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Revision 0

Central Plateau Terrestrial Ecological Sampling and Analysis Plan - Phase II

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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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

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EXECUTIVE SUMMARY

This document is the Phase II terrestrial ecological sampling and analysis plan (SAP) for the Central Plateau on the Hanford Site. This SAP is the second in a series of three being performed to assess ecological risks on the Central Plateau. The activities described in this document will result in the soil and biota data needed for informed waste site decision-making and will provide information to evaluate the health or condition of the ecosystem across the range of Central Plateau habitats. This plan is based in large part on the Phase I ecological SAP developed for Central Plateau waste sites (DOE/RL-2004-42, *Central Plateau Terrestrial Ecological Sampling and Analysis Plan - Phase I*). Both of these SAPs are based on ecological data quality objectives (EcoDQO) developed for the Central Plateau, as documented in WMP-20570, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase I* (pending). The components of the design that have changed for Phase II (e.g., aspects of the phased approach and spatial domains targeted for sampling) are described in WMP-25493, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase II* (pending). The culmination of the phased data quality objectives (DQO)/SAPs and field characterization activities will be the development of a final Central Plateau Ecological Risk Assessment, planned for fiscal year 2007, as shown in Figure ES-1.

The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) established a framework to ensure that environmental impacts associated with past and present activities at the Hanford Site are investigated and that appropriate response actions are taken to protect human health and the environment. Within this framework, the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study process is implemented to gather the information needed to arrive at records of decision that authorize remedial actions. The ecological risk assessment supported by this SAP is one of several being performed on the Hanford Site to ensure that ecological risks have been properly evaluated in support of remedial-action decision making. This document only addresses potential terrestrial ecological impacts on the Central Plateau. It does not address Central Plateau human health or groundwater impacts, nor does it consider ecological impacts in other portions of the Hanford Site.

This SAP will be implemented using a phased and tiered approach to characterize ecological risks. Phases are based on spatial domains where investigation areas will be located; tiers are types of data collected within those investigation areas. Phase I activities initially were focused on the 200 East and 200 West Areas. Phase II was to evaluate the need for ecological sampling in the US Ecology site, tank farms, BC Controlled Area, and West Lake. Phase III is planned to evaluate the need for ecological sampling in habitat (nonoperational) areas outside of the 200 East or 200 West Areas. Because of budgetary and schedule limitations that constrained the fiscal year 2004 activities, the spatial components of Phases I and II of the EcoDQO now will be characterized in fiscal year 2005. As Figure ES-1 shows, waste sites in the 200 East and 200 West Areas now will be sampled concurrently with an evaluation of the areas targeted for Phase II, as described in more detail below. This document focuses on the spatial domains considered for sampling in Phase II.

Data collection will be followed by a data quality assessment in Phase III, and Tier 2 data collection will be dependent on the results of the data quality assessment. Phase III also will include revisions to DQOs or development of DQOs for some spatial elements (e.g., West Lake, habitat sampling).

Potential Phase II Spatial Domains

BC Controlled Area. The BC Cribs and Trenches received wastes primarily from the Uranium Recovery Project and secondarily from 300 Area wastes (WMP-18647, *Historical Site Assessment of the Surface Radioactive Contamination of the BC Controlled Area*). Biotic intrusion into trenches was discovered in the late 1950s. The BC Cribs and Trenches were covered in 1969 to prevent animal intrusion. This rock and dirt cover was used to prevent contaminant spread, not to implement a final remedy. The land outside of the BC Cribs and Trenches Area that may be influenced by the BC Cribs and Trenches is referred to as the BC Controlled Area. The BC Cribs and Trenches are included in the Phase I SAP (DOE/RL-2004-42), and are therefore not included in this SAP. The BC Controlled Area is much less contaminated than the BC Cribs and Trenches Area, and selection of remedial alternatives for the BC Controlled Area could be influenced by the results of the ecological evaluation.

BC Controlled Area Contaminants of Potential Ecological Concern. The draft BC Controlled Area radionuclide contaminants of potential ecological concern (COPEC) list is based on maximum concentrations of surface soil data from BHI-01319, *Data Assessment Report for the Sampling and Analysis Activities Conducted to Support Reposting the 200 B/C Contaminated Area*. The sum of fractions for these data is 262 (or dose equal to 26 rad/day), of which Sr-90 represents 58 percent and Cs-137 is 42 percent of the sum of fractions; other radionuclides contributed less than 0.001 percent of the sum of fractions. Consequently, Cs-137 and Sr-90 are the radioactive COPECs. These and other radionuclide data are summarized in WMP-18647. The suites associated with these COPECs will include radionuclides identified through radiostrontium and gamma energy analyses. Because of the absence of empirical data on the presence of nonradionuclides in the BC Controlled Area, the process for identification of nonradionuclide COPECs was based on a characterization activity that analyzed BC Controlled Area soils for metals, total uranium, anions, and total polychlorinated biphenyls (D&D-24693, *Sampling and Analysis Instruction for BC Controlled Area Soil Characterization*). Sampling was performed in the most highly contaminated and the moderately contaminated portions of the BC Controlled Area. Because contaminants were not detected at concentrations above the WAC 173-340-900, "Tables," Table 749-3 ecological screening values, background, or analytical detection limits, nonradionuclides were not identified as COPECs in this SAP.

US Ecology. The US Ecology site is a commercial low-level radioactive waste disposal site within the Hanford Site boundaries. It is a licensed state facility and is not operated or regulated by the U.S. Department of Energy. Thus the US Ecology site is not a CERCLA waste site, although it is operated on Federal land being leased to the State of Washington. The site has been in operation since 1965 and consists of containerized solid wastes that are buried under a cover of deep fill. The site contains radionuclides and a limited set of nonradioactive constituents. Because the US Ecology site is not a Central Plateau CERCLA waste site, ecological data collected from the US Ecology site will not be used to support Central Plateau operational area decision making. Final cleanup actions will be based on closure plans already under way that include capping the low-level radioactive waste trenches. Furthermore, the US Ecology site will remain operational for another 50 years (until 2056). The site is scheduled for closure when the lease expires in September 2063, which seems to further limit the utility of

sampling current conditions at the US Ecology site and the local environs. As such, sampling is not planned for the US Ecology site in Phase II. It is recognized, however, that the potential exists for contaminants associated with the US Ecology site to influence surrounding habitat in the Central Plateau. Consequently, existing air monitoring data for the US Ecology site (e.g., air monitoring data from the Washington State Department of Health, Pacific Northwest National Laboratory, other sources) will be compiled and evaluated. Such information will help determine if the US Ecology site should be considered in the possible assessment of the Central Plateau habitat areas in Phase III.

Tank Farms. The tank farms are actively managed by the U.S. Department of Energy, Office of River Protection, using herbicides, pesticides, and physical barriers to prevent biological intrusion. Furthermore, little attractive habitat exists for biotic use. Every effort is made to capture biological intruders, and captured animals are disposed of. Tank farm sites are being evaluated using the *Resource Conservation and Recovery Act of 1976* corrective action process, and the resulting alternatives almost certainly will change the quality of ecological habitat within the tank farms. The tank farms also are subject to interim stabilization methods that include removing liquids from the tanks and sampling the waste. Until all interim tank remediation is finished, final remedial alternatives will not be evaluated. For these reasons, tank farm sites are not appropriate for ecological sampling at this time.

West Lake. West Lake's former expanse was largely a result of wastewater discharges from the Plutonium-Uranium Extraction Plant and the B Plant that elevated the water table. Contaminated media included soil, water, and sediment. Surface water was identified as the only medium of concern by a screening-level ecological risk assessment. Because subsurface discharge has been discontinued in the 200 Areas, the lake has been shrinking in size. Within the last year, the aerial footprint of the lake has been observed to be as small as 3 m^2 and as large as hundreds of square meters. Thus, West Lake is dynamic and responds to climatological and seasonal conditions such as snow melt and large rain events. Because West Lake represents a unique and changing ecological feature at the Hanford Site, further data compilation is recommended before Phase III is begun so that all existing information can be evaluated and the data gaps can be defined. Additional ecological characterization, if needed, will be coordinated with the potential remedial alternatives for West Lake and the associated groundwater operable units. Consequently, West

Lake will not be addressed in Phase II; the existing DQOs for West Lake will be revised as part of Phase III planning activities.

Other Ecological Data Quality Objective Information

The BC Controlled Area represents the only spatial domain considered for sampling in Phase II. The COPECs representing primary radionuclide risk drivers on the Central Plateau are Cs-137 and Sr-90 (WMP-20570), the same primary radiological constituents (on a concentration/dose basis) that are in the BC Controlled Area. Given the similarity of Phase I and Phase II radionuclide COPECs and the similarity of the BC Controlled Area to habitat in and around the Central Plateau waste sites, the conceptual model, risk questions, assessment endpoints, and measures developed in Phase I (WMP-20570) are used for the Phase II EcoDQO.

Assessment endpoints were developed in the EcoDQO document (WMP-20570) that are representative of terrestrial ecological receptors potentially at risk from COPECs in soil. Plants and soil macroinvertebrates are valued assessment endpoint entities, because they potentially are more exposed indicators for evaluating the adverse effects of soil COPECs. Central Plateau-specific receptors are used as ecological and societal relevant assessment endpoints that also address management goals. Central Plateau-specific receptors also are used as surrogates for the *Washington Administrative Code* feeding guilds, because they are at greater risk from COPECs in the toxicity evaluation. These feeding guilds include producers, soil biota, soil macroinvertebrates, middle-trophic-level vertebrates, and carnivorous reptiles, birds, and mammals.

Risk questions were a logical outcome of COPEC refinement and consideration of assessment endpoint attributes, and they represent the conceptual model of how contaminant stressors are most likely to impact the Central Plateau ecosystem. Risk questions are posed to identify measures of effect, exposure, and ecosystem/receptor characteristics. A full complement of risk questions was developed in the EcoDQO document (WMP-20570) for the possible measures considered in this phased and tiered approach to characterize ecological risks. The following risk questions are relevant to the data being collected in Phase II.

- For radionuclide COPECs: Is the contribution to the sum of fractions based on mean concentrations greater than 1 and also greater than the sum of fractions based on mean concentrations for the reference site or greater than the sum of fractions based on background mean concentrations?

- Do mean COPEC concentrations in the receptor increase compared to mean COPEC concentrations in reference site receptors or along a gradient with increasing COPEC concentrations greater than published levels associated with toxicity?

- Do mean COPEC concentrations in the receptor diet increase from those of the reference site (or background) or along a gradient with increasing COPEC concentrations greater than toxicity reference value?

A synopsis of the Phase II study design is provided in Table ES-1; it shows how the various data types (measures) relate to risk questions, the key features of the study design, and the basis for the design element. All aspects of the study design are subject to field verification, which may require selecting alternate measures for an assessment endpoint or other modifications to the study design (e.g., plot size, trapping density). In some cases, assessment endpoints will be evaluated by collecting data on that endpoint; e.g., data on deer mice will be collected to evaluate potential impacts on middle trophic level omnivores. In other cases, surrogates will be used to evaluate assessment endpoints, because data collection for that endpoint would be impractical. For example, while grasshopper mice represent insect-eating mammals, they are not abundant. In this case, field measures on pocket mice or deer mice would be used to infer the effects on growth or survival of insect-eating mammals.

The investigation area of 1 hectare (ha) was selected as an appropriate scale over which to evaluate the measures considered in this plan. The detailed rationale was provided in WMP-20570. The home range (most typically representing the foraging area) and the median dispersal distance were evaluated to identify 1 ha as an appropriate spatial scale to evaluate ecological risk. The mean over this 1 ha investigation area was the best estimate of the representative COPEC concentrations in soil and the concentration of COPECs in biota.

In addition, animals will be collected from the central portion of the investigation areas to increase the likelihood that resident animals are collected.

An important component of the conceptual model is the primary exposure medium, including the depth of biological activity. Data suggest that surface soil, in particular the first few inches, is important as an exposure medium for direct contact with wildlife, root uptake, and animal burrowing. For example, Cline (1981, "Aging Effects on the Availability of Strontium and Cesium to Plants") and Cline and Cadwell (1984, "Movement of Radiostrontium in the Soil Profile in an Arid Climate") showed that surface-applied radionuclides (Cs-137 and Sr-90) remain in the top 15 cm (6 in.) of soil over several decades. Thus, surface soil samples (top 15 cm [6 in.]) can be collected along with specific biological samples to test for COPEC uptake. Collecting surface-soil samples for the initial data collection activities has important practical advantages. Methods for collecting surface-soil samples are less intrusive than those needed for deeper soil characterization (e.g., backhoe, truck-mounted drill rigs) and, therefore, minimize the impacts of data collection on the shrub-steppe ecosystem. The conceptual model of the possible upward mobility of subsurface contamination through animal burrowing and plant uptake initially will be assessed using field radiological data collection. Sampled soils will be biased toward areas with high potential for mobilized subsurface waste, such as mammal burrow spoils.

The specific receptors targeted for Tier 1 sampling are mammals, lizards, and soil macroinvertebrates, because these organisms were viewed as having a high potential for accumulating COPECs. To help address Hanford Natural Resource Trustee information needs, any abnormalities on animals handled during data collection will be noted. Plant tissue initially will be assessed for radionuclide uptake using radiological field data for beta and gamma-emitting radionuclides. Phase II data collection will be followed by a data quality assessment, and subsequent investigations will be dependent on the results of the data quality assessment.

