides have relatively long half-lives and are indicative of past site operations. Metals and organics (polychlorinated biphenyls [PCBs] and pesticides) may also be monitored in soil. Onsite cleanup and remediation activities and special studies may require analyses for specific contaminants. These contaminants will be identified on a case-by-case basis.

Sampling or Measurement Methods

Soil is sampled with a shallow coring device ("cookie cutter"). The samples are 2.5-centimeters deep and 11 centimeters in diameter. Five cores are combined to form one sample. Areas with heavy vegetation cover are avoided and any vegetation in the samples is removed. Samples are dried and sieved prior to analysis.

Vegetation is sampled by clipping new growth from the dominant shrubs at the sampling site (usually sagebrush and rabbit brush).

Soil and vegetation samples are packaged in two plastic bags (double bagged). Stored vegetation samples are refrigerated or frozen to minimize deterioration.

Sampling and Analysis Frequencies

Soil and vegetation samples are collected every 3 to 5 years. This collection cycle is adequate to monitor long-term trends in environmental radioactivity and is consistent with DOE/EH-0173T requirements and the site's cleanup mission.

Sampling Locations

Soil and vegetation samples are collected from a number of locations on and around the Hanford Site (Figure III.A-6). Samples may not be collected from all of the sampling locations illustrated in Figure III.A-6 each collection period. Routine samples are collected offsite at undisturbed, unirrigated locations that are likely to have the highest concentrations of Hanford Site contaminants (i.e. locations downwind or downstream of site facilities) (see DOE/EH-0173T). Onsite sampling locations are selected to provide close-in monitoring of operational, cleanup, and remediation areas with the potential to release

radioactive materials and monitoring of contaminant concentrations along the Hanford Reach shoreline. Background samples are collected at locations upwind or upstream of, or distant from, the Hanford Site.

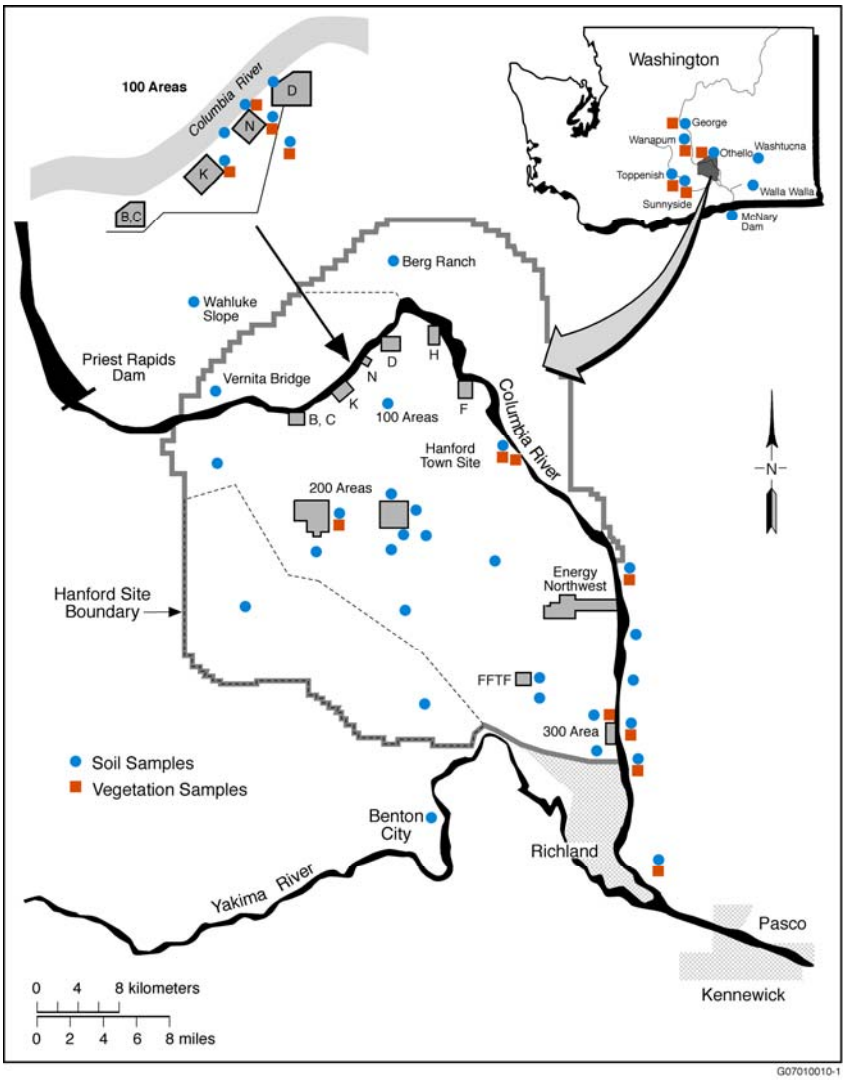

Figure III.A-6. Soil and Vegetation Sampling Locations

Soil and vegetation sampling locations are in undisturbed areas to facilitate monitoring of long-term accumulations of contaminants. When possible, soil and vegetation samples are collected near established air sampling locations to facilitate interpretation of results (see DOE/EH-0173T). Sampling locations offsite and along the Hanford Reach shoreline are selected to monitor the potential for public exposure.

Dose Assessment Methods

The radiological dose that the public potentially receives during a calendar year from Hanford Site operations is calculated in terms of the effective dose equivalent (EDE). These dose quantities are given

in units of millirem (mrem) for individuals and in units of person-rem for the collective dose received by the total population within an 80-kilometer radius of the site's operations areas.

These quantities provide a way to uniformly express the radiological dose, regardless of the type or source of radiation or the means by which it is delivered. This subsection describes how the doses are calculated.

Releases of radionuclides from Hanford Site activities are usually too low to be measured in offsite air and food crops. Therefore, in most cases, the dose calculations are based on measurements made at the point of release (stacks and effluent streams), and environmental concentrations are estimated from these effluent measurements by environmental transport computer models.

The transport of radionuclides from the release sources to the points of exposure is predicted by empirical computer models of exposure pathways. These computer models calculate concentrations of radionuclides in air, water, and food. Radionuclides taken into the body by inhalation or ingestion may be distributed among different organs and retained for various times. In addition, long-lived radionuclides deposited on the ground can be taken up by agricultural products, re-suspended and dispersed by winds, and can be possible contributors to long-term external exposure. Dietary and exposure parameters are used to calculate radionuclide intakes and radiological doses to people. Standardized computer programs are used to perform the calculations. These programs contain internally consistent mathematical models that use site-specific dispersion and uptake parameters. These programs are incorporated in a master code, GENII Version 1.485 (PNL-6584), which employs the dosimetry methodology described in reports by the International Commission on Radiological Protection (1979a, 1979b, 1980, 1981a, 1981b, 1982a, 1982b, 1988). In addition, an EPA-approved version of the CAP88-PC software (Parks 1992) is used to demonstrate compliance with the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) radionuclide air emissions standards as specified in the *Clean Air Act* regulations under 40 CFR Part 61, Subpart H, and DOE Order 5400.5. The assumptions and input data used in the GENII and CAP88-PC calculations are consistent, to the extent possible, and are described in the following paragraphs.

Types of Dose Calculations Performed

Calculations of radiological doses to the public from radionuclides released into the environment are performed to demonstrate compliance with applicable standards and regulations.

The DOE requires that estimates of radiological dose to the general public be in EDE terms. The EDE represents the total risk of potential health effects from radiation exposure. The adoption and use of the EDE were previously recommended by the International Commission on Radiological Protection (1977). In addition to implementing the EDE requirement for offsite population dose calculations, the DOE has adopted the biokinetic models and metabolic parameters for radionuclides given by the International Commission on Radiological Protection in 1977 for estimating radiological dose. As in the past, when concentrations of radionuclides in the environment are too low to measure, the DOE specifies that the doses are to be calculated from effluent data using environmental transport and dosimetry models.

The calculation of the EDE takes into account the long-term (50 years) internal exposure from radionuclides taken into the body during the current year. The EDE is the sum of individual committed (50 years) organ doses multiplied by weighting factors that represent the proportion of the total health-effect risk that each organ would receive from uniform irradiation of the whole body. Internal organs

may also be irradiated from external sources. The external exposure received during the current year is added to the committed internal dose to obtain the total EDE. The EDE is frequently expressed in rem (or millirem). The numerous transfer factors used for pathway and dose calculations have been documented in GENII Version 1.485 (PNL-6584), PNL-3777, and PNNL-13421. Parameters used with the CAP88-PC software are documented in Parks (1992).

The following types of radiological doses are estimated at Hanford:

- "Maximally exposed individual" all-pathways dose (millirem) – The maximally exposed individual is a hypothetical person living at a particular location who has a postulated lifestyle conducive to receiving higher radiological doses than other members of the public would be likely to receive. All potentially significant exposure pathways to this hypothetical individual are considered, including:
  - Inhalation of airborne radionuclides.
  - Submersion in airborne radionuclides.
  - Ingestion of foodstuffs contaminated by radionuclides deposited on vegetation and the ground by both airborne deposition and irrigation water drawn from the Columbia River downstream of Hanford Site discharges.
  - Exposure to ground contaminated by both airborne deposition and irrigation water.
  - Ingestion of fish taken from the Hanford Reach of the Columbia River.
  - Recreation along the Hanford Reach of the Columbia River, including boating, swimming, and shoreline activities.
- "Maximally exposed individual" air pathway dose (millirem) – The maximally exposed individual for demonstrating compliance with NESHAPs radionuclide air emissions standards is a hypothetical person residing or abiding at a particular location who has a postulated lifestyle conducive to receiving higher radiological doses than other members of the public from radionuclides released to the atmosphere, including both monitored sources and potential sources of fugitive radionuclide emissions. According to a recent interpretation by state and EPA regional regulatory personnel, this individual may reside offsite in a residence, school, or business or work at a non-DOE facility within the Hanford Site boundary. All potentially significant exposure pathways from airborne radionuclides to this hypothetical individual are considered, including:
  - Inhalation of airborne radionuclides.
  - Submersion in airborne radionuclides.
  - Ingestion of foodstuffs contaminated by radionuclides deposited on vegetation and the ground by airborne deposition.
  - Exposure to ground contaminated by airborne deposition.

- 80-kilometer population doses (person-rem) – Regulatory limits have not been established for population doses. However, evaluation of the doses to all residents within an 80-kilometer radius of the Hanford Site operating areas is required by DOE Order 5400.5. The 80-kilometer population dose represents the summed products of the average individual doses for the number of individuals involved for all potential exposure pathways.

The pathways assigned to the maximally exposed individual are assumed to be applicable to the offsite population. Consideration is given, however, to the fraction of the offsite population actually affected by each pathway. The exposure pathways for the population are as follows:

- Drinking water – The cities of Richland and Pasco obtain their municipal water directly, and Kennewick indirectly, from the Columbia River downstream of the Hanford Site. A total population of ~130,000 in the three cities drinks water from the Columbia River (PNNL-14428).

- Irrigated food – Columbia River water is withdrawn for irrigation of small vegetable gardens and farms in the Riverview area of Pasco in Franklin County. Commercial crops are also irrigated by Columbia River water in the Horn Rapids area of Benton County and the Ringold Area of Franklin County.

- River recreation – These activities include swimming, boating, and shoreline recreation. An estimated 125,000 people who reside within 80 kilometers of the Hanford Site's operations areas are assumed to be affected by these pathways.

- Fish consumption – Population doses from the consumption of fish obtained locally from the Columbia River were calculated from an estimated total annual catch of 15,000 kilograms per year (without reference to a specified human group of consumers).

In addition to radiological doses to the public, radiological doses to aquatic and terrestrial organisms are estimated using the RESRAD-BIOTA computer code (DOE/EH-0676; DOE/STD-1153-2002). The code compares measured radionuclide concentrations with conservative concentration guides. If more than one radionuclide is present, the fractional contributions of all radionuclides are added (sum of the fractions). If the sum exceeds 1.0, the dose guideline may have been exceeded and additional assessments may be needed. Biota dose assessments have been conducted at selected locations for Columbia River water, shoreline spring water, river sediment, and pond water and sediment.

Data

The data that are needed to perform dose calculations based on measured effluent releases include information on initial transport through the atmosphere or river, transfer or accumulation in terrestrial and aquatic pathways, and public exposure. By comparison, radiological dose calculations based on measured concentrations of radionuclides in food require data describing only dietary and recreational activities and exposure times. These data are discussed in the following sections.

Population Distribution and Atmospheric Dispersion

Geographic distributions of the population residing within an 80-kilometer radius of the four Hanford Site operating areas are based on 2000 Bureau of the Census data (PNNL-14428). These data influence the population dose by providing estimates of the number of people exposed to radioactive effluents and their proximity to the points of release.

Atmospheric dispersion and transport parameters are calculated each year using meteorological data collected during the reporting year. These data describe the transport and dilution of airborne radioactive materials, which influence the amounts of radionuclides being transported through the air to specific locations.

Terrestrial and Aquatic Pathways

Important parameters affecting the movement of radionuclides within potential exposure pathways, such as irrigation rates, growing periods, and holdup periods, are provided in the annual Hanford Site environmental report (e.g., PNNL-16623). Certain parameters are specific to the lifestyles of either "maximally exposed" or "average" individuals.

Public Exposure

The potential offsite radiological dose is related to the extent of external exposure to or intake of radionuclides released from Hanford Site operations. Parameters describing the diet, residency, and river recreation assumed for "maximally exposed" and "average" individuals are tabulated in the annual Hanford Site environmental report (e.g., PNNL-16623).

Dose Calculation Documentation

The former Hanford Environmental Dose Overview Panel had the responsibility for defining standard, documented computer codes and input parameters to be used for radiological dose calculations for the public near the Hanford Site. Only those procedures, models, and parameters previously defined by the panel are used to calculate the radiological doses to the public (PNL-3777).

Data Management, Analysis, and Statistical Treatment

Described herein are the objectives for management, analysis, and statistical treatment of surface environmental surveillance data. These objectives are primarily achieved through the use of the HEIS database (HEIS 1989). The HEIS database provides computer-based access to Hanford Site environmental data and is used to manage the data generated by the ongoing sampling efforts on and around the Hanford Site.

Objectives

Good data management, data analysis, and statistical treatment practices are essential for the production of quality results. The objectives for analyzing environmental surveillance data include:

- Managing data in a manner that assures their timely collection, validation, and reporting in accordance with an annual sampling schedule (e.g., PNNL-16369) and their traceability from scheduling to archiving in the HEIS database.
- Estimating contaminant-of-concern concentrations at each sampling and/or measurement point for each sampling and/or measurement time and estimating accuracy and precision.
- Comparing the contaminant-of-concern concentrations at each sampling and/or measurement point to previous concentrations measured at the same point to recognize changes or inconsistencies in concentration levels.
- Comparing the contaminant-of-concern concentrations at each sampling and/or measurement point to reporting (notification) limits.
- Comparing the contaminant-of-concern concentrations at individual sampling and/or measurement points to those measured at background or other points and evaluating the results of those comparisons.

Data Management Overview

The HEIS database is used as a repository for data gathered during environmental monitoring and cleanup activities at the Hanford Site. It is intended to provide current and consistent data to its users. The system and its data are accessible by all Hanford Site personnel. The components of HEIS are a database, data entry screens, and tools to access the data. The HEIS database is implemented using current industry standards, including a UNIX operating system, an Oracle database management system, Microsoft Access software (data entry screens), and a structured query language (reports and queries). The HEIS computer is managed by the Fluor Hanford Environmental Information Systems department.

In accordance with an annual sampling schedule (e.g., PNNL-16369), a schedule for collecting samples is established in the database at the beginning of each calendar year. Most samples for environmental surveillance are collected on a routine basis. To facilitate sample collections, the data management task leader generates sample identification labels and chain-of-custody forms weekly. The data management task leader also generates laboratory composite sheets to identify individual samples that are combined to form composite samples. Analytical results are provided by the laboratories and reported in either electronic or hard copy formats. Once obtained, the data are entered into the database either electronically or manually. The database can produce various status and result reports to assist project personnel in the review of data and to assure the prompt identification of unusual results. Finally, analytical results stored in the database can be retrieved for review or for use in preparing reports.

Sample Scheduling

The SESP and PSRPP managers, and their staff, revise the sampling schedule to meet monitoring needs each calendar year. The sampling locations, sample types, sample analyses, and frequencies of collection are identified and documented (e.g., PNNL-16369). In accordance with the schedule, the SESP data management task leader establishes the scheduling information in the database at the beginning of each calendar year. The database scheduling program interrogates itself to determine when a sample must be collected. The scheduled dates are automatically recalculated, based on the collection frequency, and are updated in the computer each week as the sample identification labels and chain-of-custody forms are generated. When a new sampling event is identified, the appropriate scheduling information is established in the database so that labels and forms can be created and sample and data tracking can be initiated.

Sample Collections

When a sample is collected, a chain-of-custody form is completed and a sample identification label is attached to the sample container. The sample identification label identifies the type of sample (i.e., air, water, biota, soil, sediment), HEIS sample identification number, collection date, and analyses required. The chain-of-custody form identifies the samples to be collected on a given day and includes the sample type, HEIS sample identification number, sampling location, and collection date for each sample. The chain-of-custody form accompanies the samples to the analytical laboratory where the samples are relinquished into the custody of laboratory personnel. The completed chain-of-custody form (or in some cases, a copy of the form) is returned to PNNL and becomes a permanent project record verifying sample collection and delivery to the analytical laboratory. Sample collection and handling procedures are contained in PNNL-16744.

Each month, composite sheets that identify individual samples to be combined to form composite samples are also generated. These sheets are forwarded to the analytical laboratory responsible for compiling the composite samples. On completion of the compositing process, laboratory personnel return the completed composite sheets to PNNL and they become a permanent record in the project files.

Tracking Sample Collections

The HEIS database is capable of tracking samples from the time the sample labels are produced until the sample results are entered into the database. This allows for accountability of both sample collection and sample analysis. When a sample label is generated, an accountability file is created for each analysis scheduled (i.e., radiochemical or chemical). After the sample is collected, the collection date is entered into the database, satisfying the sample collection portion of the accountability file.

The date the sample is submitted to the laboratory is also entered into the database. This date activates the sample analysis-tracking feature in the accountability file (see the section Tracking Sample Analyses on page III.A-42).

Loading Data into the Database

The contract laboratories report analytical results electronically and on hard copy. The electronic results are loaded into the HEIS database and those not received electronically are manually entered and verified against the hard copy report. The hard copy reports are considered to be the record copies and are stored in the project files.

Reporting of Analytical Data

Samples are analyzed for the constituents identified on the sample label, which can include radiochemical or chemical analyses. Results are reported in association with a 2-sigma overall propagated uncertainty. In the case of radiochemical results, a 2-sigma counting uncertainty is also reported. Data are reported electronically or on hard copy and are entered into the database.