The data quality assessment will emphasize the analysis of the Phase I and Phase II data and relevant data from the literature (both from the Hanford Site and from other locations) using exploratory data analysis tools. Such tools include box plots that are used to compare results between data groups and scatter plots that are used to visually evaluate data for trends. These graphical tools will be supported by statistical tests, as appropriate, and will be based on the

underlying distributions of the data (e.g., normal or lognormal). Probability plots and histograms, coupled with statistical tests, can help to determine the underlying statistical distribution of the data. The exploratory data analysis is expected to lead to one of four possible outcomes following Phase I and Phase II data collection.

1. COPECs are in soil and in biota.

2. COPECs are in soil only.

3. COPECs are in biota only (potentially triggering deep soil sampling in Phase III).

4. COPECs are not in soil or in biota (indicating that no additional data are needed to characterize risk to biota for the geographic areas sampled for Tier 1).

For outcomes 1-3, exposure is compared to effect levels to determine if additional data should be collected. Thus, additional data collection is dependent on the results of the Phase III data quality assessment and may include characterization of soils deeper than 15 cm (6 in.), plant tissue concentrations, population measures for mammals and lizards, field verification for middle trophic-level birds, litterbag studies, and toxicity tests for plants and invertebrates.

Figure ES-1. Phased Central Plateau Ecological Risk Assessment Emphasizing the Spatial Extent of the Investigations.

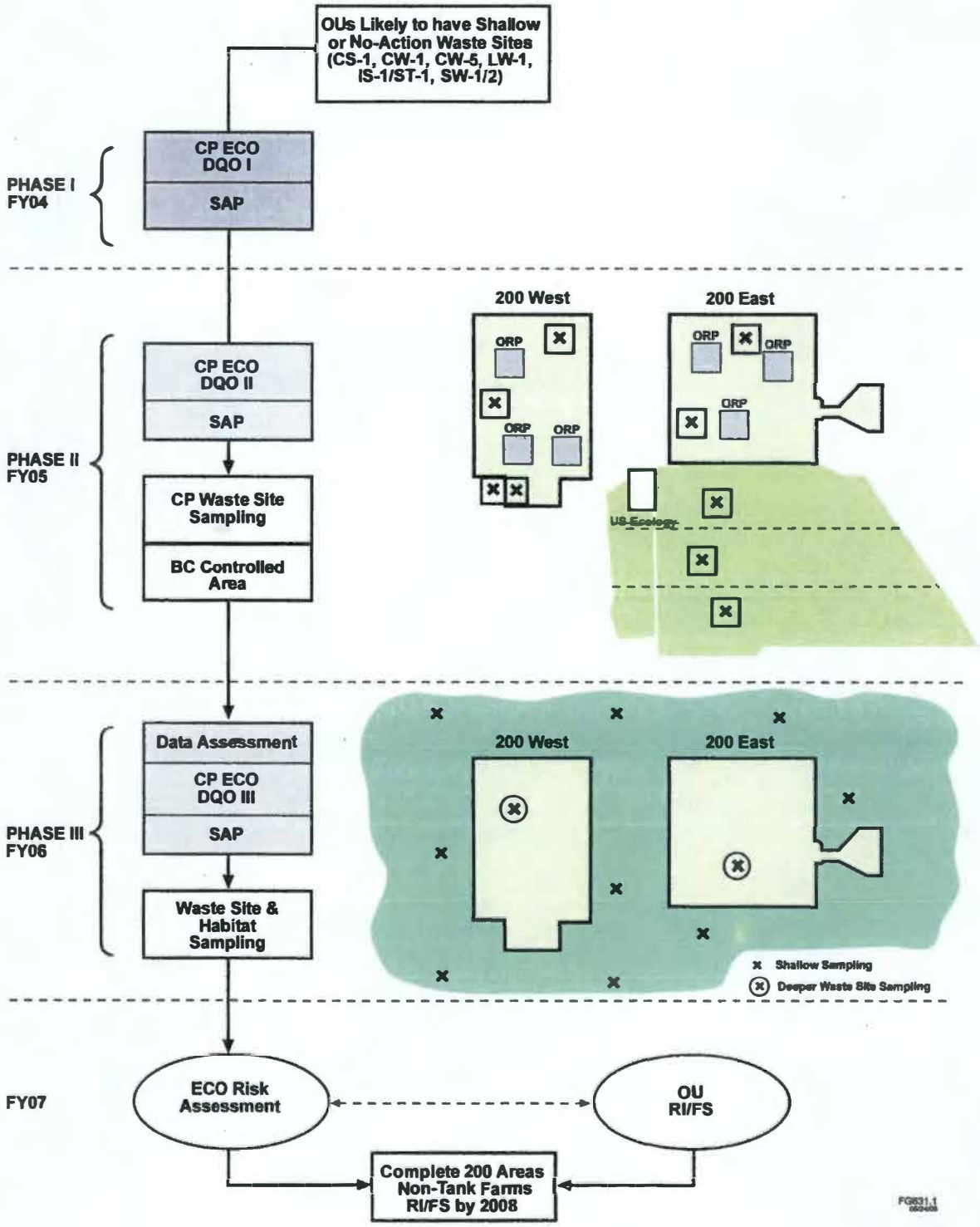

Table ES-1. Phase II Sampling Design Summary Table Linking Data to Risk Questions and Assessment Endpoints.

Data Type	Assessment Endpoint and Attribute	Measures	Population	Key Features of Design	Basis for Study Design
Reconnaissance and field verification	Herbivorous, insectivorous, and omnivorous bird and mammal, insectivorous reptile, and carnivorous bird and mammal attributes based on field measures	Basis for comparing all field-related measures in future phases of the sampling and analysis plan	BC Controlled Area and reference sites	All sites will be classified according to vegetation and habitat status. Line transects will be used to assess cover of dominant plants, bare ground, and cryptogams. Reconnaissance also will help to determine where and when to sample.	Field verification necessary to assess the comparability of habitat types among investigation areas and reference areas
Field radiological data	Information used to guide sampling and test conceptual model of contaminant transport	Radiological COPECs in soil and radiological COPECs in plant tissue	BC Controlled Area soils, plants, ant mounds, burrow spoil material	Used before sampling the soil	Supports testing of the conceptual model of biological transport
Surface soil sampling	Herbivorous, insectivorous, and omnivorous bird and mammal, and carnivorous bird and mammal attributes of survival, growth, and reproduction	COPECs in soil	BC Controlled Area and reference site soils	Multi-increment samples representing 0-15 cm (0-6 in.)	Multi-increment samples for estimate of average exposure over investigation area
Biota sampling	Insectivorous and omnivorous mammal, insectivorous reptile, and carnivorous mammal attributes of survival, growth, and reproduction	COPECs in macroinvertebrates, small mammals, and lizards	Invertebrates caught in pitfall traps, small mammals, lizards/reptiles	For invertebrates, composite of pitfall trap contents. For lizards/reptiles, individual animals. For mammals, individual animals	Samples of insects, reptiles, and small mammals provide information for comparison to literature information on toxic body burdens and for contaminant loading in middle trophic levels, to be used in modeling upper trophic-level exposure
Literature reviews on COPEC concentrations or other information relevant to risk characterization	All assessment endpoints and attributes for which information can be gathered	Compilation of existing site-specific or relevant data on COPEC concentrations or other information relevant to risk characterization	Relevant literature or unpublished but documented data sources	Consult with subject matter experts to identify relevant published or documented in-house information	Make use of existing Hanford Site or other relevant data on COPEC concentrations and other information relevant to risk characterization that will support and aid in the interpretation of other data
Exposure modeling parameters	Herbivorous, insectivorous, and omnivorous bird and mammal, and carnivorous bird and mammal attributes of survival, growth, and reproduction	Uses data on COPECs in soil and in macro-invertebrates, small mammals, and lizards	BC Controlled Area and reference site soils and biotic tissues	Use of Hanford Site-specific uptake factors for soil-to-prey reduces uncertainty in use of non-site-specific literature values	Exposure modeling especially useful in assessing endpoints for which field measures would not be resource effective

COPEC = contaminant of potential ecological concern.

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TERMS

ALARA	as low as reasonably achievable
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
COPEC	contaminant of potential ecological concern
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
EcoDQO	ecological data quality objective
EPA	U.S. Environmental Protection Agency
ERAGS	Ecological Risk Assessment Guidance for Superfund (EPA/540/R-97/006)
ERSTI	Environmental Radiological Survey Task Instructions
FE	fundamental error
FH	Fluor Hanford, Inc.
FSP	field sampling plan
GEA	gamma energy analysis
GM	Geiger-Mueller
GPC	gas proportional counter
HEIS	*Hanford Environmental Information System* database
N/A	not applicable
NaI	sodium iodide (detector)
OU	operable unit
PAM	portable alpha meter
PCB	polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory
PQL	practical quantitation limit
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RCT	radiological control technician
RL	Richland Operations Office
SAP	sampling and analysis plan
SOF	sum of fractions
TBD	to be determined
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989)
WAC	*Washington Administrative Code*

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

1.0 INTRODUCTION

This sampling and analysis plan (SAP) presents the rationale and strategy for phased sampling and analysis activities that will be performed to characterize the ecological risks associated with the Central Plateau on the Hanford Site. This SAP is based in large part on the Phase I ecological sampling and analysis plan developed for Central Plateau waste sites (DOE/RL-2004-42, *Central Plateau Terrestrial Ecological Sampling and Analysis Plan – Phase I*). Both of these SAPs are based on ecological data quality objectives (EcoDQO) developed for the Phase I Central Plateau on the Hanford Site, as documented in WMP 20570, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase I* (pending). Some aspects of these EcoDQOs are revised in the Central Plateau Phase II EcoDQO (WMP-25493, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase II* [pending]).

The sampling and analysis described in this document will provide soil and biota data to support operational area decision making and will provide information to evaluate the health or condition of the ecosystem across habitats. These data will supplement other characterization data for the Central Plateau and may assist the Hanford Natural Resource Trustees in understanding the condition of the Central Plateau ecosystem. Characterization activities described in this SAP are based on the implementation of the data quality objectives (DQO) process, as documented in the Phase I EcoDQO (WMP-20570) and the Phase II EcoDQO (WMP-25493). This DQO used EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)* (ERAGS), Steps 3 and 4, as a basis for DQO Steps 1-7.

The SAPs will be implemented using a phased and tiered approach to characterize ecological risks. Phases are based on study areas, whereas tiers are types of data collected within those study areas. This multifaceted approach has the advantage of targeting data collection to those ecological receptors found to be at risk from Hanford Site processes and associated contaminants of potential ecological concern (COPEC). Phasing allows the project to sequence the field work in a step-wise fashion that initially focuses on lower cost and less intrusive shallow-soil data. These data then will be evaluated to determine if deeper soil sampling and more extensive ecological studies are warranted. A phased approach enables the project to distribute the work over multiple years in response to work scope, time, and budget constraints, while systematically establishing the ecosystem conceptual model. A phased approach also supports refinement of the sampling design with successive sampling campaigns.

As part of the quality assurance project plan (QAPjP), the activities described in this document meet the project quality assurance requirements. The Hanford Site internal laboratory quality assurance requirements implement the following governing documents:

- *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) (Tri-Party Agreement) quality assurance requirements
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations*, EPA QA/R-5, as amended.

1.1 PHASED APPROACH OVERVIEW

An overview of the phased sampling approach and the spatial extent of the investigation phases is shown in Figure 1-1. Phase I activities are focused on the Central Plateau in the industrialized Core Zone[1]; Phase II expands the consideration of sampling domains to the US Ecology site, tank farm areas, and the BC Controlled Area; while Phase III is targeted at habitat outside of the 200 East and 200 West Areas. Because of budgetary and schedule limitations that constrained the fiscal year 2004 activities, the spatial components of both Phase I and Phase II of the EcoDQO will be characterized in fiscal year 2005, as depicted in Figure 1-1. This document focuses on the spatial domains to be sampled in Phase II. Data collection for Phases I and II will be followed by data quality assessment (DQA); Phase III investigations are dependent on the results of the DQA (see Section 2.9). In addition, the DQO developed for West Lake will be revised, and a DQO will be developed for Central Plateau habitat and for the 200 West Area carbon tetrachloride plume. The culmination of the phased DQOs/SAPs and field characterization will be the development of a final Central Plateau ecological risk assessment, planned for fiscal year 2007, as shown in Figure 1-1. The components of the characterization phases are described in the text that follows.

Phase I. Phase I characterizes exposure and ecological effects of COPECs from Central Plateau Core Zone waste sites (potentially impacted locations) and reference areas (assumed unimpacted areas, also referred to as "control" sites), focusing on waste sites with existing soil COPEC concentration data, by collecting Tier 1 soil and biota data.