The minimum required data that are stored in the HEIS database include:

- Sample identification number.
- Sampling location.
- Sample collection date.
- Analytical laboratory.
- Analysis.
- Analytical result.
- Unit for the analytical result.
- Sample volume.
- Comments, as appropriate.

Data Validations

As radiochemical results are entered into the database, several mathematical tests are performed to determine whether selected results are within the range of established limits. The tests and supporting data include:

- Test 1: Was the required detection level met?

- Test 2: Was the low limit exceeded?

- Test 3: Was the high limit exceeded?

- Statistics A: The maximum, minimum, and average of the last 10 results for this same sample type for this sampling location.

- Statistics B: The maximum, minimum, and average of results for this same sample type at all locations for the previous 12 months.

As data are collected, the results are compared to previous results to help identify unusual measurements that require investigation or further statistical evaluation. If the result is unusual and fails any of the above tests, it is considered an anomaly and a one-page anomalous data report is generated.

Outliers can represent a true extreme value or can indicate errors in sample collection, preparation, measurement, or equipment malfunctions. To assist the media task leader in determining the value of a questionable result, the contract analytical laboratory may be asked to perform a data recheck, which consists of reviewing the calculations, aliquot size, yield, counter background, counting efficiency, and other data pertinent to the reported analytical results; perform a recount of a sample by recalculating the concentration of the radionuclide in question; or perform a re-analysis of the preserved unused portion of a sample. Following these investigations, the task leader, with the approval of the project manager, decides how to handle the suspect datum. These decisions are documented on an anomalous data report, which becomes a permanent record in the project files.

Tracking Sample Analyses

To aid in the tracking of sample analyses, a maximum turnaround time for reporting of results is established with the analytical laboratory. This turnaround time, coupled with the sample submission date, provides a projected due date for the results from each analytical test ordered. If no result has been reported by the projected due date, the data management task leader can generate a “late results” report and may contact the analytical laboratory for a projected report date for the late result. An outstanding result will continue to appear on the late results report until the result is received and the accountability record has been completely satisfied.

Data Retrievals

One of the primary reasons for using a data management system is to store data and provide efficient and easy access to the thousands of analytical results obtained each year. The HEIS database contains SESP analytical data back to 1971, which can be retrieved by using Microsoft Access software.

Database Security

The HEIS database uses auto-archiving to prevent the loss of data because of fire, power failure, or other causes. The archived file can be used to recover from equipment failures that may occur during operational hours. Lockheed Martin Information Technology, a Fluor Hanford, Inc. subcontractor, performs a nightly backup of the HEIS database. In the event of a major system failure, a backup system would be available within 24 hours of the failure.

Quality Assurance

Records of data and other information developed during the operation of the HEIS database are controlled and managed in compliance with the requirements in a project QA plan, which conforms to the requirements of DOE Order 414.1C and 10 CFR 830.120. HEIS database integrity is ensured through the use of rules and constraints, which are automatically executed when data are entered into the database (QA discussed on page III.A-49).

Data Analysis and Statistical Treatment

Analytical results are reported and recorded with estimates of their uncertainty. The database contains the results as reported by the analytical laboratories, including negative results and results that are less than the estimated quantitative detection limits.

Data contained in the database vary in sample type (i.e., air, water, biota, soil, sediment), and any subset of data of a given sample type may or may not fit probability distributions typical of that type for a variety of potential reasons (e.g., sample size, mixed populations).

Parametric or non-parametric statistical tests to determine concentration differences and contaminant effects are based on sample size, distributions of the particular sample set being tested, and the hypothesis being tested.

Tests for precision and accuracy are addressed in the subsection entitled Quality Assurance and Quality Control on page III.A-49.

Analytical Procedures

All SESP environmental surveillance samples are analyzed according to established written procedures. Each sample undergoes appropriate processing prior to analysis. Contract-required detection levels for the various matrix/analysis combinations and other analytical information are shown in Table III.A-1 for radiological analytes and in Table III.A-2 for chemical analytes. In practice, actual minimum detection limits have historically been significantly lower for most analyses.

Air Samples

Gross alpha and gross beta concentrations are measured by counting an exposed glass fiber filter on a gas-flow proportional counter. Gamma emitters are measured by combining alpha-beta filters collected from specific locations during multiple sampling periods and counting them using a hyperpure germanium (HPGe) detector and a multi-channel, pulse-height analyzer. After these measurements have been conducted, the glass fiber filters are chemically leached with acid to extract strontium-90, uranium isotopes, and plutonium isotopes. The chemical processing is unique for each isotope and is followed by gas-flow proportional counting for strontium-90 or alpha energy analysis for uranium and/or plutonium.

Tritium in air is collected by drawing air through a sampler containing a silica gel absorbent. The water collected on the gel is removed by heat and vacuum and collected in a freeze trap as ice. The ice, containing tritiated water vapor, is melted and counted with a liquid scintillation spectrometer.

Until recently, iodine-129 in air was collected by drawing air through a cartridge containing a low-background petroleum-based charcoal. The iodine-129 collected on the charcoal was extracted, purified, and analyzed on a mass spectrometer. In 2006, the instrument used for this assay failed irreparably and a replacement instrument is not currently available. Project staff are working to identify another instrument or laboratory that is capable of performing this ultra-trace measurement.

Water Samples

Water samples are collected in the field and stored in the laboratory in a manner that preserves sample integrity for the required analytical method. Examples of preservation methods include refrigeration, the use of amber bottles for light sensitive materials, and the addition of acid preservatives.

Table III.A-1. Radiological Monitoring Sampling Summary

Type of Analysis	Minimum Sample Size	Required Detection Level
Air		
Gross alpha	800 m^3	0.001 pCi/m^3
Gross beta	800 m^3	0.003 pCi/m^3
HTO[(a)]	1 m^3	3.0 pCi/m^3
^{90}Sr	5,000 m^3	0.0001 pCi/m^3
^{129}I[(b)]	5,000 m^3	0.00000012 pCi/m^3
Gamma scan (^{137}Cs)	1,500 m^3	0.01 pCi/m^3
Pu (isotopic)	5,000 m^3	0.000005 pCi/m^3
U (isotopic)	1,500 m^3	0.00005 pCi/m^3
River and Surface Water		
Gross alpha	200 mL	4.0 pCi/L
Gross beta	200 mL	4.0 pCi/L
^{3}H (lo)	400 mL	10 pCi/L
^{3}H	100 mL	300 pCi/L
^{90}Sr	10 L	0.06 pCi/L
^{99}Tc	4 L	1.0 pCi/L
^{129}I[(b)]	1 L	0.000001 pCi/L
Gamma scan (^{137}Cs)[(c)]	750 L water equivalent	0.01 pCi/L
Gamma scan (^{137}Cs)	2 L	6.0 pCi/L
Pu (isotopic)[(c)]	750 L water equivalent	0.0002 pCi/L
Pu (isotopic)	1 L	0.01 pCi/L
U (isotopic)	1 L	0.06 pCi/L
Milk		
^{3}H(lo)	200 mL	10 pCi/L
^{90}Sr	1 L	2.0 pCi/L
^{129}I[(b)]	200 mL	0.00015 pCi/L
Gamma scan (^{137}Cs)	1 L	8 pCi/L
Fruit/Vegetable		
^{3}H	300 g	300 pCi/L
^{90}Sr	100 g	0.005 pCi/g
Gamma scan (^{137}Cs)	1,000 g	0.03 pCi/g
Alfalfa		
^{90}Sr	10 g	0.050 pCi/g
Gamma scan (^{137}Cs)	1,000 g	0.030 pCi/g

Table III.A-1. (contd)

Type of Analysis	Minimum Sample Size	Required Detection Level
Wildlife		
Gamma scan (^{137}Cs)[d]	500 g	0.030 pCi/g
Gamma scan (^{137}Cs)[d]	150 g	0.030 pCi/g
^{90}Sr	10	0.050 pCi/g
U (isotopic	2 g	0.020 pCi/g
Pu (isotopic)	100 g	0.0004 pCi/g
Wine		
^{3}H(lo)	200 mL	10 pCi/L
Gamma scan (^{137}Cs)	1 L	6.0 pCi/L
Soil and Sediment		
Gross alpha	1 g	6.0 pCi/g
Gross beta	1 g	3.0 pCi/g
^{90}Sr	10 g	0.050 pCi/g
Gamma scan (^{137}Cs)	500 g	0.030 pCi/g
^{99}Tc	5 g	1.0 pCi/g
^{241}Am	10 g	0.015 pCi/g
Pu (isotopic)	100 g	0.0004 pCi/g
U (isotopic)	2 g	0.020 pCi/g
Native Vegetation		
Gamma scan (^{137}Cs)	500 g	0.030 pCi/g
^{3}H	100 g	300 pCi/L
^{90}Sr	10 g	0.050 pCi/g
Pu (isotopic)	100 g	0.0004 pCi/g
U (isotopic)	2 g	0.020 pCi/g

(a) Tritiated water vapor.
(b) In 2006, the instrument used for this ultra-trace assay failed irreparably, and a replacement instrument is not currently available.
(c) Columbia River water filter/resin sample.
(d) Different sample sizes require different procedures.

Table III.A-2. Chemical Monitoring Detection Limits

Constituent	Water, µg/L	Solids, µg/kg	Soils, µg/kg	Wildlife/ Vegetation, µg/kg
Metals				
Aluminum			200,000	5,000
Antimony	0.02	30	30	10
Arsenic	0.05	100	100	100
Beryllium	0.1	30	30	40
Cadmium	0.05	20	20	10
Chromium	0.1	300	300	100
Chromium, hexavalent	0.3			
Copper	0.05	300	300	30
Lead	0.02	200	200	30
Manganese			2,000	20
Mercury	0.0005	50	50	50
Nickel	0.05	200	200	50
Selenium	0.5	500	500	200
Silver	0.05	20	20	10
Thallium	0.02	60	60	10
Thorium (total)			10	10
Uranium (total)			300	10
Zinc	0.1	600	600	200
Anions[(a)]				
Chloride	200			
Fluoride	500			
Sulfate	500			
Nitrite	250			
Nitrate	250			
Volatile Organic Compounds[(b)]				
Acetone	20			
Benzene	5			
Carbon tetrachloride	5			
Chloroform	5			
p-Dichlorobenzene	5			

Table III.A-2. (contd)

Constituent	Water, µg/L	Solids, µg/kg	Soils, µg/kg	Wildlife/ Vegetation, µg/kg
1,1-Dichloroethane	10			
1,2-Dichloroethane	5			
1,2-Dichloroethene (cis and trans)	5			
Methylene chloride	5			
2-Butanone	10			
4-Methyl-2-pentanone	10			
Tetrachloroethene	5			
Toluene	5			
1,1,1-Trichloroethane	5			
1,1,2-Trichloroethane	5			
Trichloroethene	5			
Vinyl chloride	10			
Total xylene	10			
1-Butanol	100			
Carbon disulfide	5			

(a) Method 300.0 (EPA-600/4-79-020).
(b) Method 8260 (SW-846 [EPA 1986]).

Water samples are dried on planchets and the residue is counted with a gas-flow proportional counter for gross alpha and gross beta. Gamma emitters are measured by analyzing a 500-ml water sample or a filter-resin (ion exchange) collection media using a HPGe detector coupled to a multi-channel, pulse-height analyzer. Strontium-90, technetium-99, uranium isotopes, and plutonium isotope analyses require chemical processing prior to counting. Strontium-90 is analyzed by gas proportional counting, technetium-99 by liquid scintillation, and uranium and plutonium isotopes are counted by alpha energy analysis. Tritium is analyzed by liquid scintillation spectrometry directly from aliquots of water or following electrolytic enrichment for low environmental concentrations.

Until recently, concentrations of iodine-129 in water were determined by mass spectrometer. In 2006, the instrument used for this ultra-trace assay failed irreparably, and a replacement instrument is not currently available.

Volatile organic compounds are measured in water using the procedures in EPA SW-846 and by analyzing with gas chromatograph-mass spectrometry.

Trace metals are measured in water samples by digesting with nitric acid and analyzing by either inductively coupled plasma-mass spectrometry (ICP-MS) or graphite-furnace atomic absorption (GFAA) spectrometry (EPA methods: EPA-821/R-96-005 Method 1638 or EPA-821/R-96-006 Method 1639, as

appropriate). The analysis for mercury requires a special chemical processing and the use of cold vapor atomic fluorescence by EPA Method 1631 (EPA-821-R-01-024).

Food and Farm Products

Gamma-emitting radionuclides in foodstuffs (including milk) are counted directly using a HPGe detector with a multi-channel, gamma-ray spectrometer.

Strontium-90 concentrations in foodstuffs are measured in the same manner as in air samples, but the samples are dried, ashed in a furnace, and treated with nitric acid before exposure to fuming nitric acid. For milk, strontium-90 is absorbed onto a cation exchange resin, eluted from the resin, and after several chemical steps, deposited onto a planchet and counted in a proportional flow counter.

Until recently, iodine-129 was separated from milk with an anion-exchange resin, purified, and analyzed by mass spectrometry as described for water. In 2006, the instrument used for this assay failed irreparably and a replacement instrument or laboratory is not currently available.

Tritium in water distilled from farm produce is counted directly with a liquid scintillation counter. Tritium in wine is first collected by distilling off the water from the other components of the wine. The tritium in water is then enriched by alkaline electrolysis and counted directly with a liquid scintillation counter.

Vegetation

For gamma emitters, vegetation samples are dried and chopped to accommodate the counting geometry of the Marinelli beakers used for counting samples. A HPGe detector coupled to a multi-channel, pulse-height analyzer is used for the analysis.

For strontium-90 analysis, the sample processing includes several ashing and dissolution steps with the final preparation being counted on a low-background gas-flow proportional counter.

Uranium and plutonium isotopes are assayed by alpha spectrometry after sequentially ashing the sample and dissolving it in acid, and drying the sample on a steel planchet.

Wildlife

For gamma analysis, fresh samples of muscle are placed in a Marinelli flask and counted on a HPGe detector coupled to a multi-channel, pulse-height analyzer.

Strontium-90 is measured in bone and other hard calcified tissue after chemical dissolution of the sample matrix and recovery of the strontium-90 by sequential extraction and precipitation steps. The final preparation is counted on a proportional counter.

Uranium and plutonium isotopes are assayed by alpha spectrometry of sequentially ashed and acid dissolved sample deposits on steel planchets.

Trace metals in biological tissue are digested in a Teflon bomb in a microwave oven prior to analysis by ICP-MS, GFAA, or for mercury, CVAA methods similar to those described for water.

Soil and Sediment

All soil and sediment samples are sieved, dried, and ball milled prior to analysis for radionuclides. Sample aliquots are counted without further processing for gamma emitters (HPGe detector), and gross alpha and gross beta with proportional counters. Radionuclide specific extractions for strontium-90, technetium-99, americium-241, uranium isotopes, and plutonium isotopes follow those described for wildlife samples with similar ashing and acid dissolution steps. Soil and sediment samples undergo a rigorous three acid digestion prior to trace metals analysis. The acid extracts are then processed as described for wildlife samples by ICP-MS, GFAA, and CVAA.

Quality Assurance and Quality Control

In achieving the surveillance objectives identified in previous sections, it is imperative that the accuracy, precision, traceability, and limitations of data are known. The generation of quality reports and documents requires controlled and verified data. It is also important to maintain an appropriate methodology to ensure control and legitimacy of project documentation. All components of the surveillance project are under an appropriate level of QA and quality control (QC) scrutiny.

The goal of a QA/QC program is to assure that accurate, defensible data are produced. This subsection describes the elements of the environmental surveillance QA/QC program and how they are implemented. In obtaining the QA/QC goal, a management commitment to operating a surveillance project that accurately reflects Hanford Site environmental impacts and radiation doses to the environment and public is required. A management commitment to the QA/QC program is assured through PNNL-established management philosophies that are implemented through the SBMS (PNNL 2007).

Requirements

The DOE QA requirements are contained in DOE Order 414.1C. DOE Order 414.1C requires that QA plans be developed and documented and recommends the judicious and selective application of appropriate and recognized standards. The DOE Order identifies 10 management, performance, and assessment criteria that must be addressed in a quality assurance plan. At PNNL, these criteria are implemented through the SBMS (PNNL 2007), which gives direction for developing an activity-specific QA plan.

Quality Assurance Plan

Surface environmental surveillance is conducted under a project-specific QA plan. The QA plan addresses the applicable criteria in DOE Order 414.1C, the 18 criteria of the American Society of Mechanical Engineers (ASME NQA-1-2000 Edition), and EPA guidance (EPA/240/B-01/003).

Assessments

Assessments are performed on surveillance project activities and procedures to assure compliance with project, PNNL, and DOE QA and QC requirements. The DOE Richland Operations Office (RL) program manager and SESP project manager, media task leader, or quality engineer may initiate these assessments on a routine and/or random basis. Assessment results are documented and, if appropriate,

provided to the project manager and media task leaders for review. Corrective actions, if needed, are documented and verified (e.g., field performance review) as applicable.

Quality Control

Procedures

Quality control for quality-affecting activities is maintained through written procedures. Activities that affect quality and require written procedures are identified in the project-specific QA plan.

In addition, QA/QC for services is defined in statements of work issued to the service organization. The services are performed according to QA procedures established for those services, unless a statement of work identifies special requirements.

Analytical Quality Control Program

Contracted analytical laboratories are required to maintain and participate in analytical QC programs that are used to determine analytical precision and accuracy, and to verify that the laboratories are operating according to contractually approved procedures or to procedures included in their statement of work. The project quality assurance task leader generates periodic reports (monthly or quarterly) to summarize intralaboratory QC data and performance. The media task leaders review these reports, along with the applicable minimum detectable concentrations and method detection limit determinations, and deficiencies in the QC data are identified and investigated. If corrective actions are implemented, they are documented, and implementation is verified (e.g., laboratory audits). In addition to each laboratory's internal QC program, they also participate in EPA and DOE national comparison studies. For these studies, blind samples containing specific amounts of contaminants are distributed to the participating laboratories. The laboratories analyze the samples and submit their analytical results to the EPA or DOE for comparison and evaluation. The results of the comparisons and evaluations are provided to the project quality assurance task leader.

Radiological Analyses. Most intralaboratory QC programs include analyzing blanks, replicates, and National Institute of Standards and Technology (NIST) traceable spiked samples (which must comprise no less than 15% of all ordered tests) and maintaining data that validate determinations of current minimum detectable concentrations. Equation 37 from Chapter 6 in EPA 520/1-80-012 is used for determining the minimum detectable concentrations. Quarterly reports are generated by the project quality assurance task leader to summarize intralaboratory QC data and performance. Data-accuracy (precision) requirements for internal analytical QC programs are addressed in the section Analytical Accuracy and Precision Criteria on page III.A-51.

The contracted analytical laboratory participates in two national comparison studies. The contracted laboratory is required to analyze applicable radionuclide-media samples from the DOE Mixed Analyte Performance Evaluation Program operated by the Radiological and Environmental Sciences Laboratory, and EPA Environmental Radioactivity Laboratory Intercomparison Studies Program. Additional QC data are generated by sending split or collocated duplicate samples to the DOE and EPA comparison laboratories and to other laboratories (i.e., WDOH, U.S. Food and Drug Administration [FDA]), and challenging the contracted laboratory with spiked (blind) reference samples as described in the project QC plan. The spiked (blind) reference samples are used to evaluate the capabilities of the contracted laboratory in

important radionuclide-media pathways and in historically weak analytical areas. Reference sample materials are obtained from the NIST, DOE, EPA or other sources that have proven reliability and accountability. Criteria used for judging contract laboratory performance on QC samples are derived from appropriate references (EPA-600/4-81-004; EML-608).

Performances on blind samples (split or spiked) are evaluated by project QC technical support personnel and reported to project management. These reports are reviewed by management and task leaders and corrective actions (e.g., follow-up audits) are taken if necessary.

Chemical (Non-Radiological) Analyses. The laboratories that analyze samples for chemicals are evaluated by having them analyze blank and replicate samples, matrix-spiked and matrix-spiked duplicate samples and laboratory control samples. The analytical laboratory reports the data from these evaluation samples along with the data from the surveillance samples.

Additional QC data may be generated by sending split or collocated samples to the intercomparison program analytical laboratories as well as to other laboratories (i.e., WDOH, FDA) and challenging the laboratory with spiked (blind) reference samples. Reference materials for spiked samples are obtained from the NIST, DOE, EPA, or other sources that have proven reliability and accountability.

Performances on blind-split or -spiked samples are evaluated by project QC technical support personnel and an evaluation report is prepared and provided to project management. These reports are reviewed and corrective actions (i.e., follow-up audits) are taken if necessary.

Analytical Accuracy and Precision Criteria

Data-accuracy criteria for radiological samples require that the analytical results for 95% of spiked samples be within 20% to 30% of the known spike values (Table III.A-3).

Table III.A-3. Precision Requirements

Type of Analysis	Precision
Gamma spectrometry	±20%
Liquid scintillation	±20%
Liquid scintillation with chemical separation	±30%
Alpha spectrometry	±25%
Beta proportional	±30%
Alpha proportional	±30%
Uranium total, fluorimetry or phosphorimetry	±30%
Uranium isotopic, gamma (low-energy photon spectroscopy)	±30%

Precision requirements are met when replicate sample results (above detectable concentrations) fall within ±30% relative percent difference for water samples and within three standard deviations for all other media samples.

The accuracy and precision of analytical results are assessed by analyzing spikes, blanks, and replicate samples. Such samples comprise no less than 15% of all ordered radiochemical tests.

For non-radiochemical tests ordered, QC criteria are defined in the Chemical Analysis section on page III.A-51. Spikes and blanks are included in each batch of samples. Spikes have, insofar as possible, the matrix, volume, and other relevant characteristics of the actual samples being analyzed. Blanks are matrix or reagent blanks. Reagent and sample media blanks will be analyzed with each batch of samples.

Records Management and Reporting

This section identifies record keeping and reporting requirements for environmental surveillance activities.

Record Keeping

The SESP record keeping requirements are implemented by the project QA plan, which conforms to the requirements of DOE Order 414.1C and 10 CFR 830.120. Project records are controlled in accordance with the *Records Management* portion of the QA subject area in the SBMS. The SBMS is a Web-based system for communicating the PNNL's management systems and procedures through subject areas.

DOE Order 5400.5 (p. II-15) covers information regarding records and retention of records associated with releases of radioactive materials to the environmental and their impact on the public.

Reporting

Reporting requirements associated with the potential radiological exposure of members of the public are in DOE Order 5400.5 (p. II-14). The reporting requirements applicable to environmental surveillance are contained in:

- DOE Order 231.1A:
  - Assures timely collection, reporting, analysis, and dissemination of environmental information.
  - Requires the preparation of the annual Hanford Site environmental report and requires its submission to DOE-HQ and the public by October 1 of the following year.
  - Requires that surveillance results be formally reported through the annual Hanford Site environmental report (e.g., PNNL-16623). The distribution of the report is reviewed each year to assure that potentially affected federal, state, and local governments and agencies; Indian Nations; environmental interest groups; and businesses are notified about the environmental status of the site and surroundings.
  - requires the reporting of unusual, off normal, or emergency occurrences that occur on the site.

- DOE Order 225.1A:
  - Defines accident investigation reporting requirements pertaining to release of hazardous substances, materials, waste, or radionuclides.
- DOE Order 5400.5:
  - Requires reporting when requirements of this order will not be or have not been met (p. I-4).
  - Requires reporting actual or potential exposures of the public that could result in either 1) a dose from DOE sources exceeding 10-millirem EDE in a year, or exceeding any limit or failing to meet any other requirement specified, or any other legal or applicable limits; or 2) a combined dose equal to or greater than 100 millirem EDE in a year from DOE and other man-made sources.

Unusual results or trends in surveillance data that occur between issuances of the annual Hanford Site environmental report (e.g., PNNL-16623) are reported to the DOE-RL and the appropriate contractor. Unusual concentration reporting levels have been established based on environmental concentrations that would lead to an offsite public dose of either 1 or 10 millirem per year, depending on the media, assuming that the condition persisted for an entire year. Unusual concentration reporting levels used by the Surface Environmental Surveillance Project are shown in Table III.A-4.

Table III.A-4. Established Surface Environmental Surveillance Project Unusual Concentration Reporting Levels[a,b,c]

	^{3}H	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{129}I	^{137}Cs	^{154}Eu	^{234}U, ^{235}U, ^{238}U	^{238}Pu, $^{239/240}Pu$	^{241}Am
Air, pCi/m^3	1.2E+02	2.7E-01	7.2E-02	(d,e)	1.8E-01	2.8E-03	1.1E-01	(e)	8.0E-04	3.9E-04	(d,e)
River water, pCi/L	1.0E+04	1.7E+00	3.0E-01	8.4E+00	1.5E+00	7.3E-01	3.5E-02	(e)	3.3E+00	1.1E+00	(d,e)
Milk, pCi/L	5.4E+04	(e)	2.7E+01	(d,e)	(e)	1.3E+01	8.1E+01	(e)	(d,e)	(d,e)	(d,e)
Leafy vegetables, pCi/g	5.0E+02[d]	(e)	2.7E-01	1.5E+01[d]	(e)	1.3E-01[d]	6.0E-01	(e)	(d,e)	(d,e)	(d,e)
Fruit and other vegetables, pCi/g	5.0E+01	(e)	2.5E-02	1.3E+00[d]	(e)	1.2E-02[d]	6.0E-02	(e)	1.1E-01[d]	6.2E-02[d]	(d,e)
Wine,[f] pCi/L	2.0E+05	(e)	(d,e)	(d,e)	(e)	(d,e)	3.0E+02	(e)	(d.e)	(d,e)	(d,e)
Wildlife meats,[g] pCi/g	(d,e)	9.1E-01	1.8E-01	1.1E+01[d]	(e)	(d,e)	5.4E-01	(e)	9.5E-01	5.0E-01	(d,e)
Wildlife bone	(d,e)	(d,e)	(d,e)	(d,e)	(d,e)	(d,e)	(d,e)	(d,e)	(d,e)	(d,e)	(d,e)
Soil,[h] pCi/g	(d,e)	(e)	3.0E-01	(d,e)	(e)	(d,e)	5.8E+00	(e)	3.1E+00	3.7E+00	5.5E-01
Vegetation and alfalfa, pCi/g	(d,e)	(e)	1.5E+00	1.6E+02[d]	(e)	(d,e)	2.7E-01	(e)	6.6E+00	4.2E+03	(d,e)
Sediment, pCi/g	(d,e)	1.4E+00	3.0E+04	(e)	1.4E+01	(d,e)	6.0E+00	2.6E+00	5.0E+01	8.1E+04	(d,e)
Pond water	(e)	(e)	(d,e)	(d,e)	(e)	(d,e)	(e)	(e)	(d,e)	(d,e)	(d,e)
Riverbank spring water	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(d,e)	(d,e)

(a) Concentrations greater than or equal to these levels are reported to DOE-RL and to the appropriate contractor.
(b) Established reporting levels were based on environmental concentrations that would lead to an offsite public dose of either 1 or 10 mrem per year, depending on the media, if exposure persisted for 1 year.
(c) Concentrations are shown to two significant figures for consistency, but this does not imply the analytical precision, which varies with measurement type, or the precision of the dose model used.
(d) No routine analysis for this radionuclide in this medium.
(e) No established unusual concentration reporting level.
(f) Based on estimated maximally exposed individual consumption rate of 70 L (~100 bottles) of wine per year.
(g) Based on estimated maximally exposed individual consumption rate of 40 kg of wildlife meat per year (from fish, deer, fowl, etc.).
(h) Reporting levels for ^{90}Sr and ^{137}Cs in soil based on ~10 mrem effective dose equivalent because the minimum detectable concentration exceeds a modeled dose rate of 1.0 mrem effective dose equivalent.

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Hanford Site Environmental Monitoring Plan

Section III.B. Meteorological Monitoring

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Introduction

This section describes the plan for conducting meteorological and climatological monitoring on and around the Hanford Site. The monitoring plan is designed to meet the environmental protection objectives stated in DOE Order 450.1, with DOE/EH-0173T used as guidance.

The specific components of the Hanford Site meteorological monitoring program include:

- Collecting meteorological data for dose assessment calculations.
- Collecting meteorological measurements.
- Inspecting, maintaining, and calibrating equipment.
- Summarizing and archiving data.
- Quality assurance (QA).

The following sections discuss the composition of the Hanford Site meteorological monitoring program as it relates to DOE Order 450.1 and DOE/EH-0173T.

Meteorological and Climatological Services Project

The Pacific Northwest National Laboratory's (PNNL's) Meteorological and Climatological Services Project provides the Hanford Site U.S. Department of Energy (DOE) field offices and contractors with meteorological and climatological support for emergency response, weather forecasting, climatological data, and related special requests through the operation of the Hanford Meteorology Station (HMS). The project responds to Hanford Site needs through a program that includes:

- Extensive data acquisition through a site-wide meteorological monitoring network.
- Site-specific forecasts using weather satellite imagery and National Weather Service products.
- Standard hourly surface weather observations and 6-hour synoptic observations.
- Climatological data through monthly summaries, meteorological input to annual environmental reports (e.g., PNNL-16623), and responses to ad hoc requests.

Meteorological Monitoring Network

The Hanford Site covers an area with significant variations in topography and with elevations ranging from approximately 100 to nearly 1,100 meters above sea level. To characterize the meteorological conditions on and around the Hanford Site, 30 monitoring stations have been installed onsite and nearby offsite (Table III.B-1 and Figure III.B-1). Station locations were selected to reflect the influence of the varied topography, especially on wind speed and direction, and to provide appropriate data for atmospheric transport and diffusion modeling and for site characterization. The station selection process

Table III.B-1. Hanford Site Meteorological Monitoring Towers

Site Number[(a)]	Site Name	Tower Height, m	Instrumentation
1	Prosser Barricade	9.1	WS, WD, T, P
2	Emergency Operations Center	9.1	WS, WD, T, P
3	Army Loop Road	9.1	WS, WD, T, P
4	Rattlesnake Springs	9.1	WS, WD, T, P
5	Edna	9.1	WS, WD, T
6	200-East Area	9.1	WS, WD, T, P, AP
7	200-West Area	9.1	WS, WD, T, P
8	Beverly	9.1	WS, WD, T, P
9	Fast Flux Test Facility	61	WS, WD, T, TD, DP, P, AP
10	Yakima Barricade	9.1	WS, WD, T, P, AP
11	300 Area	61	WS, WD, T, TD, DP, P, AP
12	Wye Barricade	9.1	WS, WD, T, P
13	100-N Area	61	WS, WD, T, TD, DP, P, AP
14	WNP-2	9.1	WS, WD, T, P
15	Franklin County	9.1	WS, WD, T
16	Gable Mountain	9.1	WS, WD, T
17	Ringold	9.1	WS, WD, T, P
18	Richland Airport	9.1	WS, WD, T, AP, P
19	200-West (Plutonium Finishing Plant)	3.0	WS, WD, T, AP
20	Rattlesnake Mountain	9.1	WS, WD, T, P, RH
21	Hanford Meteorology Station	124.3	WS, WD, T, DP, ST, P, AP
22	Pasco	9.1	WS, WD, T, P
23	Gable West	9.1	WS, WD, T
24	100-F Area	9.1	WS, WD, T, P
25	Vernita Bridge	9.1	WS, WD, T
26	Benton City	9.1	WS, WD, T, P, ST
27	Vista	9.1	WS, WD, T, P
28	Roosevelt	9.1	WS, WD, T, AP, P
29	K-Basin	9.1	WS, WD, T, AP, P
30	HAMMER	9.1	WS, WD, T

(a) See Figure III.B-1.
AP = Atmospheric pressure.
DP = Dew-point temperature.
RH = Relative humidity.
P = Precipitation.
ST = Subsurface soil temperature
T = Temperature.
TD = Temperature difference.
WD = Wind direction.
WS = Wind speed.

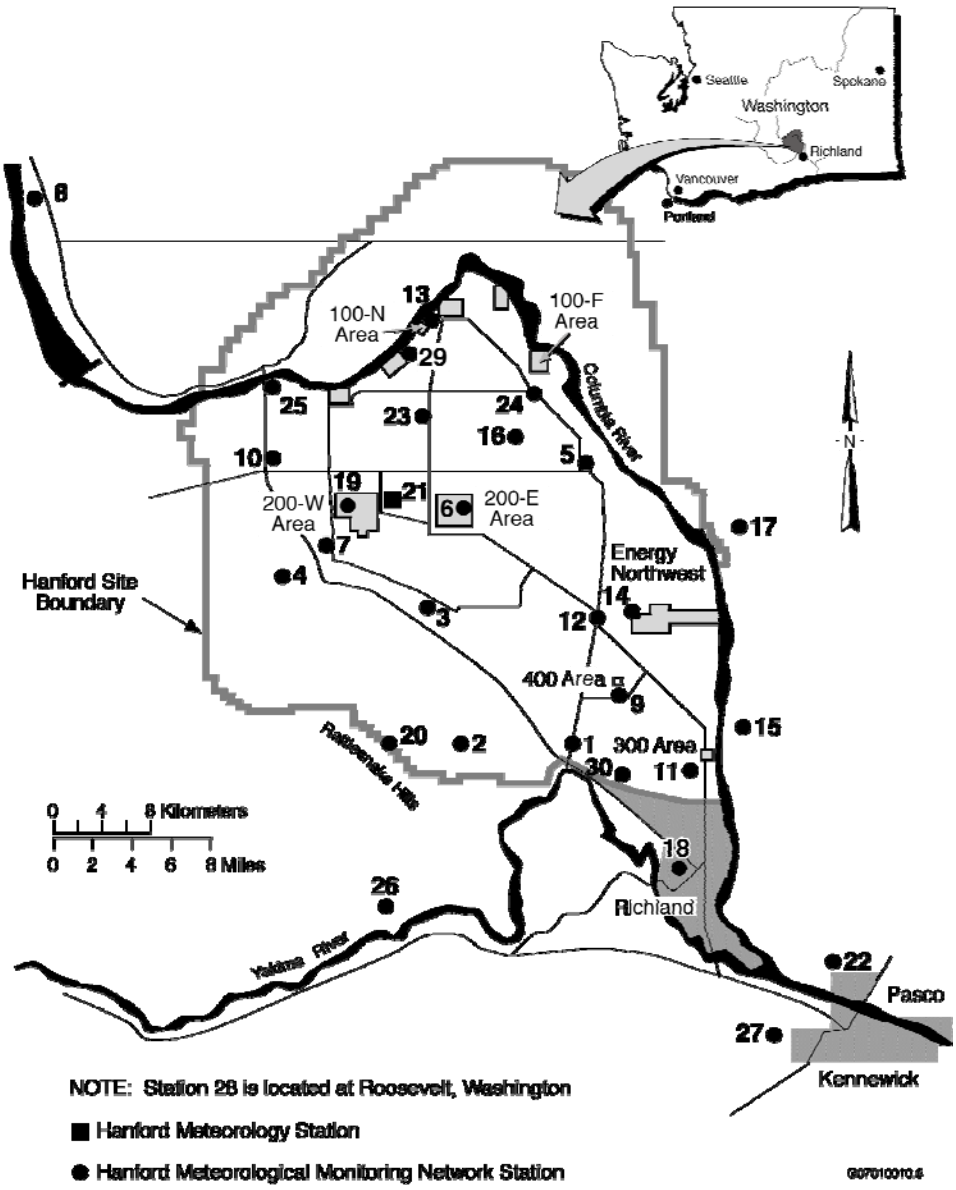

Figure III.B-1. Meteorological Monitoring Stations on the Hanford Site and in Surrounding Areas

was based on an understanding of the effects of synoptic- and meso-scale meteorological events on wind flow over the Hanford Site and on model studies of atmospheric transport that were run specifically to indicate areas where additional wind data were required. The meteorological monitoring network was designed to:

- Represent implicitly the effect of the varying topography of the Hanford Site on atmospheric circulations by strategic siting of the individual stations.

- Monitor and collect real-time meteorological data at locations where operations are conducted that could have a possible negative impact on workers, the public, biota, and the environment in an emergency situation.

- Provide meteorological data for daily operational forecasting for Hanford Site activities.
- Provide real-time meteorological data for atmospheric transport and diffusion modeling.
- Provide climatological data for environmental assessments, environmental impact statements, facilities planning, etc.

A 124.3-meter tower, located at the HMS, has instruments at multiple levels to measure wind speed and direction and temperature. This tower has been used to collect data since the mid-1940s. Three 61-meter monitoring stations, with instruments at multiple levels, are located in onsite areas where significant operations are conducted. These stations provide additional information necessary to atmospheric transport and diffusion models. Twenty-five 9.1-meter towers have instruments for wind speed and direction (at 9.1 meters) and temperature (at 1.5 meters), and one 3.0-meter tower has instruments for wind speed and direction (at 3.0 meters) and temperature (at 1.5 meters). Most stations also record precipitation. Detailed descriptions of each meteorological monitoring site, including narrative and photographic depictions of the topography proximate to each, can be found in PNL-6684.

Meteorological Instrumentation

The meteorological instrumentation provides data, including wind speed and direction, temperature, vertical temperature difference, dew-point temperature, and precipitation. Other data are collected via the surface observation program, including sky condition, cloud type and amount, ceiling height, mixing depth, atmospheric pressure, weather and obstructions to visibility, relative humidity, and solar radiation (PNL-6509).