- Collect surface soil samples to a depth of 15 cm (6 in.) for metals, radionuclides, and organics (polychlorinated biphenyls [PCB], pesticides) (note: 15 cm (6-in.) depth was selected for Phase I to evaluate the importance of near-surface contamination to biota).
- Collect radiological field data for beta- and gamma-emitting radionuclides in soils (e.g., burrow spoils), ant nests, and plant material to test the conceptual site model of upward contaminant transport (the conceptual model suggests that the 0 to 15 cm (6-in.) soil interval is important for exposure, but deeper soil also may be important).
- Collect biological data including body burden analysis for metals, radionuclides, and organics (PCBs, pesticides) in small mammals, lizards, and insects (these animals are common and should have sufficient mass for analysis of all COPECs).
- Note any abnormalities for the vertebrate animals handled in the field notes (these will provide qualitative information of the possible effects of COPECs on biota).
- Perform literature reviews of studies relevant to the Hanford Site, and collect exposure parameter data relevant to the Hanford Site terrestrial receptors and exposure pathways.

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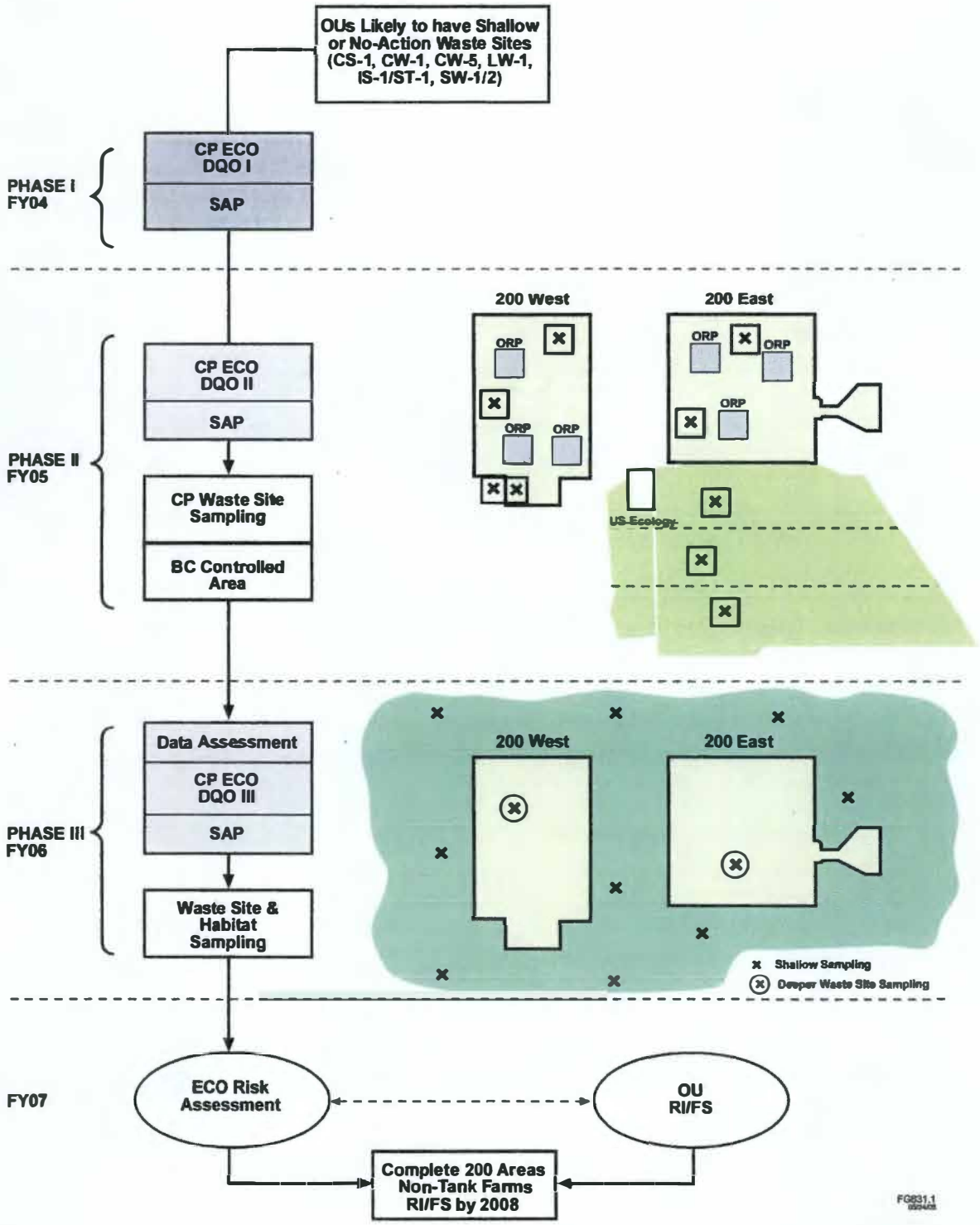
[1]This application of the Core Zone boundary is defined in the Tri-Parties response ("Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area" [Klein et al. 2002]) to the HAB advice (HAB 132, "Exposure Scenarios Task Force on the 200 Area"), and in the *Report of the Exposure Scenarios Task Force* (HAB 2002).

Figure 1-1. Phased Central Plateau Ecological Risk Assessment Emphasizing the Spatial Extent of the Investigations.



Phase II. Phase II involves consideration of ecological effects of COPECs from the BC Controlled Area by collecting Tier 1 soil and biota data.

- The US Ecology Site and the tank farm areas were determined not to be appropriate for ecological sampling in Phase II. The rationale for not sampling these locations in Phase II is discussed below (Section 1.3).
- Collect surface soil samples to a depth of 15 cm (6 in.) for radionuclides at the BC Controlled Area.
- Collect radiological field data for beta- and gamma-emitting radionuclides in soils (e.g., burrow spoils), ant nests, and plants to test the conceptual site model of biological transport.
- Collect biological data including body burden analysis for radionuclides at the BC Controlled Area in small mammals, lizards, and insects.
- Note any abnormalities for the animals handled in the field notes.
- Review Hanford Site studies relevant for Phases I and II, and collect exposure parameter data relevant to the Hanford Site terrestrial receptors and exposure pathways.

Phase III. Phase III begins with a DQA for Phase I and Phase II data, with the overall objective of testing the following aspects of the conceptual model and defining data needs for Phase III.

- Determine if mean concentrations of COPECs detected in surface soil samples are greater than mean background values (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*; Ecology 94-115, *Natural Background Soil Metals Concentrations in Washington State*; and DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*) or mean concentrations at reference sites; and also determine if these COPECs are expected from process knowledge and previous site sampling.
- Concentrations of COPECs at the reference sites are assumed to be at background levels; the Phase I and Phase II data will determine if this assumption is valid and will help determine if additional reference areas are needed.
- Determine if there is uptake of radionuclides in plants or biological transport from the activities of ants or burrowing mammals.
- Determine if COPECs are detected in biota samples (invertebrates, lizards, and small mammals) and if these COPECs are those expected from process knowledge and previous site sampling.
- Determine if biota and surface soil data correlate, suggesting that COPECs are present in surface soil and that the surface soil represents the primary exposure medium for ecological receptors.

- Evaluate the results of a literature review of studies relevant to the Hanford Site and the results of the collected exposure parameter data relevant to the Hanford Site, to guide subsequent field data collection activities.

In Phase III, the DQOs may be revised based on the DQA findings, leading to the development of a Phase III SAP. The scope of this SAP is to characterize ecological effects of COPECs in Central Plateau habitat (outside the 200 East and 200 West Areas) by collecting Tier 1 or Tier 2 soil and biota data.

- Collect surface soil samples to a depth of 15 cm (6 in.) for metals, radionuclides, and organics (PCBs) at selected sites.
- Collect biological data including body burden analysis for metals, radionuclides, and organics (PCBs) in small mammals, birds, lizards, and insects.
- Note any abnormalities for the animals handled in the field notes.

Phase III characterization may include the following Tier 2 data collection activities, dependent on the findings of the DQA.

- Collect representative samples of soil below 15 cm (6 in.) to supplement existing investigation area data, if needed, to address data gaps identified through the DQA in Phase III.
- Collect plant tissue and soil grab samples along the rooting depth. These are conditional upon measuring COPEC concentrations greater than plant soil-screening values in Phase I and Phase II soil samples.
- Collect data to evaluate population measures for mammals and lizards if the concentrations measured in biota and soil are greater than literature adverse-effect levels.
- Conduct toxicity tests, which are conditional on identifying COPECs for soil biota in Phase I and Phase II soil and biota samples.
- Evaluate the need for field verification of ground- and shrub-nesting bird measures.
- Determine if there is adequate density of ground- and shrub-nesting birds for use in evaluating measures of exposure and effect for middle trophic-level birds.
- Collect field data on nest success for birds, or implement a nestbox study (as an alternative) to obtain nest success and egg COPEC concentrations if field verification (Tier 2) shows that ground- and shrub-nesting bird density is not adequate for field studies.
- Note any abnormalities for the animals handled in the field notes.

Phase III also includes developing or revising DQOs for the following potential study design elements.

- Develop DQOs for Central Plateau habitat sampling. A focus of Phase III of the Central Plateau EcoDQO is to assess habitat in nonoperational areas to better understand the status and health of the Central Plateau ecosystem.

- Use the DQO process to evaluate the need for adding other reference sites.

- Develop DQOs to assess potential risks to fossorial mammals from the diffuse carbon tetrachloride plume in the 200 West Area. Carbon tetrachloride was identified as a COPEC, based on data reviewed in Phase I. No sampling for carbon tetrachloride is planned for Phase I or Phase II, however, because data collection is focused on the 0 to 15 cm (6-in.) depth interval; measurement of volatile organics in this interval is meaningless because of barometric pumping and solar heating of the soil.

- Revise the existing DQO for West Lake. A DQO was developed for West Lake in Phase I, and this will be revised based on an assessment of available and relevant West Lake studies.

1.2 BACKGROUND

The Hanford Site became a Federal facility in 1943, when the U.S. Government took possession of the land to produce nuclear materials for defense purposes. The Hanford Site's production mission continued until the late 1980s, when the mission changed from producing nuclear materials to cleaning up the radioactive and hazardous wastes that had been generated during the previous years.

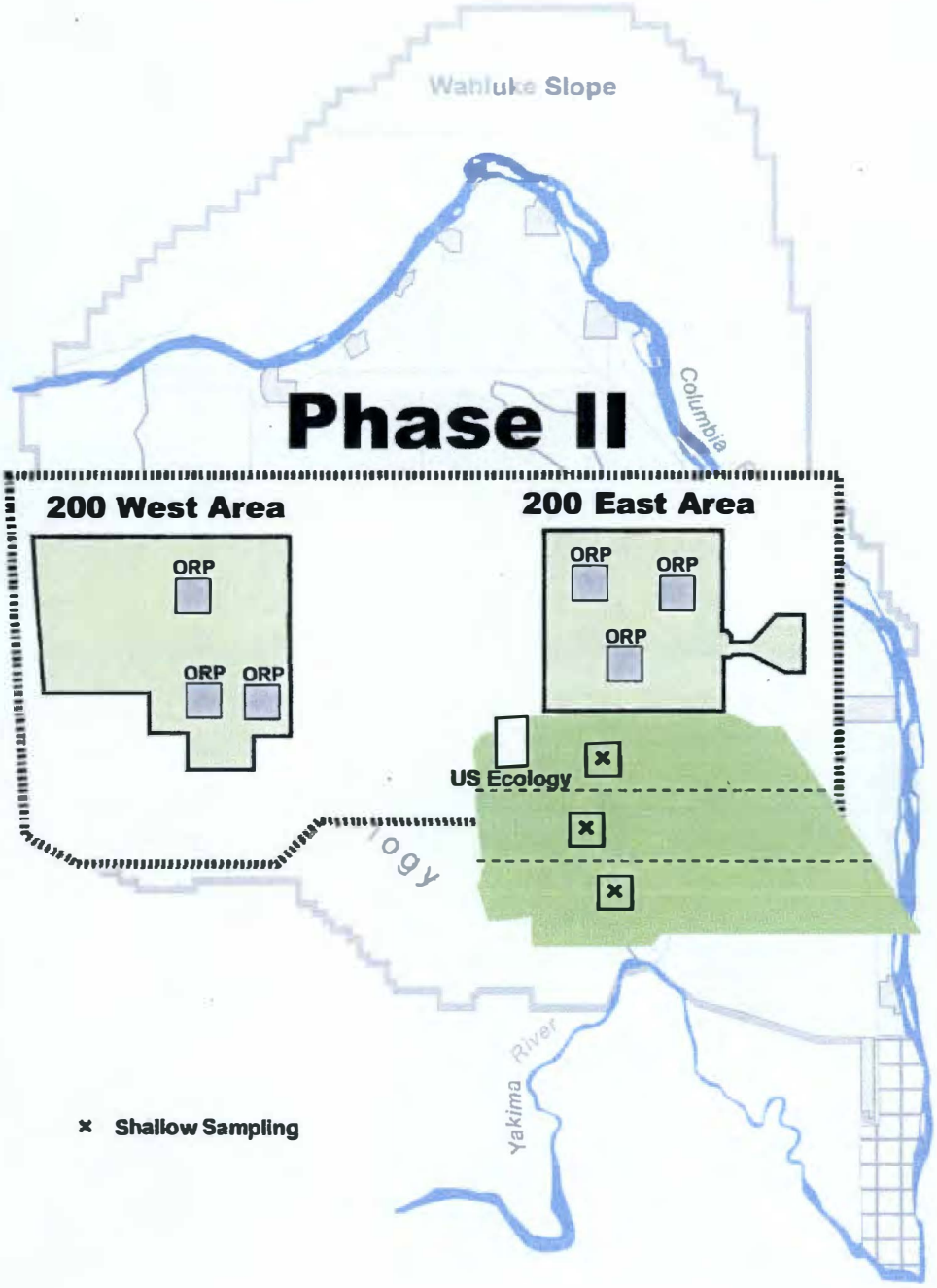
1.3 SITE DESCRIPTIONS AND HISTORY

The Central Plateau consists of approximately 75 mi^2 (195 km^2) near the middle of the Hanford Site. It contains approximately 900 excess facilities formerly used in the plutonium production process. Background on the Central Plateau waste sites and the processes contributing to those waste sites within the industrialized Core Zone is addressed in the Phase I SAP (DOE/RL-2004-42). The terrestrial spatial domains under consideration in Phase II include the following: BC Controlled Area, US Ecology Site, tank farm sites, and West Lake (Figure 1-2). Brief summaries of the areas evaluated for possible ecological sampling in Phase II are presented here.