Wind. Wind speed and direction are measured at the 9.1-meter level at most meteorological monitoring stations, at the 3-meter level at the tower at Station 19, at the 25- and 60-meter levels on the three 61-meter towers onsite (see Table III.B-1), and at the 15.2-, 61.0-, and 121.9-meter levels on the 124.3-meter tower at the HMS.

Wind speed at most monitoring stations (except Stations 19, 20, 22, and 29, see Figure III.B-1) is measured using sensors (3-cup heavy-duty aluminum anemometer) with a low starting threshold over a wide range of wind speeds. At Station 20, located on the top of Rattlesnake Mountain, where light winds are unusual and sustained wind speeds in excess of 45 meters per second are common, a sturdier anemometer (with a higher starting threshold but a greater range) is used. At Stations 19, 22, and 29, which are solar powered, a wind monitor with a propeller (rather than a cup anemometer) is used because it is less susceptible to freezing because of moisture and fog. The wind speed sensor specifications, by station number, are provided in the following list:

- **Stations 1 to 18, 23 to 28, 30**

Threshold	0.22 meter per second
Operating range	0 to 56 meters per second
Accuracy	0.07 meter per second or 1.0%, whichever is greater

- **Station 19**

Threshold	1 meter per second
Operating range	0 to 60 meters per second (gust survivability to 100 meters per second)

- **Station 20**

Threshold	1 to 2 meters per second
Operating range	0 to 90 meters per second (gust survivability to 90+ meters per second)

- **Station 22**

Threshold	1 meter per second
Operating range	0 to 60 meters per second (gust survivability to 100 meters per second)

- **Station 29**

Threshold	1 meter per second
Operating range	0 to 60 meters per second (gust survivability to 100 meters per second).

Wind direction sensors at most of the monitoring stations, except Stations 19, 20, 22, and 29 where wind monitors are used, are counterbalanced, lightweight vanes attached to a shaft coupled to a precision low-torque potentiometer. These sensors have low starting thresholds and fast dynamic response. The wind direction sensor specifications, by station number, are provided in the following list:

- **Stations 1 to 18, 23 to 28, 30**

Threshold	0.22 meter per second
Operating range	0 to 360 degrees
Accuracy	±2 degrees
Damping ratio	0.4 at 10 degrees initial angle of attack
Distance constant	1.1 meters

- **Station 19**

Threshold	1 meter per second
Operating range	0 to 360 degrees mechanical, 0 to 355 degrees electrical
Accuracy	±5 degrees

- **Station 20**

Threshold	1 meter per second
Operating range	0 to 360 degrees mechanical, 0 to 355 degrees electrical
Accuracy	±5 degrees

- **Station 22**

Threshold	1 meter per second
Operating range	0 to 360 degrees mechanical, 0 to 355 degrees electrical
Accuracy	±5 degrees

- **Station 29**

Threshold	1 meter per second
Operating range	0 to 360 degrees mechanical, 0 to 355 degrees electrical
Accuracy	±5 degrees.

The wind speed and wind direction sensors at all monitoring locations, except Stations 19, 20, 22, and 29 are heated to minimize the accumulation of rime and/or freezing precipitation during the winter.

Temperature. Air temperature is measured at 1.5 meters at all of the monitoring stations, with additional measurements at the 10- and 60-meter levels (for measurement of ΔT for atmospheric stability designation) at the three 61-meter monitoring stations (see Table III.B-1). Temperature is measured at the 0.9-, 9.1-, 15.2-, 30.5-, 61.0-, 76.2-, 91.4-, and 121.9-meter levels on the 124.3-meter tower.

The temperature sensor (on all but the 124.3-meter tower) is an epoxy coated thermistor composite that exhibits relatively large resistance changes in response to small temperature changes. Fast-response sensors (with a time constant of 3.6 seconds) are used. All of the 9.1-meter monitoring stations have naturally aspirated radiation shields, and the three 60-meter stations have mechanically aspirated shields. The thermistor temperature sensor specifications are given below:

Probe accuracy	±0.15°C
Range	-30.0°C to 50.0°C
Time constant	3.6 seconds.

On the 124.3-meter tower, temperatures are measured using a platinum resistance temperature device contained in a 15-centimeter-long stainless steel housing mounted in a mechanically aspirated radiation shield. The platinum resistance temperature sensor specifications are given below:

Probe accuracy	±0.1°C
Range	-50.0°C to 100.0°C
Time constant	15 seconds.

Subsurface soil temperature measurements are also made at depths of 0.5, 15, and 36 inches. The same sensors are used as on the 124.3-meter tower (described in the preceding paragraph).

Temperature Differencing. Temperature differencing is one of several methods used to determine atmospheric stability, which is one of the parameters used in transport and diffusion calculations. Atmospheric stability is a measurement of the buoyancy of a parcel of air. The buoyancy of a parcel of air depends on its density relative to the density of the environment at the same level. If a parcel is heavier than its environment, it will tend to sink (stable); if a parcel is lighter than its environment, it will

tend to rise (unstable); and if the weight is the same, it will remain at the same level as its environment (neutral). Stability classes can be determined by measuring the difference between air temperatures at two levels.

The ΔT calculation at the 124.3-meter tower is made using the difference between actual temperatures measured at the 61- and 9.1-meter levels of the tower. At the three 61-meter monitoring stations, the ΔT calculation is made using the difference between actual temperatures measured at 10 and 60 meters. The temperature sensors used are discussed above.

Dew-Point Temperature. Dew-point temperature is measured at the 1.5-meter level at three 61-meter towers. The dew-point sensor is housed in a mechanically aspirated temperature/dew-point shield and consists of bifilar gold electrodes wound on a lithium chloride-impregnated glass fiber wick that encloses a thermistor temperature sensor. The dew-point sensor specifications are given below:

Operating range	-40°C to +50°C
Relative humidity	from 100% to the relative humidity at which the lithium chloride salt operating limits temperature is 2°C above the ambient temperature (11% to 18% relative humidity).

At the HMS, a hygrothermometer system is used to measure the dew-point temperature. The monitor is located 1.5 meters above the ground and uses a chilled mirror system to monitor the dew point. The specifications for the hygrothermometer are the following:

Operating temperature	-50°C to +50°C
Relative humidity	5% to 100%
Ambient temperature	±1°C from -50°C to 50°C accuracy
Dew-point accuracy	±1°C when less than 0°C.

Relative Humidity. Relative humidity at Station 20 (Rattlesnake Mountain) is measured at the 1.5-meter level of the 9.1-meter tower. The Humicap® relative humidity sensor is housed in a mechanically aspirated radiation shield. The relative humidity is measured by a thin polymer film that either absorbs or exudes water vapor as the relative humidity of the ambient air rises or drops. The dielectric properties of the polymer film depend on the amount of water contained in it – as the relative humidity changes, the dielectric properties of the film change and, therefore, the capacitance of the sensor changes. The electronics of the instrument measure the capacitance of the sensor and convert it into a relative humidity reading.

Operating range	-40 to 60°C
Accuracy at 20°C	±2% relative humidity (from 0% to 90% relative humidity) ±3% relative humidity (from 90% to 100% relative humidity)
Time constant	15 seconds

Precipitation. Precipitation measurements, using recording rain gauges, are made at 23 of the 30 monitoring stations. Each rain gauge has an opening 20 centimeters in diameter to collect precipitation. Two compartments alternately fill with precipitation and tip (emptying the compartment), causing momentary closure of a mercury switch. The funnels are electrically heated to measure the water equivalent of frozen precipitation. The heater is thermostatically controlled to be activated when the

ambient temperature drops to 4°C. These gauges are sensitive to 0.25 millimeter and are accurate to 0.5% for a rainfall rate of 12.70 millimeters per hour. The average precipitation event at the HMS is only 2.3 millimeters.

Atmospheric Pressure. Atmospheric pressure is measured at the 1.5-meter level at the 10 sites indicated in Table III.B-1. The sensors are located within the signal interface unit enclosures. The pressure sensor specifications are given below:

Scaling range	800 to 1,100 millibars
Nonlinearity	±0.05% of full scale
Full-scale accuracy	±0.1% of full scale or ±0.3 millibar.

Instrument Calibration and Maintenance

All measurement and test equipment is calibrated on an annual basis, and the calibrations are spread throughout the year. However, because data are reviewed hourly by the forecaster on duty, any apparent problems with data from a particular station are immediately noted and the instrument specialists are advised. Instruments are recalibrated after any repair before being returned to use. Because of the large number of monitoring locations and the distances involved, it is not practical to perform total system calibration on a more frequent basis. Again, because of the large number of monitoring locations that contribute data to the meteorological monitoring system, the temporary loss of data from one or two locations is not critical to the operation of the system as a whole. Even so, every attempt is made to keep the amount of downtime to a minimum.

In accordance with QA requirements, the PNNL maintains the procedures to calibrate all measurement and test equipment used by the Meteorological and Climatological Services Project. Primary, secondary, and traveling calibration standards are traceable to the National Institute of Standards and Technology (NIST). The procedures state that the Instrumentation Services and Technology – Instrument Calibration Facility must generate a notice of instrument calibration 2 months before the expiration of calibration on any piece of equipment. This notice is sent to the appropriate Maintenance and Fabrication Services electrician/instrument technician. On completion of calibration, a record of calibration is generated, and copies of the record are provided to the applicable instrument laboratory, instrument custodian, and PNNL Instrument Calibration Facility.

Data Acquisition

Data are acquired and processed at each monitoring station using a signal interface unit and a telemetry unit. Most of the signal interface and telemetry units are powered commercially; however, units at six sites (7, 19, 22, 25, 28, and 29) are powered by batteries charged by solar panels. The signal interface unit acquires and processes the signals from the individual instruments, and the telemetry unit transmits the processed data to the HMS via a radio repeater on Rattlesnake Mountain. Inputs to the signal interface unit may be analog, counter, or digital. The unit scans its channels for information every 1 second, stores the information for 15 minutes, and sends the 15-minute-averaged values (made up of 900 samples) to the HMS. Values are transmitted on the hour and at 15-minute intervals. The output is a digital sequence of numbers transmitted at 416.5 megahertz with 4 watts of power.

The data transmitted from the remote monitoring stations are received at a base station located at the HMS and are sent to a personal computer network via an RS-232 serial data link.

Atmospheric Transport and Diffusion

The Air Pollutant Graphical Environmental Modeling System (APGEMS) is an atmospheric dispersion model that predicts ground-level concentrations and deposition fields of air contaminants released from point sources given contaminant release rates, source configurations and meteorological observations of winds, mixing heights, precipitation rates, and atmospheric stability. APGEMS is embedded in a Windows-based graphical user interface that allows the user to easily specify input information and view the output concentration, dose, and deposition fields on maps of the area of interest. The implementation of APGEMS for the Hanford Site uses meteorological data from the Hanford Meteorological Monitoring Network and radionuclide source information. The data from the Hanford Meteorological Monitoring Network is critical for APGEMS, which is a primary model used in the Unified Dose Assessment Center (UDAC) of the Emergency Operations Center.

APGEMS is applicable at source-to-receptor transport distances of a few hundred meters to a few hundred kilometers. The model operates at two "nested" grid resolutions; a fine grid to resolve the dispersion within a few kilometers of the release, and a course grid to track plume transport to approximately 200 kilometers from the source (assuming the source at the center of the grid). The model uses a three-dimensional diagnostic wind model to specify the varying winds over the modeling domain. A special feature of the wind model is that during stable atmospheric conditions it accounts for flow channeling and blocking from major terrain features, in addition to treating drainage flows.

Quality Assurance

QA for the Meteorological and Climatological Services Project is established and implemented by the PNNL's formal QA program, as contained in the PNNL's Standards-Based Management System (SBMS) (PNNL 2005). The QA program conforms to the requirements of DOE Order 414.lA.

Independent surveillances and audits of Meteorological and Climatological Services Project activities and procedures to assure compliance with the PNNL's quality management system and the project QA plan are conducted by the PNNL Quality and Integrated Safety Department. These surveillances and audits can be initiated by a DOE monitor, the PNNL program manager, the project manager, or the project quality engineer on either a routine and/or a random basis.

Data Management

Meteorological data from the monitoring network are collected, processed, and archived on a dedicated network of personal computers at the HMS. Incoming data are written to several independent hard drives on separate personal computers simultaneously, so that data are available even in the event of the failure of an individual hard drive or personal computer. MetViewer software is used for data management and display.

The 15-minute-averaged data from the monitoring network are used as input to atmospheric transport and diffusion models for emergency response and are maintained for 10 days. At the beginning of the

eleventh day, the first day of the 15-minute data is purged and 15-minute data from the newly designated tenth day are stored. These data are available on a network server that can be accessed by emergency preparedness organizations for their needs.

For permanent storage, the 15-minute data are converted into hourly data. These data are processed daily using the ARCHIVE computer code (PNL-6279, Vol. 10). This computer program converts hourly binary meteorological data from the 9.1-, 61- and 124.3-meter towers into formatted (ASCII) data and organizes the converted data into appropriate monthly files.

At the beginning of every month, the monthly data on the personal computer network are processed prior to permanent storage. All data are reviewed using QA computer programs (PNL-6279, Vol. 9). These programs check all data for the following types of potential errors:

- Parameters out of range (e.g., January temperature more than 16.7°C).
- Unreasonable changes in parameter magnitude from one hour to the next (e.g., temperature change more than 5.6°C).
- Parameter conflict (e.g., visibility below a specific threshold value with no obstructing phenomena indicated [fog, snow, etc.]).

These programs generate error listings that allow for the resolution of possible data irregularities. These computer-generated error listings are maintained on file; however, errors that can be readily resolved are corrected and archived. If they cannot be corrected, the data are indicated as missing.

On completion of these monthly QA checks, the final data are archived on multiple hard disks, and are available for additional processing (e.g., joint frequency distributions, wind roses, data summaries), as necessary.

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Hanford Site Environmental Monitoring Plan

Section III.C. Ecological Monitoring and Compliance Assessment

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Introduction

Ecological monitoring and ecological compliance assessment are additional aspects of the U.S. Department of Energy's (DOE's) requirements for an environmental resources protection plan and are designed to meet the environmental resources protection objectives stated in DOE Order 450.1, with DOE/EH-0173T used as guidance. Activities conducted under the Ecological Monitoring and Compliance (EMC) project directly support Hanford Site and DOE compliance with federal statutes, regulations, and directives pertaining to ecological resource protection and preservation, specifically the *National Environmental Policy Act* (NEPA) and DOE Implementation Procedures (10 CFR 1021); the *Endangered Species Act*; the *Bald and Golden Eagle Protection Act*; the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA); and the *Migratory Bird Treaty Act*. Additionally, this work element provides a basis for incorporating Washington Department of Fish and Wildlife and special species laws, regulations, and policies into Hanford Site activities, as warranted.

The specific components of the EMC project include:

- Ecological compliance, protection, and mitigation.
- Ecological characterization and impact assessment.
- Data management.
- Quality assurance (QA).

This section identifies the data required to support ecological monitoring and compliance assessment activities and other ecological information important to these activities.

Ecological Monitoring and Compliance Project

The Pacific Northwest National Laboratory's (PNNL's) EMC project provides the Hanford Site DOE field offices and contractors with ecological characterization, monitoring, and compliance assessment support. The project provides data and information to fulfill the DOE Richland Operations Office's (RL's) needs to achieve compliance with natural resource related legal and regulatory requirements for the biological resources found on the Hanford Site. Under this project, surveys and monitoring of resources and key biota are conducted to assess abundances, vigor or conditions, and distributions of populations and species on the Hanford Site. Data collection and analysis are integrated with the monitoring of biotic and abiotic media under the Surface Environmental Surveillance Project (SESP) to characterize any potential risks or impacts to the biota.

Ecological monitoring and ecological compliance activities support multiple objectives for completing the Hanford Site's waste management and environmental restoration missions. The project responds to Hanford Site needs through a program that includes:

- Conducting ecological compliance reviews to provide the environmental analysis and survey data that enable DOE projects to comply with federal regulations including the *Endangered Species Act*, NEPA, and the *Migratory Bird Treaty Act*.

- Implementing the *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington* (DOE/RL-94-150), *Threatened and Endangered Species Management Plan: Salmon and Steelhead* (DOE/RL-2000-27), and interactions with the U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, and National Oceanic and Atmospheric Administration Fisheries to facilitate DOE operations and reduce potential liabilities.

- Collecting and maintaining the data needed to provide the ecological information and impact assessments that enable the DOE to make technically defensible environmental management decisions; reduce DOE liability; and inform the public, stakeholders, and trustees about the status of ecological resources at the Hanford Site.

- Integrating and evaluating spatially explicit information describing the occurrences and distributions of ecological receptors in areas with known or probable legacy contaminants. This information can be used to assess potential site-specific and site-wide impacts to support ecological risk analyses.

- Maintaining current and historical ecological data to support Hanford issues and litigation needs (e.g., 24 Command Wildfire), land-use planning (e.g., wildland fire issues, high-value biological resources), and mitigation action planning.

Activities inherent in the operation of the EMC project include study design and implementation, data collection, sample analysis, database management, data review and evaluation, resource inventory, and reporting. Other elements of the project include project management, QA and quality control (QC), training, and records management.

Ecological Compliance, Protection, and Mitigation

The Hanford Site contains significant remnants of native Washington State shrub-steppe and semi-arid riparian habitats that are relatively undisturbed by agricultural and industrial development. The wildlife and plants found on the Hanford Site are subject to regulation by federal and state authorities. Activities to assure compliance with regulations include those that are 1) required to assure compliance with appropriate regulatory drivers and 2) required to protect specific resources of concern or to develop meaningful mitigation strategies for Hanford Site resources of concern. The ecological compliance assessment portion of the EMC project 1) assures DOE compliance with federal and state wildlife resource regulations; 2) analyzes impacts of site operations on ecological resources, including federally listed species; 3) prepares documentation in support of site NEPA analyses; 4) prepares mitigation plans for minimizing impacts to protected species and habitat; and 5) conducts informal consultations with the U.S. Fish and Wildlife Service when warranted. The *Hanford Site Biological Resources Management Plan* (DOE/RL-96-32), *Hanford Site Biological Resources Mitigation Strategy* (DOE/RL-96-88), and *Ecological Compliance Assessment Management Plan* (DOE/RL-95-11) guide ecological compliance assessment on the Hanford Site.

Routine Reviews. Ecological compliance reviews are performed for Hanford Site activities that have the potential to adversely impact species or habitats of concern. After receiving a request for an ecological compliance review from a Hanford Site contractor or other organization, project personnel conduct an initial screening to determine if the proposed action could have direct ecological impacts. Criteria used in this review include those defined in the *Ecological Compliance Assessment Management*

Plan (DOE/RL-95-11). The project databases are examined to determine whether a field survey was carried out in the area of the proposed action within the current biological year (e.g., between April 15, 2007 and April 15, 2008). A letter report is completed for each review that includes (at a minimum): a brief project description; description of the basis for the review, including field survey methods, dates, and personnel involved; results of the survey; conclusions regarding impacts; and recommendations regarding mitigation of impacts. Specific information on ecological resources of concern, habitat descriptions, and species lists are included as appropriate.

Baseline Field Surveys. Field surveys are conducted annually to acquire baseline data for ecological compliance reviews in the 100-K, 200-West, 200-East, and 300 Areas. All habitats and buildings within the fences of each area are surveyed, except for land lying within surface contamination areas or exclusion zones that are not adequately visible from the perimeter. Any reviews that fall within the baseline areas are funded by the project requesting the review. Baseline field surveys do not include surveys (such as bat surveys) within abandoned buildings scheduled for demolition. The 100-K, 300, and 200 Areas are surveyed in the spring and early summer to determine use by protected breeding wildlife, the occurrence of protected plant species, and the presence of habitats of concern. These data are used when evaluating ecological compliance review requests during the following summer, fall, and winter.

Rare Plant Monitoring. Field surveys and data analyses are conducted on the Hanford Site to map and monitor new and existing populations of plant species of federal and state concern that might be impacted by onsite activities. At least 47 of the more than 700 plant species found on or near the Hanford Site are listed by the Washington Natural Heritage Program as endangered, threatened, sensitive, review, or watch list. More than 100 populations of plant species of concern have been located across the Hanford Site. Field surveys are conducted to search for target species in potential habitat areas and for any and all plant species of concern that could potentially inhabit the surveyed areas.

Federally Threatened or Endangered Species Protection. The EMC project assists the DOE and site contractors in complying with the *Endangered Species Act*. The assistance includes developing and maintaining protection plans, posting restricted areas and maintaining the signs, educating Hanford Site personnel about rules and responsibilities, and communicating with the appropriate regulatory agencies regarding compliance issues. EMC project personnel regularly monitor known and potential use areas to determine current nesting/spawning areas for threatened or endangered species on the Hanford Site. The assessment of activities potentially affecting these use areas requires, at a minimum, regular informal interactions with the appropriate federal agencies.

Ecological Characterization and Impact Assessment

Monitoring and characterization activities conducted on the Hanford Site under the EMC project involve collecting and analyzing the appropriate ecological data to assess potential impacts and detect population trends for key species. The work includes collecting population-level information for biota in key habitat types and collecting and analyzing community and population-level data over long time periods to detect changes in population sizes and conditions. These data are used to assess relative resource values, presence or absence of organisms as risk receptors with respect to legacy contaminants in the environment, and to detect changes in population sizes that may or may not be related to Hanford Site operations.

Inventory and monitoring efforts are prioritized each year based on the current status of the species inhabiting the site, public and stakeholder concerns, and project sampling and ecological characterization needs. Results from these inventory and monitoring efforts are maintained in the project databases and are a critical component for implementing the *Hanford Site Biological Resources Management Plan* (DOE/RL-96-32). Analyses of these results provide early indications of any potential impacts to biota from Hanford Site operations and information to describe potential ecological receptors found in habitats on the Hanford Site.

Population Monitoring and Trend Analysis. Populations monitored on the Hanford Site include deer, bald eagles, ferruginous hawks, geese, salmon/steelhead, bivalves, crayfish, amphibians, vegetation in key habitats, and other species or guilds as needed. Sampling methods, frequencies, and timing are based on the species and habitats of interest, and reviews of the best and standard scientific practices available. Standard sampling procedures are maintained in project records.

Not all populations are surveyed annually. Annual surveys focus on 1) species that might be consumed by the public, 2) species of concern to state or federal authorities (e.g., species listed by state or federal agencies as threatened and endangered or candidates for listing as threatened and endangered), and 3) species that appear to have higher potentials for exposures to, or impacts from, legacy contaminants present on the Hanford Site. Annual surveys may include:

- Surveys conducted to describe the relative abundance and distribution of deer inhabiting the site.
  - Winter surveys of mule deer residing in areas adjacent to the Hanford Reach.
- Aerial surveys to document significant salmon and steelhead spawning areas in the Hanford Reach.
  - Salmon redd surveys are conducted during the peak spawning period for fall Chinook salmon (usually late October through November) to provide data on the numbers and locations of visible redds in the Hanford Reach.
  - Steelhead redd surveys are conducted in the months of February, March, and April to provide preliminary data on the occurrence and distribution of spawning steelhead in the Hanford Reach. Steelhead are considered part of the upper Columbia River Evolutionarily Significant Unit, listed as Endangered under the *Endangered Species Act*.
- Surveys of selected breeding birds in key terrestrial and riparian habitats.
  - These surveys include pedestrian and point-count surveys during spring months to inventory the relative abundance and composition of breeding birds using key habitats on the Hanford Site, and surveys of nesting for selected species (e.g., geese, herons).

Species and habitat inventories and field monitoring are also conducted at appropriate times to develop and provide spatial data sets that are maintained in the EMC project databases. These data sets are used to map the locations of threatened and endangered species, and they document physical habitat characteristics for special status species in a geographic information system used by the EMC project and

other Hanford Site projects requiring resource map layers for project planning. The following are examples of spatial data sets developed and maintained by the EMC project:

- Locations of plant species of concern.
- Bald eagle nesting and roosting areas.
- Ferruginous hawk nesting sites.
- Locations of riparian and terrestrial vegetation cover types.
- Locations of Hanford Reach fall Chinook salmon spawning areas.
- Critical habitats for sagebrush-obligate species.

Impact and Risk Characterization. Sampling and species inventory surveys are conducted to characterize impacts and risks for key indicator species with high potentials for exposures to and uptake of contaminants. These sampling and survey efforts are coordinated with contaminant monitoring activities conducted through the SESP. Key species are selected based on biological, ecological, and physiological attributes that could influence potential exposures. Sampling is prioritized based on 1) the likelihood of exposure, 2) risk assessment data gaps, 3) public interest in ecological resources, and 4) stakeholder concerns. Organisms are sampled at locations with known contaminant concentrations and analyzed to document the occurrence or absence of anatomical or morphological effects, diseases, or parasitism. Frequencies and timing of sampling efforts are determined based on the life history characteristics of the species under consideration. When feasible, the results of SESP contaminant monitoring are used to assess whether organism health can be related to tissue concentrations of specific contaminants. Typical ecological sampling may include:

- Sampling of small mammals in key terrestrial and riparian habitats to provide species inventories, seasonal abundances, recruitment estimates, information on exposures to legacy contaminants, and evaluations of reproductive conditions.

- Surveys of amphibian breeding pools and sampling of juvenile amphibians to determine exposures to contaminants and conditions of organisms.

- Sampling of macro-invertebrates and vertebrates in key aquatic habitats to provide species inventories, abundances, age demographics, recruitment estimates, information on exposures to legacy contaminants, and evaluations of histological conditions.

Data Management

Ecological data from monitoring, compliance reviews, and assessment activities are processed and archived in databases residing on a dedicated personal computer. The databases contain historical and recent ecological data collected by Hanford Site contractors, and selected data sets collected by federal, state, and private agencies. Metadata are archived using metadata specifications developed by the Ecological Society of America (Fergraus et al. 2005; Michener et al. 1997) to capture the following project and investigation specific information: sampling objectives, contractor, collection dates, geographic areas, methods used, and types of data collected. Backups of the EMC project databases and related files are done nightly.

Two separate databases are maintained within the EMC project. The characterization database is dedicated to recording and analyzing data, interpreting data, and providing information summaries on population sizes and the status, conditions, and other attributes of species and habitats found onsite. The compliance database is designed to track compliance data specific to each Hanford Site project. These databases are operated independently for their separate purposes, but linkages are maintained between the data sets for ease of use. Project descriptions, monitoring information and data, and information on species of special concern to the public or natural resource regulatory authorities are posted and electronically available on the EMC project web page (http://www.pnl.gov/ecomon/). Information on this web page is updated as needed and at a minimum, annually.

Quality Assurance

QA for the EMC project is established and implemented based on formal QA requirements contained in PNNL's Standards-Based Management System (SBMS) (PNNL 2007). The EMC project QA program conforms to the requirements of DOE Order 414.1A.

The PNNL Quality Assurance Services Department conducts surveillances and audits of project activities and procedures to assure compliance with PNNL's Quality Management System and the project QA plan (QA Project Plan ETD-011). A DOE monitor, the PNNL program manager, the project manager, or the project quality engineer can initiate these surveillances and audits on either a routine or a random basis.

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Hanford Site Environmental Monitoring Plan

Section III.D. Cultural Resources

Prepared by: Date:	Concurrence: Date:
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Introduction

The Hanford Site is rich in cultural resources important to Native Americans, interested parties, and the public. The U.S. Department of Energy (DOE), Richland Operations Office (RL) Hanford Cultural and Historic Resources Program has monitored cultural resources sites since 1989 as part of its responsibilities under the *National Historic Preservation Act* (NHPA) (Section 110). A vital part of this program involves the monitoring of cultural resources to identify and address past and current impacts.

Cultural resources staff from PNNL's Hanford Cultural Resources Project (HCRP) perform monitoring on a monthly basis, and personnel from Hanford Site contractors support the RL's Hanford Cultural and Historic Resources Program. In addition to monitoring the conditions of archaeological sites, traditional use areas, and cemeteries, HCRP provides cultural resources education to Hanford Site workers and the public, performs cultural resources surveys, and reviews the potential effects of onsite activities on Hanford Site cultural resources. Cultural resources personnel from the River Corridor contractor conduct project-specific monitoring activities and provide cultural resources education to project workers. Local Native American tribes conduct their own cultural resources activities that include cultural resources site monitoring and surveys. HCRP activities are performed in compliance with the NHPA, Sections 106 and 110; the *National Environmental Policy Act* (NEPA); the *Archaeological Resources Protection Act*; the *Native American Graves Protection and Repatriation Act*; and the DOE cultural resources policy (DOE P 141.1).

The *Hanford Cultural Resources Management Plan* (DOE/RL-98-10, Appendix C) provides procedures for monitoring important cultural resources on the Hanford Site. Analytical data from the site visits are used to update Special Protection Management Unit (SPMU) files yearly. The SPMU files are the basis for quantifying cultural resources impacts in areas of cultural concern. The information in the files is used for making effective management decisions – decisions that protect or preserve important archaeological, cultural, and historic resources. All SPMU information is stored by the HCRP. Please refer to the Hanford Site environmental report (e.g., PNNL-16623) and the *Hanford Cultural Resources Management Plan* (DOE/RL-98-10) for information and details about the cultural resources monitoring program.

Objectives

The following objectives are part of cultural resources monitoring:

- Obtain baseline data to quantify conditions of cultural resources.
- Monitor cultural resources sites and identifying impacts that need to be addressed.
- Document violations of the *Archaeological Resources Protection Act*.
- Provide a cooperative cultural resources monitoring effort through Native American participation.
- Monitor locations that may contain human remains that may appear as a result of erosion or other disturbances and which may be subject to the *Native American Graves Protection and Repatriation Act*.
- Collect and manage data, global positioning system (GPS) coordinates, and photographs.

Program Rationale and Criteria

The Hanford Cultural and Historic Resources Program has developed over the past 20 years and currently involves inspections at approximately 35 places and/or sites per year.[1] Specific program rationale and criteria are discussed below.

Monitoring Locations

The DOE-RL has been assigned the stewardship of all Hanford Site archaeological resources, traditional-use areas, cultural landscapes, and historic period properties. Categories of sites monitored include archaeological sites, traditional-use areas, historic buildings, and places associated with human remains. Typically, only places eligible for listing on the National Register of Historic Places are monitored. As time and funding allow, additional places such as cultural landscapes and newly recorded archeological resources and traditional-use areas are added to the monitoring schedule. Each year a set of sites is selected for monitoring; should there be unplanned or unexpected events (e.g., high Columbia River water levels or severe river water-level fluctuations, inadvertent discoveries, an increase in looting), the year's site selections can be modified. Site selections are based primarily on the documented presence of human remains, their eligibility for the National Register of Historic Places, and the observation of significant impacts. Site-specific monitoring information is culturally sensitive and its use may be restricted under Section 304 of the NHPA and Section 9(a) of the *Archaeological Resources Protection Act*. All site information and monitoring evaluations are stored by the HCRP.

Monitoring Criteria

Cultural resources sites are monitored for impacts from natural causes (e.g., wind or water), recreational activities, and *Archaeological Resources Protection Act* violations (e.g., looting). Observations are made about impacts sustained since the last monitoring visit. Natural impacts are generally detected by comparing recent photographs with past photographs taken from the same location. The impact of erosion is documented by comparing detailed measurements obtained at representative sites over time. Recreational activity impacts are assessed by subjective observations of litter, bullet shells, fishing debris, duck blind construction, etc. GPS coordinates are recorded to document the locations of recreational impacts created since the last monitoring visit. Looting impacts are assessed in the same manner as recreational impacts.

Monitoring Frequencies

Cultural resources sites may be monitored semiannually, annually, biennially, or every 3 to 5 years depending on the type of site and amount of damage observed in the past. For example, all sites with reported human remains are monitored annually, whereas a site that is eligible for listing on the National Register may be monitored every 5 years if little damage was observed during the previous monitoring visit. Monitoring frequency at each site is reassessed after each monitoring visit.

[1] Fallon M and DP McFarland. Draft 2007. *Hanford Cultural Resources Site Monitoring Analysis and Program Review*. Pacific Northwest National Laboratory, Richland, Washington.

Handling of Monitoring Information

All photographs and site monitoring forms are stored in the HCRP records repository. Individuals with a need-to-know may access monitoring information with the appropriate authorization. Impacts observed during monitoring visits are assigned a numerically based rating. All ratings within specified SPMU areas are evaluated to determine present damage and future threat levels for that area. The ratings are then incorporated into a Geographical Information System map to show areas of current natural and cultural damages and possible future natural and cultural threats. All quantitative monitoring site data are stored on Microsoft Excel spreadsheets by the HCRP.

Quality Control Methods

Hanford's cultural and historic resources monitoring are conducted and documented by the HCRP in accordance with written procedures (PNL-MA-270). At the end of each fiscal year, HCRP personnel review all natural damage/threat and cultural damage/threat ratings.

Reporting of Impacts and Violations

Archaeological Resources Protection Act violations require immediate notification of the DOE-RL Hanford Cultural and Historic Resources Program Manager so that appropriate Native American tribes and bands can be notified of the violations in a timely manner. Major recreational and natural impacts are also reported to the Hanford Cultural and Historic Resources Program Manager. However, minor recreational or natural impacts are noted on a cultural resources site monitoring form and stored in the cultural resources site file located in the HCRP's curation repository.

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Hanford Site Environmental Monitoring Plan

Section IV. Groundwater Monitoring

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Introduction

Groundwater monitoring is a critical element of the U.S. Department of Energy's (DOE's) environmental monitoring program at the Hanford Site. Disposal and leakage of hazardous and radioactive waste in the past contaminated the vadose zone and unconfined aquifer. Groundwater from the unconfined aquifer enters the Columbia River, which is a potential pathway for transport of contaminants to human and ecological receptors.

Groundwater monitoring is conducted at the Hanford Site for a variety of purposes to: 1) monitor the potential impacts of specific waste sites, 2) monitor regional contaminant plumes, 3) assess the effectiveness of groundwater remediation activities, and 4) monitor offsite to assure the public that Hanford Site contaminants are not present.

Regulatory Drivers

The regulatory framework governing groundwater monitoring at the Hanford Site consists of federal and state regulations, agreements, and DOE Orders.

DOE Orders 450.1 and 435.1

DOE Order 450.1, "Environmental Protection Program," implements requirements of the *Atomic Energy Act*. This Order requires environmental monitoring to detect, characterize, and respond to releases from DOE activities, assess impacts, and characterize exposure pathways [Section (5)(d)(14)]. The Order recommends implementing a site-wide approach for groundwater protection [Section (4)(b)(1)].

DOE Order 450.1 also requires that analytical work is implemented using:

- A consistent system for collecting, assessing, and documenting environmental data of known and documented quality.
- A validated and consistent approach for sampling and analysis of radionuclide samples.
- An integrated sampling approach to avoid collecting duplicative data [Section (5)(d)(15)].

The Order requires compliance with other applicable environmental protection requirements. For Hanford Site groundwater, federal requirements include the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) and the *Resource Conservation and Recovery Act* (RCRA), administered by the U.S. Environmental Protection Agency (EPA). Washington State Administrative Code (WAC) requirements include the "Dangerous Waste Regulations" (WAC 173-303), "Waste Discharge Permit Program" (WAC 173-216), and "Minimum Functional Standards for Solid Waste Handling" (WAC 173-304). Monitoring to comply with these state and federal requirements makes up the major part of the groundwater monitoring performed on the Hanford Site.

DOE Order 435.1, "Radioactive Waste Management," is relevant to the continued operation of low-level waste disposal facilities at the Hanford Site. This Order requires a disposal authorization statement for continued operation of existing low-level waste disposal facilities. Two facilities on the Hanford Site

are authorized to transfer, receive, process, and dispose of low-level radioactive waste: the 200-East Area and 200-West Area low-level burial grounds and the Integrated Disposal Facility.

Comprehensive Environmental Response, Compensation, and Liability Act

This act and the *Superfund Amendments and Reauthorization Act*, which are implemented through EPA regulations in 40 CFR 300, establish groundwater-monitoring requirements for inactive past-practice waste sites. Pursuant to these acts, three general areas of the Hanford Site (100, 200, and 300 Areas) are currently listed on the National Priorities List (40 CFR 300, Appendix B).

Resource Conservation and Recovery Act

RCRA establishes regulatory standards for the generation, transportation, storage, treatment, and disposal of hazardous waste that applies to active waste management facilities and facilities undergoing closure. Groundwater monitoring is required at certain RCRA-regulated facilities for detection, evaluation, and remediation of contamination from the facilities. As authorized by the EPA, the state of Washington has regulatory primacy, hence Washington's dangerous waste regulations (WAC 173-303) implement RCRA groundwater requirements in lieu of the federal regulations. For the purposes of this document, the requirements of Washington's dangerous waste regulations will be considered to constitute the RCRA requirements.

State Waste Discharge Permit Program and Minimum Functional Standards for Solid Waste Handling

Washington's "Waste Discharge Permit Program" (WAC 173-216), which deals with permitted liquid discharges, and the state's "Minimum Functional Standards for Solid Waste Handling" (WAC 173-304) contain groundwater protection and monitoring requirements that apply to certain waste sites at the Hanford Site that are not covered under RCRA.

Integration of Regulatory Requirements

The DOE, EPA, and Washington State Department of Ecology (Ecology) established the *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement; Ecology et al. 1989) to coordinate the actions of various regulatory authorities and provide a strategy to achieve regulatory compliance and waste-site cleanup. The agreement specifies that both active and inactive treatment, storage, or disposal (TSD) units that have received RCRA permits will be managed and closed under RCRA regulations, including groundwater monitoring requirements. Non-RCRA, past-practice waste sites will be addressed under CERCLA. Contaminated groundwater will be addressed as a CERCLA source of contamination. However, all CERCLA actions will meet RCRA corrective action standards under the agreement. Under criteria established in the Tri-Party Agreement, a lead regulatory agency is designated for each operable unit to avoid duplication of effort.