BC Controlled Area. Sample results documented that elevated concentrations of radionuclides exist in the 0 to 15 cm (6-in.) soil interval (BHI-01319, *Data Assessment Report for the Sampling and Analysis Activities Conducted to Support Reposting the 200 B/C Contaminated Area*; Cline 1981, "Aging Effects on the Availability of Strontium and Cesium to Plants"; Cline and Cadwell 1984, "Movement of Radiostrontium in the Soil Profile in an Arid Climate"). It is possible that biological transport can lead to distributing contamination on the ground surface (i.e., the first few millimeters) to deeper depths. This may lead to distributing contaminants into soil at deeper than 15 cm (6 in.). However, this process gradually would blend high concentrations in the surface into lower concentrations at deeper depths, and samples collected from the top 15 cm (6 in.) should be representative of the greatest contaminant concentrations.

Figure 1-2. Spatial Areas Evaluated for Phase II of the Central Plateau EcoDQO.

(West Lake included in the document but not shown in the figure.)



The land outside of the BC Cribs and Trenches Area that may be influenced by wastes from the BC Cribs and Trenches is referred to as the BC Controlled Area, the aerial extent of which is 13.4 mi^2. The BC Controlled Area excludes the BC Cribs and Trenches, which are included in the Phase I SAP (DOE/RL-2004-42).

BC Controlled Area key points

⇒ BC Cribs and Trenches were the original contamination source

⇒ Contamination varies across three zones

Approach

⇒ Include BC Controlled Area in Phase II design

⇒ Radiological COPECs and resulting analytical suites are based on existing data

⇒ Nonradiological COPECs and analyses are based on March 2005 characterization data

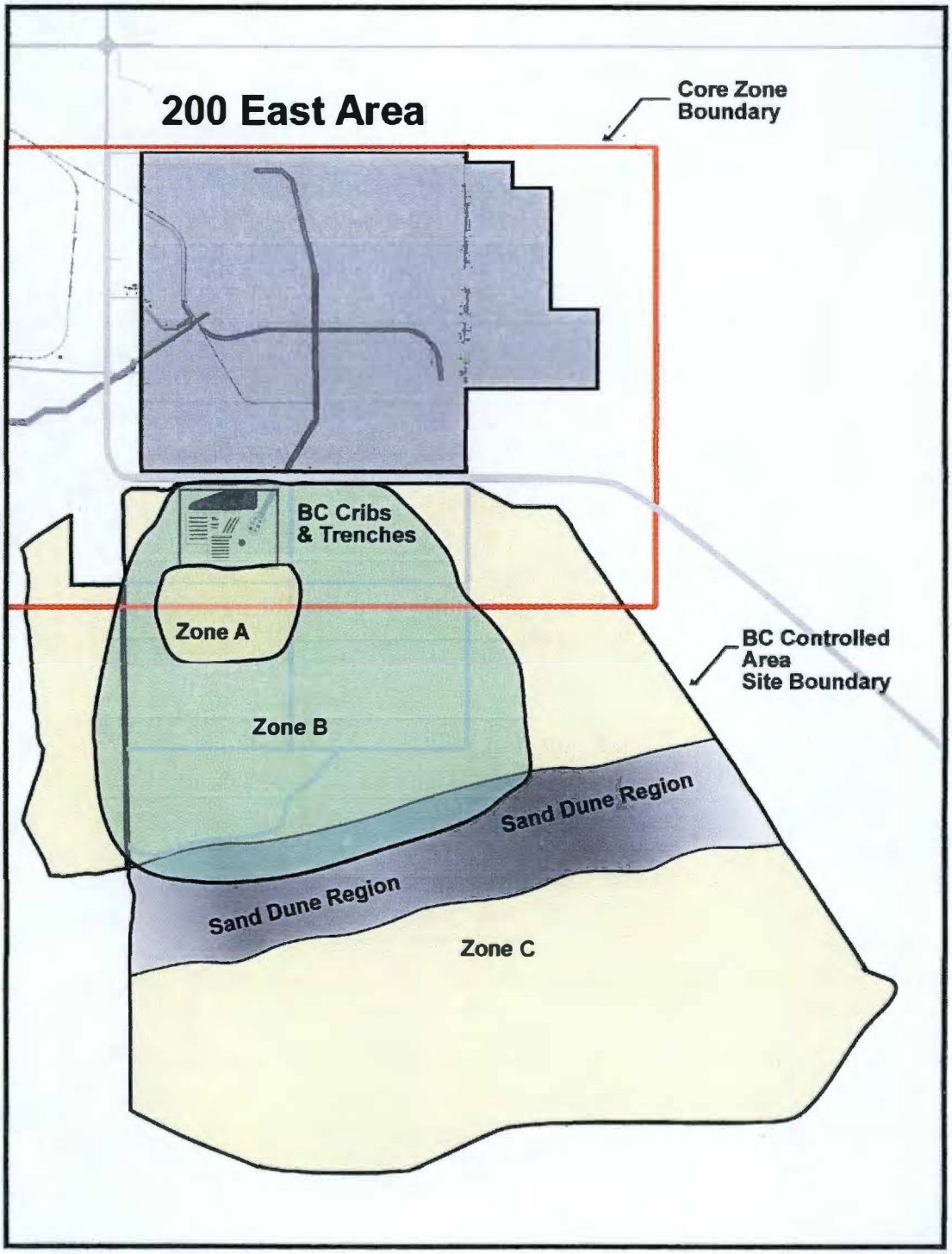
The BC Controlled Area has been spatially delineated into three zones of relative radiation contamination levels (Figure 1-3). These zones are due south of the BC Cribs and Trenches Area and include Zone A, showing the highest contamination levels; Zone B, showing intermediate contamination; and Zone C, showing radiation at levels similar to Hanford Site background. Existing radiological data will be used to define radiological COPECs and resulting radiological analytical suites (WMP-18647, *Historical Site Assessment of the Surface Radioactive Contamination of the BC Controlled Area*). Nonradiological sample data were used to define the nonradiological COPECs (D&D-24693, *Sampling and Analysis Instruction for BC Controlled Area Soil Characterization*).

These zones are based on aerial radiological surveys and on surface radiological surveys documented in the following:

- BHI-01319, 1999, *Data Assessment Report for the Sampling and Analysis Activities Conducted to Support Reposting the 200 B/C Contaminated Area*, Decisional Draft
- WMP-18647, 2004, *Historical Site Assessment of the Surface Radioactive Contamination of the BC Controlled Area*, Rev. 0.

In addition, surface soil and cryptogamic layer samples were collected from the same locations, and the data were reported in BHI-01319. The data showed good correlation between the levels of radionuclides in the soil and the cryptogamic layer. Soil samples were collected at locations of higher deposition based on radiological surveys.

Figure 1-3. Conceptual Site Model Zones within the BC Controlled Area.



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US Ecology key points
⇒ Not a Central Plateau waste site
⇒ Will continue to operate for more than 50 years
Approach
⇒ Evaluate the potential impacts from US Ecology when developing the DQOs for the Central Plateau habitat sampling

US Ecology. The US Ecology site is a commercial low-level radioactive waste disposal site within the boundaries of the Hanford Site. It is a licensed state facility and is not operated or regulated by the U.S. Department of Energy (DOE). Thus, the US Ecology site is not a CERCLA waste site, although it is operated on Federal land that is being leased to the State of Washington. The site has been in operation since 1965 and consists of containerized solid wastes that are buried under a cover of deep fill. The site contains radionuclides and a limited set of nonradioactive constituents.

Because the US Ecology site is not a CERCLA waste site, ecological data collected from the US Ecology site will not be used to support Central Plateau decision making. Furthermore, the US Ecology site is expected to remain operational for another 50 years (until 2056). The site is scheduled for final cleanup action when the lease expires in September 2063, which seems to further limit the utility of sampling current conditions at the US Ecology site and the local environs. As such, sampling is not planned for the US Ecology site in Phase II. It is recognized, however, that the potential exists for contaminants from the US Ecology site to influence surrounding habitat in the Central Plateau. Consequently, existing air monitoring data for the US Ecology site (air monitoring data from the Washington State Department of Health, Pacific Northwest National Laboratory, and other sources) will be evaluated. Such information will help determine if the US Ecology site should be considered in the possible assessment of the Central Plateau habitat areas in Phase III. This evaluation will occur as part of the Phase III DQO activity.

Tank Farms key points
⇒ Managed to minimize biological attraction
⇒ Evaluated under RCRA
Approach
⇒ Not appropriate for ecological sampling at this time
⇒ Integrate EcoDQO approaches into future assessments

Tank Farms. The tank farms are actively managed by the DOE Office of River Protection using herbicides, pesticides, and physical barriers to prevent biological intrusion. There is little ecological habitat within the tank farm areas that would attract biotic colonization, as shown in Figure 1-4.

Figure 1-4. Photograph Illustrating Lack of Habitat at Tank Farm Sites.

However, some biological intruders do get into the tank farms; typically they are captured and disposed of. Tank farm sites are being evaluated using the *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action process. The resulting alternatives almost certainly will change the quality of ecological habitat within the tank farms. The tank farms also are subject to interim stabilization methods that include removing liquids from the tanks and sampling the waste. Until all interim tank remediation is finished, final remedial alternatives will not be evaluated. For these reasons, tank farm sites are not appropriate for ecological sampling at this time. Preliminary biotic assessments are under way, and the methodologies and data resulting from the Central Plateau EcoDQO activities will be available and may be used to help guide future assessments and evaluations of data needs.

West Lake. West Lake's former expanse was largely a result of Plutonium-Uranium Extraction Plant wastewater discharge that elevated the water table. Contaminated media included soil, water, and sediment. A screening-level ecological risk assessment identified surface water as the only medium of concern. Because wastewater discharge has been discontinued in the 200 Areas, the lake has been shrinking in size. The aerial extent of surface water has been observed to be as small as 3 m^2 and as large as hundreds of square meters in 2004 and 2005. Thus, West Lake is dynamic and responds to climatological/seasonal conditions such as spring snow melt. Because West Lake represents a unique and changing ecological feature at the Hanford Site, further data compilation is recommended before Phase III is begun, so that all existing information can be evaluated and the data gaps can be defined. EcoDQOs developed for West Lake in WMP-20570 will be revised upon receiving the most current information. Additional

West Lake key points
⇒ Unique ecology
⇒ Dynamic nature
Approach
⇒ Revise existing DQO with an assessment of available studies

ecological characterization of West Lake will be coordinated with the potential remedial alternatives for West Lake and the associated groundwater OUs.

Spatial Domain Synopsis. A synopsis of the data collection activities and geographic areas addressed in this SAP and the Phase I SAP (DOE-RL-2004-42) is presented in Table 1-1.

Table 1-1. Sampling Activities in the Proposed Investigation Phases, Structured by Study Area and Tier of Data Collection.

Phase	Study Area	Data Collection	
		Tier 1	Tier 2
I and II	Central Plateau waste sites	X	-
	BC Controlled Area	X	-
	Reference sites (bunchgrass and shrub)	X	-
III	Nonoperational (habitat) areas in the Central Plateau	TBD [a]	TBD
	Central Plateau waste sites	-	If needed
	BC Controlled Area	-	If needed [b]
	Reference sites (bunchgrass and shrub)	-	If needed
	West Lake	TBD	TBD
	Additional reference site(s)	TBD	TBD
	200 West Area diffuse carbon tetrachloride plume	TBD	TBD

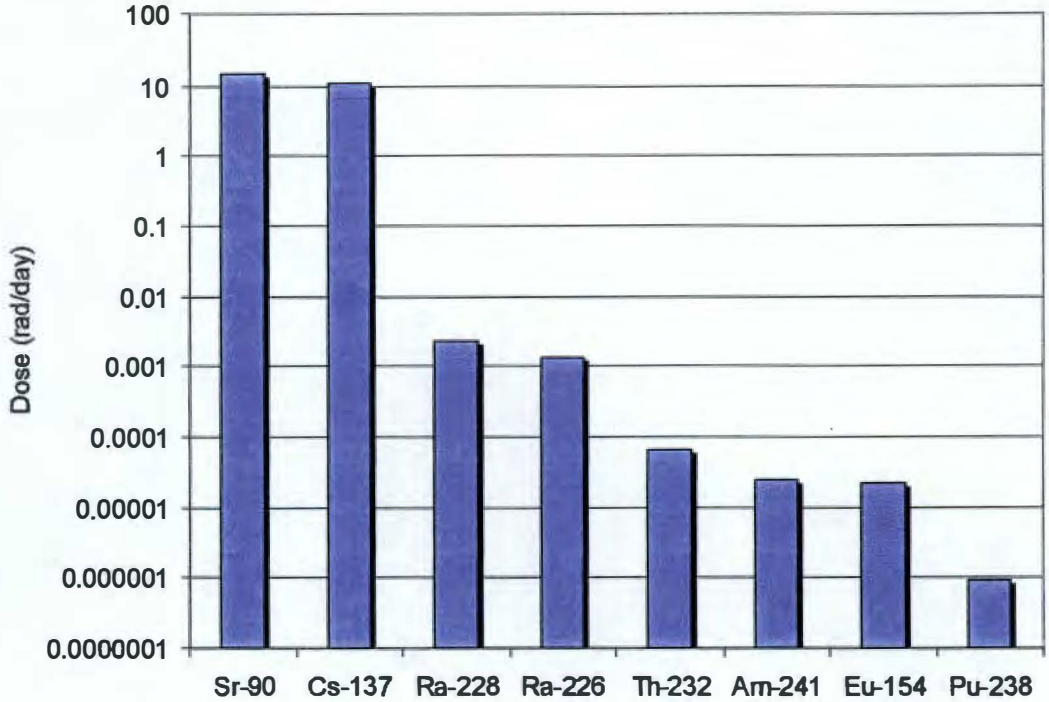
[a] "TBD" or to be determined based on ecological data quality objectives developed for Phase III.
[b] "If needed" determination is based on data quality assessment results from the preceding phase.

1.4 CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

The BC Controlled Area radionuclide COPEC list is based on an evaluation of maximum concentrations of surface soil data from BHI-01319 (Figure 1-5; expressed as dose). The sum of fractions (SOF) for these data is 262 (or equal to dose of 26 rad/day), of which Sr-90 represents 58 percent and Cs-137 is 42 percent; other radionuclides contributed less than 0.001 percent of the SOF. Consequently, Cs-137 and Sr-90 are the radioactive COPECs, and the resulting radionuclide analytical suites are gamma energy analysis and radiostrontium. These and other radiological data are summarized in WMP-18647.

Sampling to identify nonradionuclide COPECs and the resulting analytical suites was performed under the 200-UR-1 OU remedial investigation. This activity sampled areas having the highest contamination levels in Zone A and moderate contamination levels in Zone B. This was based on the understanding that the nonradionuclides coincide with the radionuclides, because the BC Controlled Area contamination was the result of biological discharges from animals that consumed contaminated water and waste material from the BC Cribs and Trenches Area. Zone A sampling was focused on radiological hotspots determined by radiological field measurements. In addition, random soil sampling was performed in both Zone A and Zone B.

Figure 1-5. BC Controlled Area Dose Based on Maximum Surface Soil Radionuclide Concentrations (based on 7 sampling locations in Zone A).



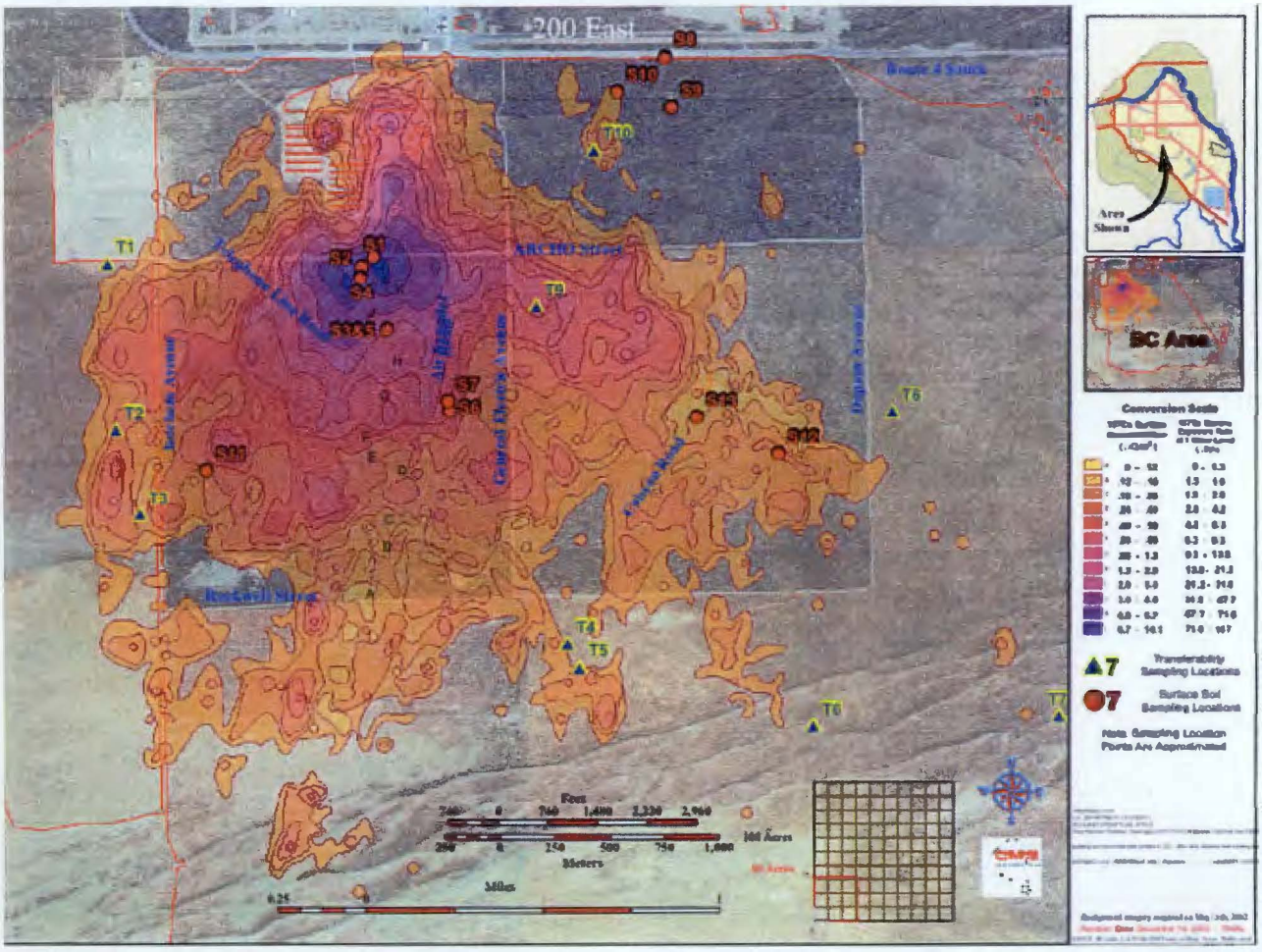
Nonradionuclide analyses on these samples included inductively coupled plasma metals, anions, and PCBs. The analytical results showed that the nonradionuclide constituents were not detected at concentrations above the WAC 173-340-900, "Tables," Table 749-3, ecological screening values, background, or analytical detection limits. Therefore, the nonradionuclides were dropped from further consideration as COPECs in this SAP.

1.5 SITE SELECTION PROCESS

Of the spatial domains considered for sampling in Phase II, only the BC Controlled Area is targeted for field data collection. Three investigation areas will represent the BC Controlled Area: one each in Zones A, B, and C (Figure 1-3). Radiological field data and soil analytical data suggest that the zones are relatively homogeneous with regard to contamination levels. Consequently, one investigation area is appropriate to characterize the ecological effects in each zone.

The radiological results of surface soil samples taken from the top 1 cm of soil are given in BHI-01319. These locations are shown in Figure 1-6. Relative to Figure 1-3, and as shown in Figure 1-6, Zone A may be represented by the sampling points S1-S7, and Zone B may be represented by points S8-S13. The doses based on maximum radionuclide concentrations from Zone A and B sample results were evaluated and, in both cases, Cs-137 and Sr-90 represented greater than 99.9 percent of the radiation dose.

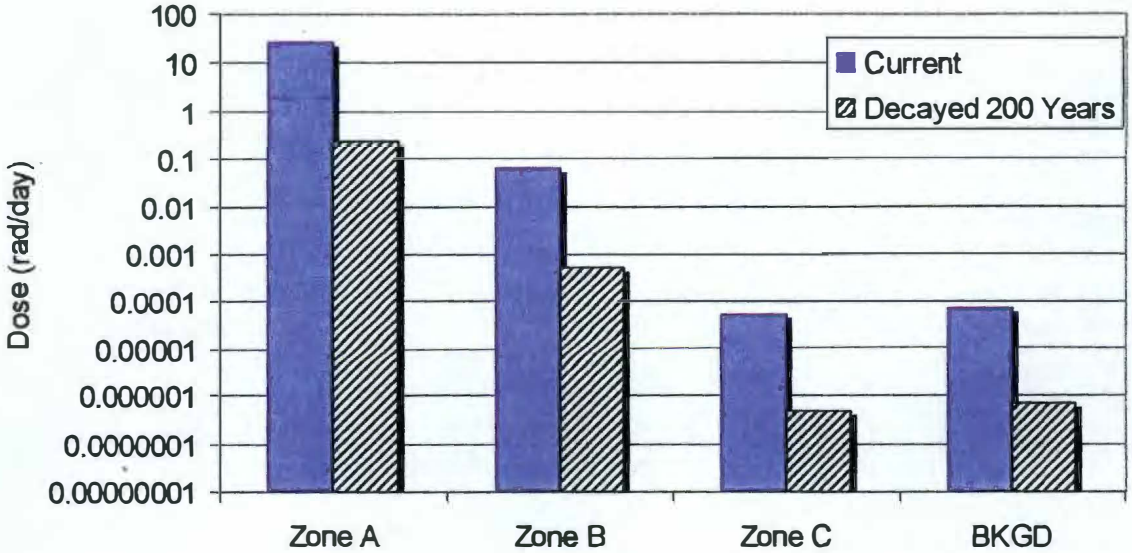
Figure 1-6. Surface Soil Radionuclide Sampling Locations in the BC Controlled Area (WMP-18647).



Zone C may be represented by soil samples collected near the southern boundary of the BC Controlled Area (WHC-EP-0771, *Comparison of Radionuclide Levels in Soil, Sagebrush, Plant Litter, Cryptogams and Small Mammals*), and results from the most representative locations were evaluated (WHC-EP-0771, sampling locations B0-B5). Similar to Zones A and B, cesium and strontium represented 99.8 percent of the Zone C radiation dose. Doses based on Cs-137 and Sr-90 concentrations in each zone are plotted in Figure 1-7.

These soil analytical results are consistent with the aerial radiological surveys showing that Zone A has the highest radioactivity levels, Zone B displays intermediate radioactivity levels, and Zone C has radioactivity levels around background. In addition, the doses remaining after 200 years of radionuclide decay are presented alongside current-day dose for the radioactivity remaining after institutional control of the BC Controlled Area is relinquished.

Figure 1-7. BC Controlled Area Dose by Zone; Current Maximum and Decayed Values for Cesium-137 and Strontium-90 Relative to Background.



The investigation of candidate reference sites for the Phase II sampling considered the fact that the BC Controlled Area, unlike the Phase I waste sites, consists of a large expanse of native steppe habitat dominated by sagebrush, which is located downwind of the revegetated BC Crib and Trenches Area waste sites.

The Phase I SAP and EcoDQO have documented that the reference site should be as ecologically similar as possible to the contaminated sites except for the concentrations of COPECs. COPEC concentrations at the reference site should be consistent with Hanford Site background levels. Because airborne deposition of COPECs is possible, it is advantageous to locate the reference site upwind of the prevailing (northwest) winds and existing waste management facilities. Other factors to consider in selecting and justifying the selection of the reference site are the dominant plant species and cover, soil type and texture, burn history, and elevation. The reference site should match as many of these characteristics as possible while also meeting the primary requirement of having COPEC concentrations at background levels.

Because the Phase I study waste sites had been revegetated with wheatgrass, the Phase I reference site chosen also was a revegetated site, located west-northwest of the 218-W-5 Burial Ground and upwind of all other Central Plateau waste management sites.

However, the Phase II sampling activities require the selection of a reference site that is comparable to the sagebrush habitat that occupies much of the BC Controlled Area. To meet the soil, vegetation, cover, and upwind requirements, a reference site was selected that consists of native shrub-steppe habitat. It is located approximately 1.2 mi further northwest than the Phase I reference site and in the general direction of the Yakima Barricade and Vernita Bridge area. This area represents the northwestern-most (upwind) portion of conterminous, fairly undisturbed sagebrush habitat on the Hanford Site that is a good match to that of the BC Controlled Area and that meets the reference site selection criteria.