In 2003, the DOE, EPA, and Ecology developed *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection* (DOE/RL-2002-68). The plan is designed to accelerate cleanup, which will return groundwater to its beneficial use, where practicable, or at least prevent further degradation.

The plan includes remediating high-risk waste sites, shrinking contaminated areas, reducing recharge through contaminated soil, remediating groundwater, and monitoring groundwater. The plan includes the following groundwater monitoring activities:

- Monitoring RCRA units to determine if the facilities have affected groundwater quality.
- Assessing the nature and extent of contamination from RCRA units known to have affected groundwater quality.
- Assessing the groundwater within CERCLA groundwater operable units to determine types and extent of contamination to support preparation of records of decision.
- Assessing the effectiveness of groundwater remedial actions.

General Groundwater Monitoring Information

This section provides general information for groundwater monitoring regardless of the specific purpose or regulatory driver.

Many Hanford Site wells are sampled for multiple objectives and requirements, e.g., RCRA, CERCLA, *Atomic Energy Act*. The work is conducted to manage any overlap, eliminating redundant sampling, optimizing the schedule, and meeting the needs of each sampling objective.

Data Quality Objectives

To determine the type of groundwater data required, staff apply the EPA's data quality objectives (DQO) process as described in *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA/240/B-06/001 (QA/G-4, 2006, as revised). The DQO process is a standard working tool to determine the type, quantity, and quality of data needed to reach defensible decisions or make credible estimates. The process is applied to individual TSD units or groundwater operable units for a particular monitoring purpose, e.g., to determine if a waste facility is leaking or if a remedial action is effective. Results of unit-specific DQO assessments may be published or summarized in sampling and analysis plans or as separate documents for individual units.

The DQO process also was applied broadly to support the choice of sample collection methods, analytical protocols, and quality control (QC) processes. The process was used to define reporting limits, precision, accuracy, and completeness, which are described in a quality assurance (QA) plan for groundwater monitoring. They are also summarized in this chapter.

Limits for precision and accuracy for chemical analyses are based on criteria stipulated in the methods (e.g., EPA/SW-846 or EPA 600 series). Precision and accuracy limits for radiochemical results are specified in laboratory contracts or equivalent documents. Completeness is defined as the percentage of data points judged to be valid. The completeness goal each quarter is 85%.

Construction and Maintenance of Wells

Since the mid-1980s, Hanford Site monitoring wells have been designed to meet state requirements (WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"). Wells are constructed to maintain the integrity of the monitoring well borehole and prevent contamination from the surface or other zones from reaching the aquifer. The well casing isolates the sampled interval of the well from the vadose zone and other non-sampled intervals of the aquifer. Screens are used to filter out sediment particles and enhance collection of representative groundwater samples from the aquifer. Most monitoring wells are constructed of 10-centimeter-diameter stainless steel casing. Ecology has approved the use of longer well screens than specified in WAC 173-160 in the 200 Areas. In those areas, the water table is declining because liquid waste is no longer disposed of to ground, so long well screens (up to 10.7 meters in length) increase the monitoring life of the well.

Most older monitoring wells on the Hanford Site are 10, 15, or 20 centimeters in diameter and are constructed with casing made of carbon steel. These wells are used most extensively in site-wide monitoring of existing plumes for the objectives of the *Atomic Energy Act* and CERCLA.

Well maintenance is conducted when a problem is identified during sampling. Routine well maintenance may be scheduled to meet specific requirements.

Sampling and Analysis Protocol

This section describes protocols for equipment decontamination, water-level monitoring, and sample collection, preservation, and analysis.

Equipment Decontamination

Well-drilling equipment is decontaminated according to a documented procedure, using high temperature and pressure washing with an approved cleaning solution. The equipment is then rinsed with clean water.

Equipment for collecting soil samples during drilling for later chemical analysis and for measuring depth to water is decontaminated according to established procedures. The procedures call for washing equipment with phosphate-free detergent, rinsing three times with de-ionized water, rinsing once with nitric acid (glass or stainless steel equipment only), rinsing three more times with de-ionized water, and rinsing last with hexane. After heat drying, equipment is wrapped in unused aluminum foil and sealed with tape until needed.

Most monitoring wells in use on the Hanford Site are equipped with dedicated sampling pumps. When temporary pumps, bailers, or other special devices are used, they are decontaminated between wells according to a documented procedure, and wherever possible, sampling sequence is from lower levels of contamination to the higher levels of contamination.

Water-Level Monitoring

Procedures for measuring water levels were developed in accordance with the techniques described in American Society for Testing and Materials (1988), Garber and Koopman (1968), OSWER 9950.1, and

U.S. Geological Survey (1977). Water levels are measured primarily with laminated steel electrical sounding tapes, although graduated steel tapes are used occasionally.

The water level is measured before each well is sampled, unless that is impossible (e.g., no access for steel tape; used as a pumping well). Additional measurements are made as part of site-wide water-table mapping and as required by individual monitoring plans (e.g., for RCRA sites or CERCLA operable units).

Chain of Custody

Groundwater sample collection personnel use chain-of-custody forms to document the integrity of groundwater samples from the time of collection through data reporting. The forms are generated during sample scheduling and managed through a documented procedure. Sample collection personnel enter required information on the forms, for example:

- Collector's name.
- Method of shipment and destination.
- Collection date and time.
- Sample identification numbers.
- Sample analysis methods.
- Sample preservation methods.

When samples are transferred from one custodian to another (e.g., from collector to shipper or from shipper to analytical laboratory), the receiving custodian inspects the form and samples and notes any deficiencies. Each transfer of custody is documented by the printed names and signatures of the custodian relinquishing the samples and the custodian receiving the samples, and the time and date of transfer.

Sample Collection

Groundwater monitoring follows a QA plan that meets *EPA Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003 (EPA QA/R-5, March 2001, as revised). The work follows documented procedures for sample collection, which are summarized in this section.

Project personnel schedule samplings, initiate paperwork, and oversee sample collections, shipping, and analyses. Quality requirements for any work subcontracted meet EPA/240/B-01/003 (EPA QA/R-5, March 2001, as revised) and are specified in statements of work or contracts.

Field personnel measure water levels in each well before sampling and then purge stagnant water from the well. Samples generally are collected after three casing volumes of water have been purged from the well or after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized (i.e., after two consecutive measurements are within 0.2 units pH, 0.2°C for temperature, 10% for specific conductance, and turbidity is <5 nephelometric turbidity units [NTUs]). If a well is purged to dryness, it is allowed to recover and then sampled.

In most cases, field parameters are measured in a flow-through chamber. When circumstances make the use of a flow-through chamber impractical, personnel measure field parameters in a cup or other container.

Unless the site-specific monitoring plan directs otherwise, samples for metals analyses are filtered in the field with 0.45-micrometer, in-line, disposable filters to ensure results represent dissolved metals and do not include particulates (40 CFR 136.3[1]).

Deviations from standard sampling procedures are allowed when circumstances warrant. For instance, some wells have large volumes of water in the casing and would require excessive time to purge three casing volumes. In that case, the wells are generally purged for 1 hour and until field parameters stabilize. A number of wells are subject to high turbidity so the <5 NTUs requirement cannot be met. The samples for additional constituents from those wells may be filtered per direction from scientific staff. Deviations from standard sampling procedures are documented on field records.

Sample Preservation and Shipment

Sample preservation techniques will follow EPA approved procedures (e.g., SW-846, Table 11-1). For routine groundwater samples from monitoring wells, preservatives are added to the collection bottles, if necessary, before their use in the field. A chemical-preservative label is affixed to the sample container listing the specific preservative. The preservative's brand name, lot number, concentration, and container opening date are recorded. A calibrated dispenser or pipette is used to dispense preservatives. Appropriate measures are taken to eliminate any potential for cross contamination.

Sample packaging and transfer/shipping are done in accordance with documented procedures. Samples are labeled and sealed with evidence tape, wrapped with bubble wrap, and placed in a U.S. Department of Transportation (DOT) approved container with coolant, if required. Hazardous samples have packaging parameters determined by their associated hazards. Samples for offsite laboratories are shipped according to DOT regulations. A chain-of-custody form accompanies all samples.

Analytical Protocols

Instruments for field measurements (e.g., pH, specific conductance, temperature, and turbidity) are calibrated using standard solutions before use and are operated according to the manufacturer's instructions. Each instrument is assigned a unique number that is tracked on field and calibration documentation.

Laboratory analytical methods are specified in contracts with the laboratories and are standard methods from *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (SW-846, as amended) or *Methods for Chemical Analysis of Water and Wastes* (EPA-600/4-79-020, 1983, or other methods, as approved). Radiological parameters are analyzed by EPA or laboratory-specific methods.

[1] Note to Table 1B, note 4 states "…Dissolved metals are defined as those constituents which will pass through a 0.45 micron membrane filter."

Quality Assurance and Quality Control

The QA program for groundwater monitoring meets *EPA Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003 (EPA QA/R-5, March 2001, as revised). The QA program also is based on the QA requirements of DOE Order 414.1C, "Quality Assurance;" Tri-Party Agreement, Article XXXI, *Quality Assurance*; and 10 CFR 830, Subpart A, "General Provisions/Quality Assurance Requirements." Additional requirements are described in the *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD, DOE/RL-96-68). A QC plan is included in the QA plan. The level of QA/QC for the collection, preservation, transportation, and analysis of each sample shall be dependent upon the DQOs for the sample. The QA/QC requirements could range from those necessary for non-laboratory field screening activities to those necessary to support a comprehensive analysis that will be used in final decision-making.

QC sampling requirements for subcontracted work are discussed in the statement of work with the subcontractor. The subcontractor's QA protocols also will meet *EPA Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003 (EPA QA/R-5, March 2001, as revised). The laboratory QA/QC plans must be submitted to the lead regulatory agency for review as secondary documents in accordance with the *Tri-Party Agreement Action Plan* (Ecology et al. 1989, Sections 6.5 and 7.8) before use of the laboratory. This has been completed for the laboratories currently in use.

The QC program is designed to assess and enhance the reliability and validity of groundwater data. This is accomplished by evaluating the results of QC samples, conducting audits, and validating groundwater data. The QC practices are based on EPA guidance cited in the *Tri-Party Agreement Action Plan*, Sections 6.5 and 7.8 (Ecology et al. 1989). Accuracy, precision, and detection are the primary parameters used to assess data quality (Mitchell et al. 1985). Data for these parameters are obtained from two categories of QC samples: those that provide checks on field and laboratory activities (field QC) and those that monitor laboratory performance (laboratory QC). Table IV-1 summarizes the types of samples in each category and the sampling frequencies and characteristics evaluated.

Quality Control Criteria

Limits for precision and accuracy for chemical analyses are based on criteria stipulated in the methods (e.g., EPA/SW-846, EPA 600 series). Method detection limits as low as one third the EPA drinking water standards are preferred, but not always achievable. Reporting limits for radionuclides are defined in the laboratory contract or equivalent document. Reporting limits as low as one-third the derived 4-mrem-dose requirement are preferred, but not always achievable.

QC data are evaluated based on established acceptance criteria for each QC sample type, as discussed in the QC plan and summarized here. For field and method blanks, the acceptance limit is generally two times the instrument detection limit (metals), or method detection limit (other chemical parameters). However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and phthalate esters, the limit is five times the method detection limit. Groundwater samples that are associated (i.e., collected on the same date and analyzed by the same method) with out-of-limit field blanks are flagged with a "Q" in the Hanford Environmental Information System (HEIS) (HEIS 1989) database to indicate a potential contamination problem.

Table IV-1. Groundwater Monitoring Quality Control Samples

Sample Types	Primary Characteristics Evaluated	Frequencies
	Field Quality Control	
Full trip blank	Contamination from containers or transportation	1 per 20 well trips
Field transfer blank	Airborne contamination from the sampling site	1 each day volatile organic compound samples are collected
Equipment blank	Contamination from non-dedicated sampling equipment	As needed[(a)]
Duplicate samples	Reproducibility	1 per 20 well trips
	Laboratory Quality Control	
Method blank	Laboratory contamination	1 per batch
Laboratory duplicates	Laboratory reproducibility	[(b)]
Matrix spike	Matrix effects and laboratory accuracy	[(b)]
Matrix spike duplicate	Laboratory reproducibility and accuracy	[(b)]
Surrogates	Recovery/yield	[(b)]
Laboratory control sample	Method accuracy	1 per batch

(a) For portable Grundfos pumps, equipment blanks are collected one per ten well trips. Whenever a new type of non-dedicated equipment is used, an equipment blank is collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination procedure for the non-dedicated equipment.
(b) As defined in the laboratory contract or quality assurance plan and/or analysis procedures.

Field duplicates must agree within 20%, as measured by the relative percent difference, to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit are evaluated. Unacceptable field duplicate results are flagged with a "Q" in the database.

The acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples generally are derived from historical data at the laboratories in accordance with *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA/SW-846, 1986 as revised). Acceptance criteria are listed in Table IV-2.

Table IV-3 lists the acceptable recovery limits for the double-blind standards. These samples are prepared by spiking background well water (currently wells 699-19-88 and 699-49-100C) with known concentrations of constituents of interest. Spiking concentrations range from the detection limit to the upper concentration limit measured in groundwater on the Hanford Site. Investigations of double-blind standards that are outside of acceptance limits may include 1) reviewing raw data from the laboratory, 2) communicating the problem to the laboratory, 3) requesting re-analyses of the samples, 4) scheduling additional QC blinds or other QC samples such as blanks or splits, and 5) obtaining and evaluating laboratory QC data. Depending on the results of the investigations, corrective actions may include flagging data in the HEIS database, requiring the laboratory to fix a problem, or identifying an alternative laboratory until the issue has been resolved.

Table IV-2. Acceptance Criteria for Groundwater Samples

Constituent	QC Element	Acceptance Criterion	Corrective Action
General Chemical Parameters			
Chemical oxygen demand, oil and grease, total dissolved solids	MB	<MDL	Flagged with "C"
	LCS	80% to 120% recovery[a]	Data reviewed[b]
	DUP	±20% RPD[a]	Data reviewed[c]
	MS[d]	75% to 125% recovery[a]	Flagged with "N"
Total organic carbon, total organic halides	EB, FTB	<2 times MDL	Flagged with "Q"
	Field Duplicate	±20% RPD[d]	Flagged with "Q"
Ammonia and Anions			
Ammonia, anions	MB	<MDL	Flagged with "C"
	LCS	80% to 120% recovery[a]	Data reviewed[b]
	DUP	±20% RPD[a]	Data reviewed[b]
Cyanide	MS	75% to 125% recovery[a]	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field Duplicate	±20% RPD[d]	Flagged with "Q"
Metals			
Arsenic, cadmium, chromium, lead, mercury, selenium, thallium, ICP metals, ICP/MS metals	MB	<CRDL	Flagged with "C"
	LCS	80% to 120% recovery[a]	Data reviewed[b]
	MS	75% to 125% recovery[a]	Flagged with "N"
	MSD	±20% RPD[a]	Data reviewed[b]
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field Duplicate	±20% RPD[d]	Flagged with "Q"
Volatile Organic Compounds			
Volatiles by GC/MS	MB	<MDL	Flagged with "B"
	LCS	Statistically derived[e]	Data reviewed
	MS	Statistically derived[e]	Flagged with "N"
	MSD	Statistically derived[e]	Data reviewed[b]
Total petroleum hydrocarbons by GC	SUR	Statistically derived[e]	Data reviewed[b]
	EB, FTB, FXR	<2 times MDL[f]	Flagged with "Q"
	Field Duplicate	±20% RPD[d]	Flagged with "Q"
Semivolatile Organic Compounds			
Herbicides by GC, PCBs by GC, pesticides by GC, phenols by GC, semivolatiles by GC/MS	MB	<2 times MDL	Flagged with "B"
	LCS	Statistically derived[e]	Data reviewed[b]
	MS	Statistically derived[e]	Flagged with "N"
	MSD	Statistically derived[e]	Data reviewed[b]
	SUR	Statistically derived[e]	Data reviewed[b]
	EB, FTB	<2 times MDL[f]	Flagged with "Q"
	Field Duplicate	±20% RPD[d]	Flagged with "Q"

Table IV-2. (contd)

Constituent	QC Element	Acceptance Criterion	Corrective Action
Radiological Parameters			
Gamma scan, iodine-129, plutonium (isotopic), strontium-89/90, technetium-99, tritium (low-level), uranium (isotopic), uranium (total)	MB	<2 times MDA	Flagged with "B"
	LCS	70% to 130% recovery	Data reviewed[a]
	DUP	±20% RPD	Data reviewed[a]
	MS[g]	60% to 140% recovery	Flagged with "N"
Gross alpha, gross beta, tritium	EB, FTB	<2 times MDA	Flagged with "Q"
	Field Duplicate	±20% RPD[c]	Flagged with "Q"

(a) Laboratory-determined, statistically derived control limits may also be used. Such limits are reported with the data.
(b) After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data as suspect (Y flag) or rejected (R flag).
(c) Applies to total organic carbon and total organic halides only.
(d) Applies only in cases where one or both results are >5 times the detection limit.
(e) Determined by the laboratory based on historical data. Control limits are reported with the data.
(f) For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criterion is <5 times the MDL.
(g) Applies only to technetium-99 and total uranium analyses.

Data Flags:
B, C = Possible laboratory contamination (analyte was detected in the associated method blank).
N = Result may be biased (associated matrix spike result was outside the acceptance limits).
Q = Problem with associated field quality control sample (blank and/or duplicate results were out of limits).

Abbreviations:
CRDL = Contract required detection limit.
DUP = Laboratory matrix duplicate.
EB = Equipment blank.
FTB = Full trip blank.
FXR = Field transfer blank.
GC = Gas chromatography.
GC/MS = Gas chromatography/mass spectrometry.
ICP = Inductively coupled plasma.
ICP/MS = Inductively coupled plasma-mass spectrometry.
LCS = Laboratory control sample.
MB = Method blank.
MDA = Minimum detectable activity.
MDL = Method detection limit.
MS = Matrix spike.
MSD = Matrix spike duplicate.
PCBs = Polychlorinated biphenyls.
RPD = Relative percent difference.
SUR = Surrogate.