1.6 DATA QUALITY OBJECTIVES

The COPECs representing primary radionuclide risk drivers on the Central Plateau are Cs-137 and Sr-90 (WMP-20570), and these same radionuclides are the primary radiological constituents (on a concentration/dose basis) for the BC Controlled Area. Given the similarity of radionuclide COPECs between Phase I and Phase II and the similarity of the BC Controlled Area to habitat in and around the Central Plateau waste sites, the conceptual model, risk questions, assessment endpoints, and measures developed in Phase I (WMP-20570) will be used for the Phase II EcoDQO.

The Phase II EcoDQO builds on the Phase I EcoDQO (WMP-20570) and is focused on ERAGS Steps 3 and 4 (EPA/540/R-97/006). In Step 3, problem formulation establishes the goals, scope, and focus of the baseline ecological risk assessment, and it establishes the conceptual model and specific ecological values to be protected for the Central Plateau. Step 4 establishes the measures used to complete the conceptual model initiated in Step 3 and structures the assessment in the remedial investigation. Steps 3 and 4, respectively, provide the foundation of the ecological risk assessment and the ecological risk assessment's study design; in effect, Steps 3 and 4 are the DQO process for the baseline ecological risk assessment.

As part of the DQO process, the SAP is the basis for establishing the quantity and quality of data needed to support ecological risk management decisions. EPA/600/R-96/055, *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, was used to support the development of this SAP. The DQO process is a strategic planning approach that provides a systematic process for defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application.

This section summarizes the key outputs resulting from ERAGS (EPA/540/R-97/006), which was used to implement the seven-step DQO process. Additional details are provided in the Phase I EcoDQO (WMP-20570) and the Phase II EcoDQO (WMP-25493).

1.6.1 Statement of the Problem

The purpose of the DQO document is to define the scope and data needs to support a baseline ecological risk assessment of the BC Controlled Area. This SAP describes the general approach and data to be collected in Phase II of the phased and tiered approach to characterize ecological risks.

1.6.2 Risk Characterization Questions

A full complement of risk questions was developed for all the possible measures considered in this phased and tiered approach to characterize ecological risks. The following risk questions are relevant to the data being collected in Phase II.

- For radionuclide COPECs: Is the contribution to the SOF based on mean concentrations greater than 1 and also greater than the SOF based on mean concentrations for the reference site or greater than the SOF based on background mean concentrations?

- Do mean COPEC concentrations in the receptor increase compared to mean COPEC concentrations in the reference site receptors or along a gradient with increasing COPEC concentrations greater than published levels associated with toxicity?

- Do mean COPEC concentrations in the receptor diet increase from those of the reference site or along a gradient with increasing COPEC concentrations greater than toxicity reference value?

The investigation area of 1 hectare (ha) was selected as an appropriate scale over which to evaluate the measures considered in this plan. The detailed rationale was provided in the Phase I EcoDQO (WMP-20570). The home range (most typically representing the foraging area) and the median dispersal distance were evaluated to identify 1 ha as an appropriate spatial scale to evaluate ecological risk, particularly for middle trophic-level receptors. The mean over this 1 ha investigation area was the best estimate of the representative COPEC concentrations in soil and the concentration of COPECs in biota. The assumption is that the animals are resident to the investigation areas, because transients likely would experience different concentrations of COPECs. This problem is partly addressed by collecting animals from the central portion of the investigation area and therefore minimizing the chance of collecting transients. Issues associated with potentially collecting transient animals is not expected to be a significant problem for the BC Controlled Area investigation areas, because the investigation zones are much larger than 1 ha and are relatively homogenous in contaminant concentration and ecological habitat.

These questions will be evaluated using various exploratory data analysis tools. These tools include box plots that are used to compare concentrations between data groups and scatter plots that are used to visually evaluate data for trends. These graphical tools will be supported by statistical tests, as appropriate, and will be based on the underlying distributions of the data (e.g., normal or lognormal). Probability plots and histograms coupled with statistical tests can help to determine the underlying statistical distribution of the data.

1.6.3 Limits of Decision Error

A fundamental aspect of this assessment, and of ecological risk assessments in general (Fairbrother 2003, "Lines of Evidence in Wildlife Risk Assessments"), is to find evidence of exposure and effects. Multiple lines of evidence are being evaluated using a weight- (or strength-) of-evidence approach (Menzie et al. 1996, "A Weight-of-Evidence Approach for Evaluating Ecological Risks: Massachusetts Weight-of-Evidence Workshop"), and this is particularly true for the middle trophic-level birds and mammals; e.g., one set of lines of evidence involves tissue COPEC concentrations for three different middle trophic-level taxa (invertebrates, lizards, and small mammals) for multiple COPECs at all investigation and reference areas. The middle trophic-level species are the focus of this assessment, because they have the potential to bioaccumulate contaminants, and their spatial scales (e.g., home range) match the scale of investigation areas better than those of the higher trophic-level species.

It is important to note that evaluation of uncertainty in ecological risk assessments requires more than simply calculating confidence limits on means used in exposure concentrations. Given the complexity of interpreting ecological data, professional judgment was used to structure the study design for this ecological risk assessment. A judgmental design is based on the reliability of the

experts who are knowledgeable about the Central Plateau ecosystem. While limits on decision errors will be qualitative, some aspects of the study design will benefit from randomization (e.g., selection of some sample locations). The design also will use data generated to make more quantitative assessments of the sample coverage needed to characterize the 0- to 15 cm (6-in.) surface soil interval. Subsequent phases may be more amenable to statistical sampling design options as relevant data become available on which to develop a quantitative design.

1.6.4 Study Design Summary

A synopsis of the proposed study design is provided in Table 1-2 and shows how the various data types relate to assessment endpoints, the population, the key features of the study design, and the basis for the design element.

For example, field verification and reconnaissance are performed to assess vegetation and habitat on investigation areas and reference sites for applicability of the sites and future comparability of the proposed wildlife field measures. All aspects of the study design are subject to field verification, which may require selecting alternate measures for an assessment endpoint or other modifications to the study design (e.g., plot size, trapping density). The study design builds on the Phase I EcoDQO described in detail in WMP-20570. Phasing also allows for testing aspects of the conceptual model that were used to develop the overall design. One key aspect of the conceptual model is the list of radionuclide COPECs, which is based on existing soil-sampling data.

Table 1-2. Phase II Sampling Design Summary Table Linking Data to Risk Questions and Assessment Endpoints.

Data Type	Assessment Endpoint and Attribute	Measures	Population	Key Features of Design	Basis for Study Design
Reconnaissance and field verification	Herbivorous, insectivorous, and omnivorous bird and mammal, insectivorous reptile, and carnivorous bird and mammal attributes based on field measures	Basis for comparing all field-related measures in future phases of the sampling and analysis plan	BC Controlled Area and reference site	All sites will be classified according to vegetation and habitat status. Line transects will be used to assess cover of dominant plants, bare ground, and cryptogams. Reconnaissance also will help to determine where and when to sample.	Field verification necessary to assess the comparability of habitat types among investigation areas and reference areas
Field radiological data	Information used to guide sampling and test conceptual model of contaminant transport	Radiological COPECs in soil and radiological COPECs in plant tissue	BC Controlled Area soils, plants, ant mounds, burrow spoil material	Used before sampling the soil	Supports testing of the conceptual model of biological transport
Surface soil sampling	Herbivorous, insectivorous, and omnivorous bird and mammal, and carnivorous bird and mammal attributes of survival, growth, and reproduction	COPECs in soil	BC Controlled Area and reference site soils	Multi-increment samples representing 0-15 cm (0-6 in.)	Multi-increment samples for estimate of average exposure over investigation area
Biota sampling	Insectivorous and omnivorous mammal, insectivorous reptile, and carnivorous mammal attributes of survival, growth, and reproduction	COPECs in macroinvertebrates, small mammals, and lizards	Invertebrates caught in pitfall traps, small mammals, lizards/reptiles	For invertebrates, composite of pitfall trap contents. For lizards/reptiles, individual animals. For mammals, individual animals	Samples of insects, reptiles, and small mammals provide information for comparison to literature information on toxic body burdens and for contaminant loading in middle trophic levels. to be used in modeling upper trophic-level exposure
Literature reviews on COPEC concentrations or other information relevant to risk characterization	All assessment endpoints and attributes for which information can be gathered	Compilation of existing site-specific or relevant data on COPEC concentrations or other information relevant to risk characterization	Relevant literature or unpublished but documented data sources	Consult with subject matter experts to identify relevant published or documented in-house information	Make use of existing Hanford Site or other relevant data on COPEC concentrations and other information relevant to risk characterization that will support and aid in the interpretation of other data
Exposure modeling parameters	Herbivorous, insectivorous, and omnivorous bird and mammal, and carnivorous bird and mammal attributes of survival, growth, and reproduction.	Uses data on COPECs in soil and in macro-invertebrates, small mammals, and lizards	BC Controlled Area and reference site soils and biotic tissues	Use of Hanford Site-specific uptake factors for soil-to-prey reduces uncertainty in use of non-site-specific literature values	Exposure modeling especially useful in assessing endpoints for which field measures would not be resource effective

COPEC = contaminant of potential ecological concern.

The nonradionuclide COPEC list also is derived from empirical data, in this case the BC Controlled Area characterization performed in March 2005. The results of that activity showed that the nonradionuclide constituents were not detected at concentrations above the WAC 173-340-900, Table 749-3, ecological screening values, background, or analytical detection limits and were dropped from further consideration as COPECs.

An important component of the study design is field reconnaissance and verification. This activity will support all field measures proposed in the study design and will provide a basis for documenting inclusion/exclusion of investigation areas selected as ecological study plots and appropriate reference sites. Radiological field data also will be acquired and used to assist with investigation area location selection and to test the conceptual model of contaminant movement driven by biological uptake and transport. Also, a literature review of information related to the Hanford Site will be used to augment the results of data collection activities in the assessment. For example, toxicity reference values for upper trophic-level mammals and birds will be obtained from literature for representative carnivorous mammals and birds of the Central Plateau. These toxicity reference values will be used in exposure modeling, along with site-specific estimates of contaminant levels, in the prey of Central Plateau upper trophic levels.

The design uses multi-increment soil samples to characterize concentrations of COPECs in surface soil. This methodology emphasizes obtaining a representative sample of the particle size fraction of interest. In this case, 2 mm was selected, because this is the typical definition of soil-sized particles. Another specification for the multi-increment sampling design is the fundamental error term. A value of 10 percent was selected, which corresponds to a standard error of 10 percent on the mean concentration. This value was selected such that the fundamental error would be low relative to other sources of error (i.e., analytical measurement error typically is 30 percent).

The number of biota samples is based on the availability of these organisms for sampling and the minimum number of animals or replicates needed for making statistical inferences. Six lizards or mammals are targeted, because it is believed that this is a reasonable number to collect from a 1 ha investigation area, and six values provides enough information to construct a box plot and also provides some statistical power for detecting differences between sites. Three replicate invertebrate measurements per investigation area provides the minimum number to determine differences in concentrations between investigation areas. The number of biota samples is sufficient for calculating the mean and standard deviation. For evaluating bioaccumulation, these tissue concentration data can be used to develop bioaccumulation models based on the soil concentrations measured in the 11 Phase I and Phase II investigation areas.

Radionuclide toxicity data are expressed as dose limits (0.1 rad/day), which were translated to radionuclide-specific concentrations (picocuries per gram) using DOE/EH-0676, *RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation*, and DOE-STD-1153-2002, *A Graded Approach For Evaluating Radiation Doses To Aquatic And Terrestrial Biota*. Radionuclide analytes were identified as COPECs if they significantly contributed to the sum of fractions. Chemical constituents are not considered as COPECs in this SAP, as discussed in Section 1.4.

Another important component of the conceptual model is the primary exposure medium, including the depth of biological activity. Air, groundwater, deep soil, shallow soil, and biota

were media considered for sampling, based on the general conceptual exposure model developed for the Phase I EcoDQO (WMP-20570). Inhalation of surface air is not typically a risk driver in ecological assessments. Groundwater is approximately 61 m (200 ft) below ground surface and thus is an unlikely exposure medium under current conditions. Hypothetical future groundwater-use scenarios cannot be evaluated by ecological data collected in this plan. Data suggest that surface soil, in particular the first foot, is important as an exposure medium for direct contact with wildlife, root uptake, and animal burrowing.

In the mid-1950s, an experimental situation was set up that is analogous to the contaminant dispersal that occurred at the BC Controlled Area. This constituted the Hanford Site's strontium gardens research, wherein Cs-137 and Sr-90 were applied to the soil surface on plots near the 100-F Reactor (Cline and Rickard 1972, "Radioactive Strontium and Cesium in Cultivated and Abandoned Field Plots"). This experimental application represents approximately the same time interval as that when radiological contaminants were dispersed from the BC Cribs and Trenches Area into what is now the BC Controlled Area. Cline (1981) and Cline and Cadwell (1984) showed that 70 percent of the surface-applied Cs-137 was remaining in the top inch after 8 yr and that the peak in Sr-90 activity was at 15 cm (6 in.) below the ground surface after 25 yr. The authors speculated that surface-applied radionuclides would remain homogeneously distributed in the top foot and would decrease over time through radiological decay. Thus, surface samples (of the first 15 cm [6 in.]) will capture representative radionuclide levels in BC Controlled Area soils and can be collected along with specific biological samples to test for COPEC uptake.

Collecting surface soil samples for the initial data collection activities has important practical advantages. Methods for collecting surface soil samples are less intrusive than those needed for deeper soil characterization and therefore minimize the impacts of data collection on the shrub-steppe ecosystem. The conceptual model of the possible upward mobility of buried waste through animal burrowing and plant uptake also will be initially assessed, using field radiological data.

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2.0 QUALITY ASSURANCE PROJECT PLAN

The QAPjP establishes the quality requirements for environmental data collection, including sampling, field measurements, and laboratory analysis. This QAPjP complies with the requirements of the following:

- DOE O 414.1A, Quality Assurance
- 10 CFR 830, Subpart A, "Quality Assurance Requirements"
- EPA/240/B-01/003, EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, EPA QA/R-5, as amended.

The following sections describe the quality requirements and controls applicable to this investigation. Correlation between EPA/240/B-01/003 (QA/R-5) requirements and information provided in the 200 Areas QAPjP and/or this chapter is provided in Table 2-1.

Table 2-1. Quality Assurance Crosswalk. (2 Pages)

EPA QA/R-5 Criteria	EPA QA/R-5 Title	Reference Section
Project Management	Project/Task Organization	2.1 and 2.1.1
	Problem Definition and Background	1.1, 1.2, 1.6.1
	Project Task Description	1.0, 1.1, 2.0
	Quality Objectives and Criteria	1.6, 2.2, 2.3
	Special Training/Certification	2.1.2
	Documents and Records	2.1.1.2, 2.7, and 2.9
Data Generation and Acquisition	Sample Process Design	3.0 and 3.2
	Sampling Methods	2.10, 3.3, 3.4, Tables 3-1, 3-2
	Sample Handling and Custody	2.4, 2.10.4, 2.10.5, Tables 2-3 through 2-6, Section 3.5
	Analytical Methods	2.3, Table 2-2, 2.7.1
	Quality Control	2.2 and 2.3
	Instrument/Equipment Testing, Inspection and Maintenance	2.3.1 and 2.10.7
	Instrument/Equipment Calibration and Frequency	2.3.1, 2.5, 2.8
	Inspection and Acceptance of supplies and consumables	2.3.1
	Non Direct Measurement	1.1, Table 1-2
	Data Management	2.7

Table 2-1. Quality Assurance Crosswalk. (2 Pages)

EPA QA/R-5 Criteria	EPA QA/R-5 Title	Reference Section
Assessment and Oversight	Assessment and Response Actions	2.1.1 and 2.6
	Reports to Management	2.6
Data Validation and Usability	Data Review, Verification and Validation	2.8
	Verification and Validation Methods	2.8
	Reconciliation with User Requirements	2.7 and 2.9

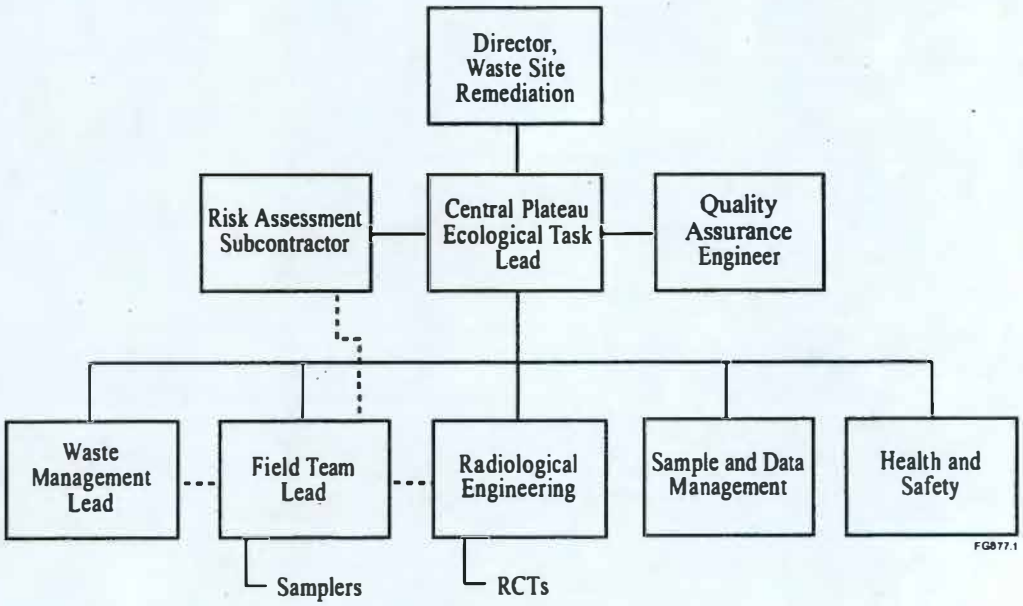
EPA = U.S. Environmental Protection Agency

2.1 PROJECT MANAGEMENT

This section addresses the basic areas of project management, and it ensures that the project has a defined goal, that the participants understand the goal and approach to be used, and that the planned outputs have been appropriately documented.

2.1.1 Project/Task Organization

Fluor Hanford, Inc. (FH), or its approved subcontractor, will be responsible for collecting, packaging, and shipping soil and biota samples to the laboratory. The project organization is described in the subsections that follow and is shown graphically below.



2.1.1.1 Director, Waste Site Remediation

The Director of Waste Site Remediation provides oversight for all activities and coordinates with the DOE Richland Operations Office (RL), regulators, and FH management in support of ecological sampling activities. In addition, support is provided to the Central Plateau Ecological Task Lead to ensure that the work is performed safely and cost-effectively.

2.1.1.2 Central Plateau Ecological Task Lead

The Central Plateau Ecological Task Lead is responsible for direct management of sampling documents and requirements, field activities, and subcontracted tasks. The Ecological Task Lead ensures that the Field Team Lead, Samplers, and others responsible for implementation of this SAP and QAPjP are provided with current copies of this document and any revisions thereto. The Ecological Task Lead also works closely with the Quality Assurance and Health and Safety organizations and the Field Team Lead to integrate these and the other lead disciplines in planning and implementing the workscope. The Ecological Task Lead also coordinates with, and reports to RL, the regulators, and FH management on all ecological sampling activities.

2.1.1.3 Risk Assessment Subcontractor

The Risk Assessment Subcontractor is responsible for the performance of U.S. Environmental Protection Agency's 8-step ERAGS process that, for this project, results in the development of the ecological sampling design. Responsibilities include development and documentation of the ecological sampling DQOs and sampling design and associated presentations and the resolution of technical issues.

2.1.1.4 Quality Assurance Engineer

The Quality Assurance Engineer is matrixed to the Central Plateau Ecological Task Lead and is responsible for quality assurance (QA) issues on the project. Responsibilities include oversight of implementation of the project QA requirements; review of project documents, including DQO summary reports, SAPs, and the QAPjP; and participation in QA assessments on sample collection and analysis activities, as appropriate.

2.1.1.5 Waste Management Lead

The Waste Management Lead communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner. Other responsibilities include identifying waste management sampling/characterization requirements to ensure regulatory compliance and interpreting the characterization data to generate waste designations, profiles, and other documents that confirm compliance with waste acceptance criteria.

2.1.1.6 Field Team Lead

The Field Team Lead has the overall responsibility for the planning, coordination, and execution of field characterization activities. Specific responsibilities include converting the sampling

design requirements into field task instructions that provide specific direction for field activities. Responsibilities also include directing training, mock-ups, and practice sessions with field personnel to ensure that the sampling design is understood and can be performed as specified. The Field Team Lead communicates with the Central Plateau Ecological Task Lead and the Risk Assessment Subcontractor to identify field constraints that could affect the sampling design. In addition, the Field Team Lead directs the procurement and installation of materials and equipment needed to support the field work.

2.1.1.7 Radiological Engineering

Radiological Engineering is responsible for the radiological engineering and health physics support within the project. Specific responsibilities include conducting as-low-as-reasonably-achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for all work planning. In addition, radiological hazards are identified and appropriate controls are implemented to maintain worker exposures to hazards at ALARA levels. Radiological Engineering interfaces with the project health and safety representative and plans and directs radiological control technician (RCT) support for all activities.

2.1.1.8 Sample and Data Management

The Sample and Data Management organization selects the laboratories that perform the analyses. This organization also ensures that the laboratories conform to Hanford Site internal laboratory quality assurance requirements, or their equivalent, as approved by RL, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology. Sample and Data Management receives the analytical data from the laboratories, performs the data entry into the *Hanford Environmental Information System* (HEIS), and arranges for data validation.

2.1.1.9 Health and Safety

The Health and Safety organization responsibilities include coordination of industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by Federal regulation or by internal FH work requirements. In addition, assistance is provided to project personnel in complying with applicable health and safety standards and requirements. Personnel protective clothing requirements are coordinated with Radiological Engineering.

2.1.2 Special Training Requirements/Certification

Typical training or certification requirements have been instituted by the FH management team to meet training requirements imposed by the Project Hanford Management Contract, regulations, DOE orders, DOE contractor requirements documents, American National Standards Institute/American Society of Mechanical Engineers, *Washington Administrative Code*, etc. For example:

- Training or certification requirements needed by sampling personnel will be in accordance with Site analytical requirements.

The environmental safety and health training program provides workers with the knowledge and skills necessary to safely execute assigned duties. Field personnel typically will have completed the following training before starting work:

- Occupational Safety and Health Administration 40-hour hazardous waste worker training and supervised 24-hour hazardous waste site experience
- 8-hour hazardous waste worker refresher training (as required)
- Hanford general employee radiation training
- Radiological worker training.

A graded approach is used to ensure that workers receive a level of training that is commensurate with their responsibilities and that complies with applicable DOE orders and government regulations. Specialized employee training includes prejob briefings, on-the-job training, emergency preparedness, plan of the day, and facility/worksite orientations.

2.2 FIELD QUALITY CONTROL

Field quality control (QC) samples will be collected to evaluate the potential for cross-contamination and laboratory performance. Field QC for sampling in the Central Plateau will require the collection of field duplicates and equipment blanks. The QC samples and the required frequency for collection are described in this section.

2.2.1 Field Replicates

Field replicate samples are used to evaluate laboratory consistency and the precision of field sampling methods. Field replicate samples are applicable to soil, but are not applicable to biota samples, because the latter are independent units. Because all soil samples will be multi-increment samples, the field replicates will be collected as two additional multi-increment samples in one investigation area; i.e., a total of three multi-increment samples will be collected from the site targeted for field QC. The field replicate samples shall be retrieved from the same depth interval as the primary multi-increment sample but at additional randomly-selected locations.

2.2.2 Equipment Blanks

Equipment blanks are collected for any soil-sampling device that is reused. Biota will be rinsed of external soil before radiological analysis, and thus any bias associated with the trap or other collection device is not relevant. Equipment blanks will be collected from a minimum of 5 percent of the total collected soil samples, or one equipment blank for every 20 samples (whichever is greater) and will be used to verify the adequacy of sampling equipment decontamination. The field team leader may request that additional equipment blanks be taken. Equipment blanks will consist of silica sand poured over the decontaminated sampling

equipment and placed in containers, as identified on the project Sampling Authorization Form.

Equipment blanks will be analyzed for the following, as appropriate:

- Cs-137
- Sr-90
- Gross alpha and beta/gamma contamination levels.

These analytes are considered to be the best indicators of decontamination effectiveness.

2.2.3 Prevention of Cross-Contamination

Special care should be taken to prevent cross-contamination of soil samples to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events.

2.3 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

Quality objectives and criteria for soil and biota measurement data are presented in Table 2-2 for radiological analytes. The detection limits are based on calculations presented in WMP-20570. The ability to meet practical quantitation limits is dependant on the amount of sample obtained (especially biota) and matrix interferences.

2.3.1 Measurement and Testing Equipment

Measurement and testing equipment used in the field or in the laboratory that directly affects the quality of analytical data will be subject to preventive maintenance measures to ensure minimization of measurement system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (such as parts lists and documentation of routine maintenance) will be included in the individual laboratory and the onsite organization QA plan or operating procedures (as appropriate). Calibration of laboratory instruments will be performed in a manner consistent with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, as amended, or with auditable DOE Hanford Site and contractual requirements. Calibration of radiological field instruments is discussed in Section 2.8.

Table 2-2. Analytical Performance Requirements.

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology	Units	Detection Limit Requirement (PQL) [a]	Matrix Specific Target Required Quantitation Limits for Ecological Receptors			Precision Soil and Biota	Accuracy Soil and Biota
					Soil	Vertebrate tissues (fresh wt)	Invertebrate tissues (fresh wt)		
Cesium-137	10045-97-3	GEA	pCi/g	0.1	20.8	2290	2290	±30%	70-130% [b]
Strontium-90	Rad-Sr	Total radioactive strontium – GPC	pCi/g	1	22.5	1710	1710	±30%	70-130%[d]

[a] The ability to meet PQLs is dependant on the amount of sample obtained (e.g., especially biota) and matrix interferences.
[b] Accuracy criteria for associated batch laboratory control sample percent recoveries. Except for GEA, additional analysis-specific evaluations also are performed for tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.