Table IV-3. Groundwater Double-Blind-Standard Constituents and Recovery Limits

Constituents	Frequency	Recommended Recovery (%)[a]	Precision (%RSD)[a]
Carbon tetrachloride	Quarterly	±25%	±25%
Chloroform	Quarterly	±25%	±25%
Trichloroethylene	Quarterly	±25%	±25%
Fluoride	Quarterly	±25%	±25%
Nitrate	Quarterly	±25%	±25%
Cyanide	Quarterly	±25%	±25%
Chromium	Annually	±20%	±20%
Total organic carbon[b]	Quarterly	Varies according to spiking compound	Varies according to spiking compound
Total organic halides[c]	Quarterly	Varies according to spiking compound	Varies according to spiking compound
Gross alpha[d]	Quarterly	70% to 130%	±20%
Gross beta[e]	Quarterly	70% to 130%	±20%
Tritium	Annually	70% to 130%	±20%
Tritium (low level)	Semiannually	70% to 130%	±20%
Cobalt-60	Annually	70% to 130%	±20%
Strontium-90	Quarterly	70% to 130%	±20%
Technetium-99	Quarterly	70% to 130%	±20%
Iodine-129	Semiannually	70% to 130%	±20%
Cesium-137	Annually	70% to 130%	±20%
Uranium	Quarterly	70% to 130%	±20%
Plutonium-239/240	Quarterly	70% to 130%	±20%

(a) If the results are less than five times the required detection limit, then the criterion is that the difference of the results of the replicates is less than the required detection limit.
(b) The spiking compound generally used for total organic carbon (TOC) is potassium phthalate. Other spiking compounds may also be used.
(c) Two sets of spikes for total organic halides (TOX) will be used. The spiking compound for one set should be 2,4,5-trichlorophenol. The spiking compound for the second set should include the constituents used for the volatile organic compounds (VOC) sample (carbon tetrachloride, chloroform, trichloroethylene).
(d) The gross alpha sample will be prepared from plutonium-239.
(e) The gross beta sample will be prepared from strontium-90.
RSD = Relative standard deviation.

Holding time is the elapsed time period between sample collection and analysis. Exceeding recommended holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Recommended holding times depend on the analytical method, as specified in *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA/SW-846, 1986 as revised) or *Methods for Chemical Analysis of Water and Wastes* (EPA-600/4-79-020, 1979 as revised). These holding times are specified in laboratory contracts or equivalent documents. Data associated with exceeded holding times are flagged with an "H" in the HEIS database.

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. Personnel periodically audit the analytical laboratories to identify and solve quality problems or to prevent such problems. Audit results are used to improve performance. Summaries of audit results and performance evaluation studies are presented in the annual groundwater monitoring report.

Data Validation and Verification

Validation of groundwater data consists of assessing whether the data collected and measured truly reflect aquifer conditions. Verification means assessing data accuracy, completeness, consistency, availability, and internal control practices that serve to determine the overall reliability of the data collected. The work activities follow documented procedures for data validation and verification, as summarized below.

Personnel perform an array of computer checks on electronic data files for formatting, allowed values, data flagging (qualifiers), and completeness. Verification of the hard copy results includes checks for 1) completeness, 2) notes on conditions of samples upon receipt by the laboratory, 3) notes on problems that arose during the analyses of the samples, and 4) correct reporting of results. If data are incomplete or deficient, personnel work with the laboratory to get the problems corrected. Field data such as specific conductance, pH, temperature, turbidity, and depth-to-water are entered into the HEIS database manually through computer data-entry screens. Staff verify each value against the hard copy, and initial the hard copy.

The data validation process provides requirements and guidance for validations of groundwater data that are routinely collected. Validation is a systematic process of reviewing data against a set of criteria to determine whether the data are acceptable for their intended use. This process applies to groundwater data that have been verified and loaded into the HEIS database. The outcome of the activities described below is an electronic data set in which suspect or erroneous data are corrected or flagged. Staff document the validation process quarterly. Documentation is stored in the project file.

Responsibilities for data validation are divided among staff. Each RCRA unit or geographic region is assigned to a scientist who is familiar with the hydrogeologic conditions of that site. As soon as practical after data have been loaded into the HEIS database, these scientists review the data to identify changes in groundwater quality or potential data errors. Evaluation techniques include comparing the data for key constituents to historical data trends or spatial patterns. Other data checks may include comparisons of general parameters to their specific counterparts (e.g., conductivity to ions) and calculations of charge balances.

Staff may request data reviews if appropriate. If necessary, the laboratory may be asked to check calculations or re-analyze a sample, or the well may be resampled. Results of the data reviews are used to flag the data appropriately in the HEIS database (e.g., “R” for reject, “Y” for suspect, “G” for good), and/or add comments.

Data Management and Reporting

This section describes how analytical and field data are loaded into the HEIS database, and how data are reported.

Loading Data into the Database

The contract laboratories report analytical results electronically and on hard copy. The electronic results are loaded into the HEIS database. Hard copy data reports and field records are considered to be the record copies and are stored in project files.

Field data such as specific conductance, pH, temperature, turbidity, and depth-to-water are recorded on field records. Data management personnel enter these into the HEIS database manually through computer data-entry screens and verify each value against the hard copy.

Interpretation

After data are validated and verified, the acceptable data are used to interpret groundwater conditions at the site. Interpretive tools include:

- **Hydrographs –** Plot water levels versus time to determine decreases, increases, seasonal, or manmade fluctuations in groundwater levels.
- **Plume maps –** Map distributions of chemical or radiological constituents in the aquifer to determine extent of contamination.
- **Changes in plume distribution over time** – Aid in determining movement of plumes and direction of flow.
- **Water-table maps –** Use water-table elevations from multiple wells to construct contour maps to estimate flow directions. Groundwater flow is generally assumed to be perpendicular to lines of equal potential.
- **Trend plots –** Graph concentrations of chemical or radiological constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water-table maps to determine if concentrations relate to changes in water level or groundwater flow directions.
- **Contaminant ratios –** Illustrate relative abundances, which can sometimes be used to distinguish between different sources of contamination.

Reporting

Annual reports on results of groundwater monitoring are issued in March (e.g., PNNL-16346). These reports include pertinent information for CERCLA, RCRA, WAC, and *Atomic Energy Act* groundwater monitoring and electronic files of groundwater data. Chemistry and water-level data also are available in the HEIS database shortly after they are received.

Results of RCRA monitoring are reported to Ecology quarterly. Any unusual results for CERCLA operable units are summarized in letter reports or informal reports (e.g., reports via e-mail or presented at unit manager's meetings).

Change Control

The general approach to making changes to monitoring activities, associated documents, and approval requirements are listed in Table VI-4.

Table VI-4. Change Control for Groundwater Monitoring Activities

Type of Change	Action	Documentation
Temporarily (≤1 year) adding or deleting constituents, wells, or sampling frequency	Project management approval; notify regulatory agency if appropriate	Schedule tracking system
Permanently (>1 year) adding or deleting constituents, wells, or sampling frequency	Revise monitoring plan	Interim Change Notice or complete document revision
Unavoidable changes (e.g., dry wells, delayed samples, one-time missed samples due to broken pump, lost bottle, etc.)	Notify regulatory agency if appropriate	Schedule tracking system; e-mail or meeting minutes

Groundwater Monitoring at Regulated Units

Facilities regulated under RCRA and state laws are monitored to 1) comply with state and federal requirements, 2) assess potential impact on groundwater quality, and 3) provide an early warning of unexpected occurrences and trends. Ecology and the EPA issued the Hanford Facility RCRA Part B Permit in September 1994 (Ecology 1994). In the permit, Ecology and the EPA designated the Hanford Site as a single RCRA facility that originally contained approximately 70 TSD units. Some of the units have been closed, thereby reducing the number. Of the remaining TSD units, 19 require groundwater monitoring to determine if operations are impacting the uppermost aquifer. Some of these units (single-shell tanks and low-level burial grounds) are divided into multiple waste management areas because they are geographically separated. Others (1324-N surface impoundment and 1324-NA percolation pond; 216-A-10, 216-A-36B, and 216-A-37-1 [PUREX] cribs) are combined into waste management areas for groundwater monitoring. There are 25 RCRA sites (i.e., units or waste management areas) that require groundwater monitoring (Table IV-5 and Figure IV-1).

The Tri-Party Agreement (Ecology et al. 1989) recognized that all of the units cannot be permitted simultaneously and set up a schedule to submit unit-specific Part B RCRA/dangerous waste permit applications and closure plans to Ecology and the EPA. As of April 2007, 17 of the 25 RCRA sites are monitored under interim status requirements (WAC 173-303-400 and by reference 40 CFR 265) until they are incorporated into the Hanford Facility RCRA Permit (Ecology 1994) as scheduled in the Tri-Party Agreement. The other sites are already incorporated into the permit and are monitored under final status requirements (WAC 173-303-645). Table IV-5 lists the RCRA sites and status of monitoring as of April 2007 and provides references for site-specific RCRA groundwater monitoring plans.

Table IV-5. RCRA Interim and Final Status Groundwater Monitoring, April 2007

Treatment, Storage, or Disposal Unit or Waste Management Area	Monitoring Phase	Calendar Year Site Incorporated into Site Permit (closing or operating)	Monitoring Plan and Comments
1301-N Liquid Waste Disposal Facility 1325-N Liquid Waste Disposal Facility	Final Status Detection	1999 (closing)	BHI-00725. Closure plan states that during and after closure, monitoring will continue under the interim-status detection plan.
1324-N Surface Impoundment and 1324-NA Percolation Pond	Final Status Detection (see comments)	1999 (closing)	BHI-00725. Post-closure corrective action monitoring plan will be implemented following permit modification. RCRA corrective action decisions pending 100-NR-2 Operable Unit final record of decision.
183-H Solar Evaporation Basins	Final Status Corrective Action	1994 (closing)	PNNL-11573. Unit has contributed to chromium and nitrate contamination. RCRA monitoring continuing without statistical evaluation during period of 100-HR-3 Operable Unit's interim action for hexavalent chromium. RCRA corrective action decisions pending 100-HR-3 Operable Unit final record of decision.
216-A-29 Ditch	Interim Status Detection	Submitted 2006 (clean closure)[a]	PNNL-13047.
216-B-3 Pond	Interim Status Detection	Submitted 2003 (clean closure)[a]	PNNL-15479.
216-B-63 Trench	Interim Status Detection	Submitted 2006 (clean closure)[a]	PNNL-14112.
216-S-10 Pond and Ditch	Interim Status Detection	Submitted 2006 (closing)	PNNL-14070. Network comprises two downgradient wells and one deep well due to dropping water table.
216-U-12 Crib	Interim Status Assessment	Submitted 2006 (administrative closure)[b]	PNNL-14301. Crib has contributed to nitrate contamination.

Table IV-5. (contd)

Treatment, Storage, or Disposal Unit or Waste Management Area	Monitoring Phase	Calendar Year Site Incorporated into Site Permit (closing or operating)	Monitoring Plan and Comments
316-5 Process Trenches	Final Status Corrective Action	1996 (closing)	WHC-SD-EN-AP-185. RCRA corrective action decisions pending 300-FF-5 Operable Unit final record of decision.
Integrated Disposal Facility	Final Status Detection	2006 (operating)	Ecology (2006).
Liquid Effluent Retention Facility	Final Status Detection suspended	1998 (operating)	WHC-SD-EN-AP-024. Water table dropping below bottom of aquifer. Network comprises one downgradient well and one upgradient well. Ecology directed the DOE to cease statistical evaluations. Continuing to monitor available wells. Revised draft permit conditions under discussion with Ecology.
Low-Level Burial Grounds (Low-Level WMAs 1, 2, 3, and 4)	Interim Status Detection	Submitted 2002 (operating)	PNNL-14859. Permit application submitted in 2002; interim status monitoring continues until approval of permit. New wells being installed to replace dry wells.
Nonradioactive Dangerous Waste Landfill	Interim Status Detection	TBD (closing)	PNNL-12227.
PUREX Cribs (216-A-10, 216-A-36B, and 216-A-37-1)	Interim Status Assessment	Submitted 2006 (administrative closure)[(b)]	PNNL-11523. Cribs have contributed to nitrate contamination.
Single-Shell Tanks WMA A-AX	Interim Status Assessment	TBD (closing)	PNNL-15315. Nitrate elevated.
Single-Shell Tanks WMA B-BX-BY	Interim Status Assessment	TBD (closing)	PNNL-13022. WMA has contributed to nitrate and nitrite contamination.
Single-Shell Tanks WMA C	Interim Status Detection	TBD (closing)	PNNL-13024.

Table IV-5. (contd)

Treatment, Storage, or Disposal Unit or Waste Management Area	Monitoring Phase	Calendar Year Site Incorporated into Site Permit (closing or operating)	Monitoring Plan and Comments
Single-Shell Tanks WMA S-SX	Interim Status Assessment	TBD (closing)	PNNL-12114. WMA has contributed to chromium contamination.
Single-Shell Tanks WMA T	Interim Status Assessment	TBD (closing)	PNNL-15301. WMA has contributed to chromium and nitrate contamination.
Single-Shell Tanks WMA TX-TY	Interim Status Assessment	TBD (closing)	PNNL-16005. WMA has contributed to chromium and nitrate contamination.
Single-Shell Tanks WMA U	Interim Status Assessment	TBD (closing)	PNNL-13612. WMA has contributed to nitrate contamination.

DOE = U.S. Department of Energy.
Ecology = Washington State Department of Ecology.
PUREX = Plutonium-Uranium Extraction (Plant).
RCRA = *Resource Conservation and Recovery Act*.
TBD = To be determined.
TSD = Treatment, storage, and disposal (unit).
WMA = Waste management area.

(a) If clean closure is approved, no post-closure groundwater monitoring is required.
(b) Administrative closure means no RCRA groundwater monitoring is required.

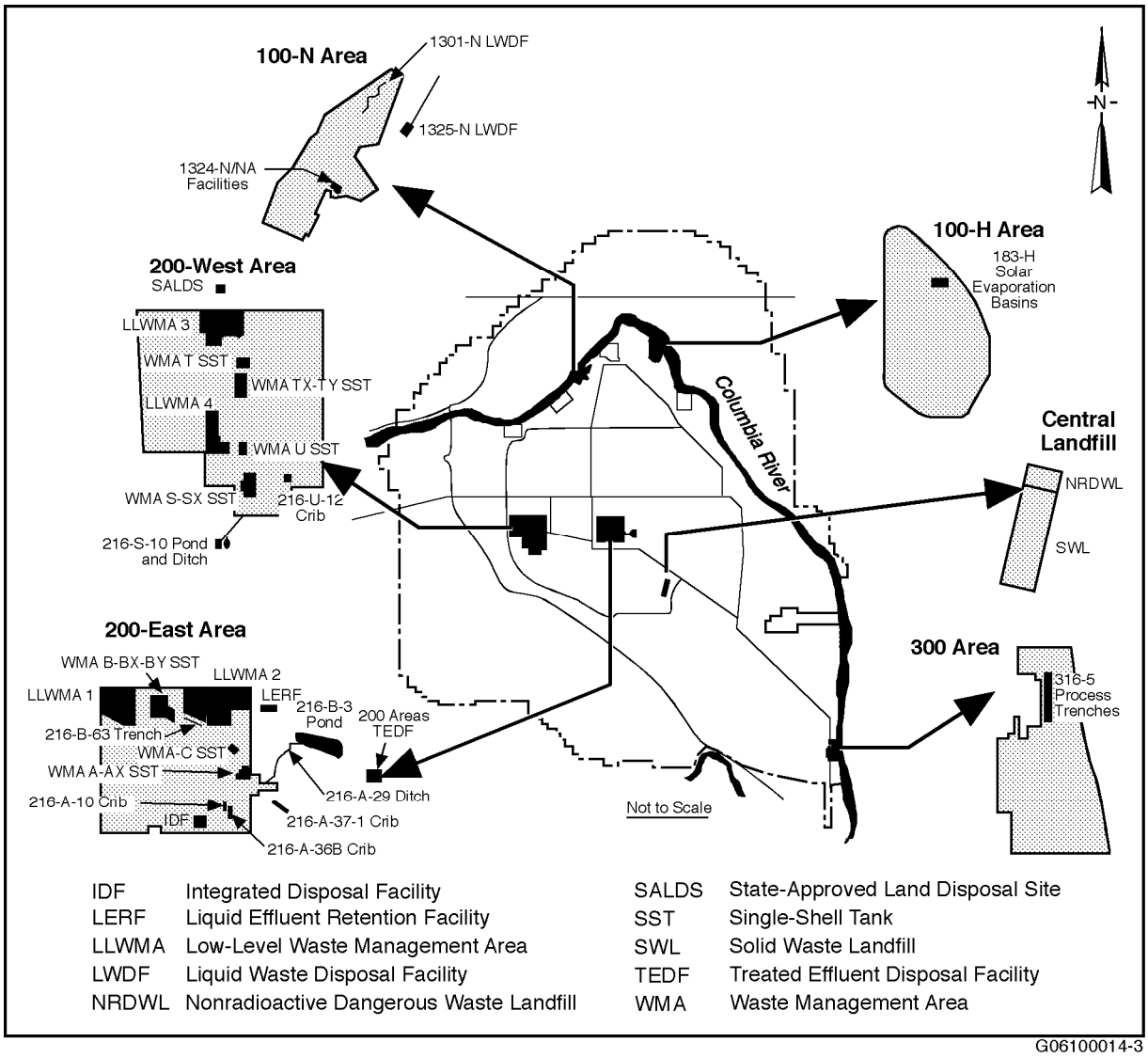

Figure IV-1. Locations of Regulated Units Requiring Groundwater Monitoring on the Hanford Site. (The 216-A-10, 216-A-36B, and 216-A-37-1 cribs are monitored as a single waste management area, PUREX cribs.)

RCRA Interim Status

For RCRA sites under interim status, data from quarterly samples collected the first year are evaluated statistically to establish initial background groundwater quality. After the first year, sampling and analysis are conducted at least annually for the parameters related to groundwater quality and semi-annually for the indicator parameters related to groundwater contamination (i.e., pH, specific conductance, total organic carbon, and total organic halides). Statistical comparison values are recalculated as needed when the well network, flow direction, or baseline (i.e., background concentration) changes.

If indicator parameters show a confirmed, statistically significant increase (or decrease for pH) of an indicator over background levels, the DOE notifies Ecology and develops a groundwater quality

assessment monitoring plan. The objective of assessment monitoring is to determine if dangerous waste or dangerous waste constituents from the regulated unit have entered the groundwater and, if so, to determine the concentration, rate, and extent of migration of the constituents in the groundwater. Monitoring must continue during the active life of the facility and the post-closure care period unless the unit is clean closed.

RCRA Final Status

For final status RCRA units, there are three stages of groundwater monitoring and follow-up activities: detection, compliance, and corrective action (WAC 173-303-645). Two additional types of monitoring programs, integrated and alternative, are allowed at Hanford under special circumstances. The monitoring requirements are included in attachments to the Hanford Facility RCRA Part B Permit (Ecology 1994) and, in most cases, in groundwater monitoring plans. Each plan specifies methods to collect and interpret groundwater monitoring data. The choice of an appropriate statistical method depends on the monitoring stage and the nature of the data.

The final status detection monitoring program is designed to determine whether a RCRA-regulated unit has adversely affected groundwater quality in the uppermost aquifer beneath the Hanford Site. This is accomplished by testing for statistically significant evidence of contamination at a downgradient compliance monitoring well relative to baseline levels. Depending on the appropriate statistical technique chosen, these baseline levels may be obtained from upgradient (background) wells, or from historical measurements from that same well. If a statistically significant increase (or pH decrease) over baseline conditions occurs in a downgradient compliance well, a compliance monitoring program might be required. The DOE must institute a compliance monitoring program if they cannot successfully demonstrate that a source other than the regulated unit has caused the contamination or that the increase resulted from an error in sampling, analysis, or evaluation.

In a compliance monitoring program, the monitoring objective is to determine whether groundwater protection standards have been exceeded. This is accomplished by routine monitoring (at least semi-annually) to compare the concentration of a constituent obtained from samples collected at the point of compliance to groundwater protection standards, such as a drinking water standard, health-based standard, or any other standard that constitutes an applicable, relevant, and appropriate requirement. Monitoring must continue through the post-closure care period.

Maximum concentration limits in groundwater are identified for the dangerous constituents identified for the unit. Alternate concentration limits may be proposed after considering the observed concentrations of chemical constituents in the groundwater that might originate from the regulated unit in question. The area background, natural background, and other standards and requirements that are applicable, relevant, and appropriate are evaluated when proposing an alternate concentration limit.

If, during compliance-level monitoring, the referenced concentration limit(s) for a given groundwater parameter(s) is significantly exceeded, a corrective action program is developed and implemented to protect human health and the environment. Details for the corrective action program are specified in the unit-specific permit applications or closure plans. Additionally, a groundwater monitoring plan used to assess the effectiveness of the corrective action measures is submitted. That monitoring plan is similar in scope to the compliance-level groundwater monitoring program and includes all relevant information

pertaining to the location and description of monitoring wells, monitoring network, well construction and development, sampling and analysis plans, statistical methods, and quality procedures.

In accordance with the Hanford Facility RCRA Permit (Dangerous Waste Portion, General Condition II.K.7) (Ecology 1994), RCRA unit closures can be integrated with other cleanups, such as those required under CERCLA. An "integrated monitoring program" may be proposed when one or more of the following conditions arise:

- A compliance, corrective action, or alternative monitoring program is not appropriate.
- An integrated monitoring program is more cost-effective.
- An integrated monitoring program will allow alignment of remedial action objectives with RCRA closure.

When an integrated monitoring program is chosen for a RCRA site, monitoring requirements are determined on a case-by-case basis with Ecology. Because groundwater cleanup at RCRA units is typically deferred to the CERCLA operable unit cleanup, an integrated monitoring program might initially just monitor the existing groundwater conditions until the final cleanup begins.

An "alternative monitoring program" may be established in accordance with WAC 173-303-610(1)(e), when Ecology determines that:

> *(i) A dangerous waste unit is situated among other solid waste management units or areas of concern, a release has occurred, and both the dangerous waste unit and one or more of the solid waste management units or areas of concern are likely to have contributed to the release; and*
>
> *(ii) It is not necessary to apply the requirements of this section (or the unit-specific requirements referenced in subsection (2)(b) of this section) because the alternative requirements will protect human health and the environment.*

When an alternative monitoring program is chosen for a RCRA site, monitoring requirements are determined on a case-by-case basis with Ecology.

For detection and compliance programs, all wells at each RCRA unit must be sampled at least semi-annually. The default sampling procedure requires that a sequence of at least four samples be taken over a time interval that ensures, to the greatest extent technically feasible, that an independent sample is obtained. Alternative sampling procedures may be approved by the regulator(s) (40 CFR 264.97; WAC 173-303-645). For integrated or alternative monitoring programs, sampling frequencies are determined on a case-by-case basis with Ecology. Specific sampling frequencies and statistical evaluation methods are provided in the unit-specific groundwater monitoring documentation in the Hanford Facility RCRA Permit (Ecology 1994).

Other Regulated Units

In addition to RCRA facilities, there are non-RCRA operational facilities on the Hanford Site that are regulated under the requirements of Washington State regulations and the Tri-Party Agreement (Ecology et al. 1989). These include disposal facilities that receive treated effluents from the 200 and 600 Areas. In December 1991, an agreement was reached to include all miscellaneous waste streams and/or any new waste stream discharges to the ground under the waste discharge permit system defined in WAC 173-216. Groundwater monitoring is conducted at two of these sites: the 200 Area Treated Effluent Disposal Facility and the State-Approved Land Disposal Site (see Figure IV-1). Current operations and groundwater monitoring conducted at the Solid Waste Landfill are regulated by WAC 173-304-490. Current groundwater monitoring plans for these three facilities are referenced in Table IV-6.

Table IV-6. Other Regulated Units, April 2007

Regulated Unit	Applicable Regulation	Monitoring Plan
200 Areas Treated Effluent Disposal Facility	WAC 173-216	PNNL-13032
State-Approved Land Disposal Site	WAC 173-216	PNNL-13121
Solid Waste Landfill	WAC 173-304	PNNL-13014

Groundwater Monitoring of Operable Units

Groundwater monitoring is conducted to support the CERCLA objectives at inactive sites. For the purpose of conducting these activities, the waste sites (called past-practice sites) and associated contaminated groundwater have been grouped into operable units. There are 74 source (waste site) operable units and 11 groundwater operable units. Groundwater operable units are linked to numerous source operable units, which may have contributed to regional plumes of contamination. Groundwater operable units are treated separately from the source operable units for remediation. The locations of the groundwater operable units are shown on Figure IV-2. In addition, the site has been divided into groundwater interest areas based on the official operable units. The interest areas extend beyond the operable unit boundaries and facilitate monitoring by assigning primary responsibility to staff scientists. These interest areas, as currently defined, also are shown on Figure IV-2.

CERCLA groundwater operable units are monitored to assess the performance of groundwater remediation, to characterize further the nature and extent of contamination for decision-making, or to track plumes and trends (long-term monitoring). A listing of the groundwater operable units, sampling and analysis plans, the current status of each relative to their record of decision, and the general category of groundwater monitoring is given in Table IV-7.

The operable units, defined in the Tri-Party Agreement, are designated as either RCRA past-practice units or CERCLA past-practice units. This designation ensures that only one past-practice program is applied to each operable unit. This discussion will use the term CERCLA for simplicity. The DOE, EPA, and Ecology determine methods for remediating contaminated groundwater via formal documents called records of decision.

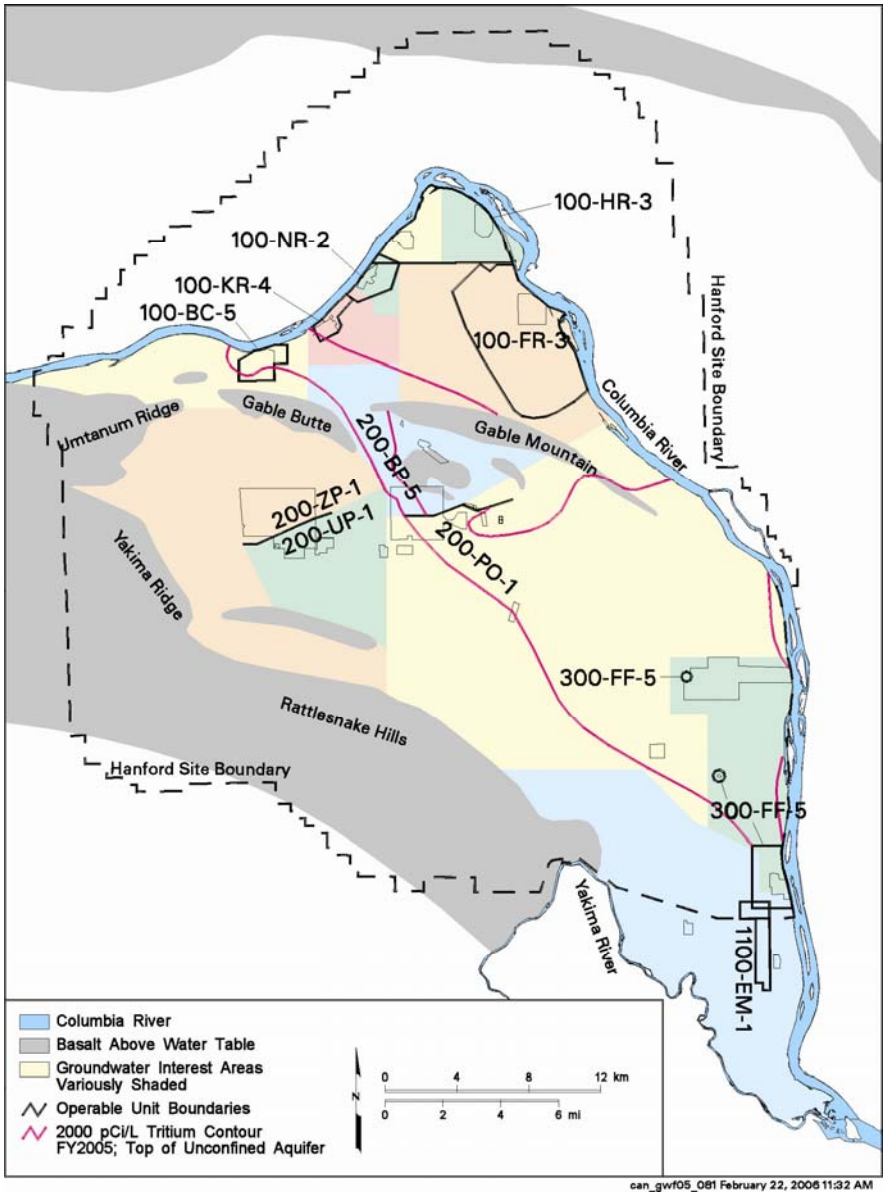

Figure IV-2. Locations of the Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site. The 200-PO-1 Operable Unit is bounded by the 2,000-pCi/L tritium contour. The boundaries of the 200-BP-5 Operable Unit are being redefined.

One operable unit, 1100-EM-1 (Richland North Area), has a final record of decision calling for natural attenuation of volatile organic compounds. The operable unit has been removed from the National Priorities List (NPL) but groundwater is monitored to determine the success of this approach. Since fiscal year 2001, contaminant concentrations have remained below their target levels.

Another operable unit, 300-FF-5 (300 Area and satellite areas to the north) has an interim record of decision that calls for natural attenuation of the cis-1,2-dichloroethene, trichloroethene, and uranium plumes. In fiscal year 2005, concentrations of the trichloroethene were low, but cis-1,2-dichloroethene and uranium remained elevated. A remedial investigation and feasibility study are underway to support final cleanup decisions.

Table IV-7. Groundwater Operable Unit Monitoring

Operable Unit Designation	SAP Reference	Status Relative to ROD	Monitoring Category
1100-EM-1	PNNL-12220	Post-ROD	Long-term monitoring
300-FF-5	DOE/RL-2002-11	Interim ROD	Long-term monitoring; interim action; remedial investigation/feasibility study
100-BC-5	DOE/RL-2003-38	Pre-ROD	Long-term monitoring
100-FR-3	DOE/RL-2003-49	Pre-ROD	Long-term monitoring
100-HR-3	DOE/RL-96-90 (pump and treat); DOE/RL-2003-63 (ISRM)	Interim ROD	Interim action
100-KR-4	DOE/RL-96-90	Interim ROD	Interim action
100-NR-2	DOE/RL-2001-27	Interim ROD	Interim action
200-BP-5	DOE/RL-2001-49	Pre-ROD	Long-term monitoring
200-PO-1	DOE/RL-2003-04	Pre-ROD	Long-term monitoring
200-UP-1	DOE/RL-92-76	Interim ROD	Interim action
200-ZP-1	DOE/RL-2003-55	Interim ROD	Interim action

ISRM = In situ redox (reduction-oxidation) manipulation.
ROD = Record of decision.
SAP = Sampling analysis plan.

At four operable units, there are no imminent threats to human health or the environment; therefore, no interim remedial actions are required. These operable units include 100-BC-5 (100-B/C Area), 100-FR-3 (100-F Area), and 200-BP-5 and 200-PO-1 (200-East Area). Waste sites and plumes will continue to be monitored until there are final records of decision.

At five of the operable units, groundwater monitoring is focused on evaluating the performance of groundwater interim remedial measures and primarily is the responsibility of Fluor Hanford, Inc. This monitoring also provides information to support final records of decision, and is outside of but consistent with this Environmental Monitoring Plan.

- **100-HR-3 (100-D and 100-H Areas)** – Chromium may pose a threat to aquatic organisms in the Columbia River. Interim records of decision require two interim remedial actions to address chromium contamination: pump-and-treat systems in the 100-D and 100-H Areas, and an in situ treatment method in the south 100-D Area. In fiscal year 2006, chromium concentrations in compliance wells remained above cleanup targets.

- **100-KR-4 (100-K Area)** – An interim record of decision requires a pump-and-treat system as an interim remedial action to address chromium contamination. The system was expanded in fiscal year 2006, and chromium concentrations in compliance wells remained above cleanup targets.

- **100-NR-2 (100-N Area)** – Strontium-90 concentrations remain much higher than the drinking water standard in wells at the river shore. The DOE operated a pump-and-treat system for strontium-90 as an expedited response action from 1995 until March 2006 when the system was put on cold standby. In summer 2006, testing of an alternative remediation method began.

- **200-UP-1 (200-West Area)** – An interim record of decision required operation of a pump-and-treat system to reduce technetium-99 and uranium contamination from 1994 until January 2005. In fiscal year 2006, concentrations remained below target levels.

- **200-ZP-1 (200-West Area)** – An interim record of decision requires operation of a pump-and-treat system to prevent carbon tetrachloride from spreading. In fiscal year 2005, the system continued to limit migration of the heart of the plume and was expanded to reach another portion of the plume. The DOE also operates two soil-gas extraction systems to remove carbon tetrachloride from the vadose zone. A remedial investigation report was written and released in 2006 (DOE/RL-2006-24).

Site-Wide Environmental Surveillance of Groundwater

Additional groundwater monitoring is required to meet requirements of the *Atomic Energy Act*, as implemented by DOE Orders 450.1 and 435.1. A primary objective is tracking contaminant plumes and trends. This objective is shared with long-term CERCLA monitoring. In addition, facility-specific monitoring is performed at burial grounds and waste storage facilities that have the potential to impact groundwater but where monitoring requirements are not completely covered by other regulatory drivers. These facilities include low-level burial grounds, the integrated disposal facility, and the 100-K Area fuel storage basins.

Data from other groundwater monitoring programs (e.g., RCRA, CERCLA) are integrated with information from wells monitored specifically for the *Atomic Energy Act*. The site-wide monitoring program divides the Hanford Site into regional "groundwater interest areas" that encompass CERCLA operable units (see Figure IV-2). Wells selected for *Atomic Energy Act* sampling address the following objectives:

- **Monitoring contaminant source areas** – Source areas include regions with active waste disposal facilities or with facilities that have generated or received waste in the past. These data are generally provided by facility-specific monitoring networks. Performance assessment monitoring of low-level burial grounds (DOE/RL-2000-72) and the integrated disposal facility (RPP-PLAN-26534) is performed to meet the requirements of DOE Order 435.1. The groundwater monitoring components of these plans are designed specifically to address potential releases of radionuclides from the facilities to the saturated zone. Monitoring for non-radioactive hazardous chemicals is performed per RCRA monitoring requirements. Monitoring of the 100-K Area fuel storage basins is performed to evaluate past and potential future leakage from the basins at the KW and KE Reactor buildings (PNNL-14033). Until 2004, these basins contained irradiated fuel from the 100-N Reactor, a small amount of miscellaneous fuel debris from other reactors, and radioactive

sludge built-up from years of operation. The basin water contains dissolved radionuclides and is a potential source of groundwater contamination.

- **Tracking known contaminant plumes** – Wells located within known contaminant plumes are monitored to characterize and identify trends in the concentrations of radiological or chemical constituents. These wells are also monitored to quantify existing groundwater quality problems and to provide baselines of environmental conditions against which future changes can be assessed.

- **Protecting water supplies** – Water-supply wells on and near the site, including those at the Fast Flux Test Facility and those used by the city of Richland, potentially provide a route for human exposure to contaminants in groundwater. Monitoring wells near these water supply wells and, in some cases, the water-supply wells themselves, are monitored to identify the potential impact to water quality.

- **Protecting the Columbia River** – Wells and sampling tubes near the Columbia River are monitored to assess the quality of groundwater as it leaves the unconfined aquifer. The Columbia River provides a pathway for contaminants to leave the Hanford Site and potentially enter a drinking water supply. Fish and other wildlife could also be exposed to contaminants at the Columbia River. Data from this area help evaluate existing and potential offsite impacts of groundwater contaminants, establish a baseline of groundwater quality, and assess existing and emerging groundwater quality problems.

- **Determining vertical distribution of contaminants** – Staff sample wells completed in the basalt-confined aquifer and deep in the Hanford-Ringold sediment to assess the depth of contamination and to assess potential pathways for offsite migration of contaminants.

- **Assessing remediation performance** – Staff monitor groundwater to assess the performance of groundwater remedial actions.

- **Monitoring offsite groundwater quality** – Groundwater is used for domestic and agricultural purposes outside the Hanford Site. Offsite wells may be monitored periodically to ensure that contaminants from Hanford Site sources are not present and to maintain a baseline of information on offsite water quality.

- **Monitoring background areas** – Wells in areas upgradient from Hanford Site operations are sampled to provide information on background groundwater quality. These data are needed to assess the impact of site operations on groundwater and also to identify contaminants contributed by offsite upgradient sources.

- **Monitoring for public assurance** – Data to meet the objectives above are presented to the public in less technical summaries to communicate how their safety is being addressed. Some additional data may be collected to address public concerns in areas of particular visibility or interest. The data are communicated through the annual site environmental report (e.g., PNNL-16623), the summary for the annual Hanford Site groundwater monitoring report (e.g., PNNL-16346-SUM), and through presentations to groups such as the Hanford Advisory Board.

Sampling frequency for *Atomic Energy Act of* monitoring varies from quarterly to triennially, depending on specific monitoring objectives and concentration variability in the well. The site-wide network currently contains approximately 700 wells. Results of site-wide groundwater monitoring are discussed in annual groundwater reports (e.g., PNNL-16346 for fiscal year 2006). Wells completed in the upper basalt-confined aquifer system are sampled to monitor deeper groundwater conditions, especially in the 200-East Area where contaminants have been detected in this aquifer. The site-wide monitoring well network changes from year to year based on groundwater flow conditions, movement of contaminant plumes, and monitoring objectives. Analytes for site-wide monitoring are selected based on the constituents present in nearby plumes and the inventories of potential groundwater contaminants at upgradient sources.

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