GEA = gamma energy analysis.
GPC = gas proportional counter
PQL = practical quantitation limit.

Consumables, supplies, and reagents will be reviewed per SW-846 requirements and will be appropriate for their use. Note that contamination is monitored by the QC samples discussed in Section 2.3.3.

2.3.2 Laboratory Sample Custody

Sample custody during laboratory analysis will be addressed in the applicable laboratory standard operating procedures. Laboratory custody procedures will ensure the maintenance of sample integrity and identification throughout the analytical process.

2.3.3 Quality Assurance Objective

The QA objective of this plan is to develop implementation guidance that will provide data of known and appropriate quality. Data quality is assessed by representativeness, comparability, accuracy, precision, and completeness. The applicable QC guidelines, quantitative target limits, and levels of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical method. Each of these is addressed below.

2.3.3.1 Representativeness

Representativeness is a measure of how closely the results reflect the actual concentration and distribution of the radiological constituents in the matrix sampled. Sampling plan design, sampling techniques, and sample handling protocols (e.g., storage, preservation, transportation) have been developed and are discussed in subsequent sections of this document. The documentation will establish that protocols have been followed and will ensure sample identification and integrity.

2.3.3.2 Comparability

Comparability expresses the confidence with which one data set can be compared to another. Data comparability will be maintained using standard procedures, consistent methods, and consistent units. Table 2-2 lists applicable fixed laboratory methods for analytes and target detection limits. Actual detection limits will depend on the sample matrix and the sample quantity available. Data will be reported as defined for specific samples.

2.3.3.3 Accuracy

Accuracy is an assessment of the closeness of the measured value to the true value. Radionuclide measurements that require chemical separations use this technique to measure method performance. For radionuclide measurements that are analyzed by gamma spectroscopy, laboratories typically compare results of blind audit samples against known standards to establish accuracy. Validity of calibrations are evaluated by comparing results from the measurement of a standard to known values and/or by generation of in-house statistical limits based on three standard deviations (+/- 3s). Table 2-2 lists the accuracy provided for fixed laboratory analyses for the project.

2.3.3.4 Precision

Precision is a measure of the data spread when more than one measurement has been taken on the same sample. Precision can be expressed as the relative percent difference for duplicate measurements or relative standard deviation for triplicates. Analytical precision for fixed laboratory analyses are listed in Table 2-2.

2.3.3.5 Completeness

Completeness is a measure of the amount of valid data obtained from the analytical measurement process and the complete implementation of defined field procedures.

2.3.3.6 Detection Limits

Detection limits are functions of the analytical method used to provide the data and the quantity of the sample available for analyses.

2.3.4 Laboratory Quality Control

Instead of laboratory duplicates, triplicate samples will be analyzed. Two additional laboratory QC samples will be analyzed from the primary sample from the investigation area selected for field QC (field QC/triplicates are discussed in Section 2.2.1). This will result in triplicate laboratory analyses for one sample.

The laboratory method blanks and laboratory control sample/blank spike are defined in Chapter 1 of SW-846 and will be run at the frequency specified in Chapter 1 of SW-846. Instead of laboratory duplicates, triplicates will be analyzed, as previously discussed.

2.4 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIMES

Soil sample preservation, containers, and holding times for the radiological analytes of interest and physical property tests are presented in Table 2-3. Requirements for biological samples are provided in Tables 2-4 through 2-6. Final sample collection requirements will be identified on the Sampling Analysis Form.

Table 2-3. Sample Preservation, Container, and Holding Times for Soil Samples.

Priority	Analytes	Container		Volume	Preservation	Packing Requirements	Holding Time
		Number	Type				
1	Gamma spectroscopy	1	Plastic	500 g	None	None	NA
2	Radiogenic strontium	1	Plastic	[a]	None	None	NA

[a] The 500 g sample is sufficient to meet the needs of all radionuclide suites.

NA = not applicable.

Table 2-4. Sample Preservation, Container, and Holding Times for Invertebrate Samples.

Priority	Analytes	Container		Volume [a]	Preservation	Packing Requirements	Holding Time
		Number	Type				
1	Gamma spectroscopy	1	Plastic	TBD	None	None	N/A
2	Radiogenic strontium	1	Plastic	TBD	None	None	N/A

[a] Optimal volumes, which may be adjusted downward to accommodate the possibility of small sample recoveries. Minimum sample size will be defined in the Sampling Authorization Form.
N/A = not applicable.
TBD = to be determined.

Table 2-5. Sample Preservation, Container, and Holding Times for Small Mammal Samples.

Priority	Analytes	Container		Volume [a]	Preservation	Packing Requirements	Holding Time
		Number	Type				
1	Gamma spectroscopy	1	Plastic	TBD	None	None	N/A
2	Radiogenic strontium	1	Plastic	TBD	None	None	N/A

[a] Optimal volumes, which may be adjusted downward to accommodate the possibility of small sample recoveries. Minimum sample size will be defined in the Sampling Authorization Form.
N/A = not applicable.
TBD = to be determined.

Table 2-6. Sample Preservation, Container, and Holding Times for Lizard Samples.

Priority	Analytes	Container		Volume[a]	Preservation	Packing Requirements	Holding Time
		Number	Type				
1	Gamma spectroscopy	1	Plastic	TBD	None	None	N/A
2	Radiogenic strontium	1	Plastic	TBD	None	None	N/A

[a] Optimal volumes, which may be adjusted downward to accommodate the possibility of small sample recoveries. Minimum sample size will be defined in the Sampling Authorization Form.
N/A = not applicable.
TBD = to be determined.

2.5 ONSITE MEASUREMENTS QUALITY CONTROL

The collection of QC samples for onsite measurement QC is not applicable to the field-screening techniques described in this SAP. Field-screening instrumentation will be calibrated and controlled according to Sections 2.7 and 2.8, as applicable.

2.6 ASSESSMENT/OVERSIGHT

Routine evaluation of data quality described for this project will be documented and filed along with the data in the project file.

2.6.1 Assessments and Response Action

The FH Regulatory Compliance group may conduct random surveillance and assessments to verify compliance with the requirements outlined in this SAP, project work packages, the QAPjP, procedures, and regulatory requirements.

Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. Plateau Projects Quality Assurance coordinates the corrective actions/deficiencies in accordance with the FH QA program. When appropriate, corrective actions will be taken by the Central Plateau Ecological Task Lead.

2.6.2 Reports to Management

Management will be made aware of all deficiencies identified by self-assessments. Identified deficiencies will be reported to the Fluor Hanford Director, Waste Site Remediation, as appropriate.

2.7 DATA MANAGEMENT

Ecological and analytical data resulting from the implementation of this QAPjP will be managed and stored in accordance with the applicable programmatic requirements governing data management procedures. At the direction of the task lead, all analytical data packages will be subject to final technical review by qualified personnel before they are submitted to the regulatory agencies or included in reports. Electronic data access, when appropriate, will be via a database (e.g., HEIS or a project-specific database). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement (Ecology et al. 1989).

Planning for sample collection and analysis will be in accordance with the programmatic requirements governing fixed laboratory sample collection activities, as discussed in the sample team's procedures. In the event that specific procedures do not exist for a particular work evolution, or it is determined that additional guidance to complete certain tasks is needed, a work package will be developed to adequately control the activities, as appropriate. Examples of the sample team's requirements include activities associated with the following:

- Chain of custody/sample analysis requests
- Project and sample identification for sampling services
- Control of certificates of analysis
- Logbooks, checklists
- Sample packaging and shipping.

Approved work control packages and procedures will be used to document radiological measurements when this SAP is implemented. Examples of the types of documentation for field radiological data include the following:

- Instructions regarding the minimum requirements for documenting radiological controls information as per 10 CFR 835, "Occupational Radiation Protection"

- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of FH radiological records
- The minimum standards and practices necessary for preparing, performing, and retaining radiological-related records
- The indoctrination of personnel on the development and implementation of sample plans
- The requirements associated with preparing and transporting regulated material.

Ecological data will be cross referenced to the analytical data and radiation measurements to facilitate interpreting the investigation results. Units for analytical sample results for biological tissues will be explicit in terms of fresh weight and dry weight measurements.

2.7.1 Resolution of Analytical System Errors

Errors reported by the laboratories are reported to the Sample Management Project Coordinator, who initiates a Sample Disposition Record in accordance with FH procedures. This process is used to document analytical errors and to establish resolution with the project task lead. In addition, the FH QA Engineer receives quarterly reports that provide summaries and summary statistics of the analytical errors.

2.8 VALIDATION AND VERIFICATION REQUIREMENT

Completed data packages will be validated by qualified FH Sample and Data Management personnel or by a qualified independent contractor. Validation will consist of verifying required deliverables, requested versus reported analyses, and transcription errors. Validation also will include evaluating and qualifying the results, based on holding times, method blanks, laboratory control samples, laboratory duplicates, and chemical and tracer recoveries, as appropriate. No other validation or calculation checks will be performed. At least 5 percent of all data types will be validated. All data, except "R" qualified or rejected data, will be used.

A data validation package will be generated for at least one of the hectare plots sampled in the BC Controlled Area. Validation requirements identified in this section are consistent with Level C validation, as defined in data validation procedures. No validation for physical property data will be performed.

Formal data validation will not be performed on field-screening analytical results. Field QA/QC will be reviewed to ensure that the data are useable. Field instrumentation, calibration, and QA checks will be performed in accordance with the following.

- Calibration of radiological field instruments on the Hanford Site is performed under contract by Pacific Northwest National Laboratory (PNNL) as specified in PNNL program documentation.

- Daily calibration checks will be performed and documented for each instrument used to characterize areas that are under investigation. These checks will be made on standard materials sufficiently like the matrix under consideration that direct comparison of data can be made. Analysis times will be sufficient to establish detection efficiency and resolution.

The approval of field data collection plans by the Radiological Engineering Manager represents the data validation and usability review for handheld field radiological measurements.

2.9 DATA QUALITY ASSESSMENT

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project DQOs. The U.S. Environmental Protection Agency DQA process, EPA/600/R-96/084, *Guidance for Data Quality Assessment*, identifies five steps for evaluating data generated from this project, as summarized below:

Step 1. Review Data Quality Objectives and Sampling Design. This step requires a comprehensive review of the sampling and analytical requirements outlined in the project-specific DQO summary report and SAP.

Step 2. Conduct a Preliminary Data Review. In this step, a comparison is made between the actual QA/QC achieved (e.g., detection limits, precision, accuracy, completeness) and the requirements determined during the DQO. Any significant deviations will be documented. Basic statistics will be calculated from the analytical data at this point, including an evaluation of the distribution of the data.

Step 3. Select the Data Analyses. Using the data evaluated in Step 2, select appropriate statistical hypothesis tests or graphical data analyses and justify this selection.

Step 4. Verify the Assumptions. Assess the validity of the data analyses by determining if the data support the underlying assumptions necessary for the analyses or if the data set must be modified (e.g., transposed, augmented with additional data) before further analysis. If one or more assumptions is questioned, return to Step 3.

Step 5. Draw Conclusions from the Data. The analyses are applied in this step, and the results will be used to select among four possible outcomes for each COPEC (Figure 2-1).

Implementing the DQA process will require a set of plots and associated data analysis tools that are outlined below. These tools are used to assist in determining the presence of outliers or other anomalous data that might affect statistical results and interpretations. These tools also provide methods for determining differences between potentially impacted and reference areas and for determining if COPECs are bioaccumulating in tissues.

2.9.1 General Plot Descriptions

Exploratory data analysis plots allow visual inspection and summary of the data (Chambers et al., 1983, *Graphical Methods for Data Analysis*). Each plot described below provides a different visual presentation of the distributions of COPECs. The choice of plotting procedure(s) depends on the hypothesis being tested and may include and/or depend on the following:

- The type of difference that is to be displayed, such as an overall shift in data (shift of central location), or
- When the centers are nearly equal, a difference between the upper tails of the two distributions (e.g., elevated concentrations in a small fraction of one distribution).

The plotting method chosen will accommodate characteristics of the data sets (e.g., the rate of detection, censoring) or the amount of overlap or multiplicity of results reported at a few values. Additional details are provided below on the types of plots that may be used.

2.9.1.1 Histograms

Histograms split the full range of results for an analyte into equal-width results classes (intervals). Each interval is represented by a vertical bar, and the height of each bar may depict the number of samples that fall into that results class. The horizontal axis indicates the observed results in the appropriate units. Units are provided with each histogram, and the total number of observations included ("n") is presented in text below the histogram. When separate histograms are presented for different data sets (e.g., site data and background data), the same scale often is used for the axes of both plots to aid comparison.

2.9.1.2 Estimated (Probability) Density Functions

In density functions, the horizontal axis indicates the analyte results in the appropriate units. The curve, or density estimate, is merely a smoothed histogram. As an estimate of a density function, the area under the curve is approximately equal to one. The area under the curve between two possible observed values gives an estimate of the relative frequency for which observations of those magnitudes occur as compared to the other observations within the data set. These density estimates are nonparametric (i.e., they have no shape restriction).

2.9.1.3 Box Plots

Box plots summarize information about the shape and spread of the distribution of results from a data set. Box plots consist of a box, a (median) line across the box, whiskers (lines extended beyond the box and terminated with a perpendicular line segment), and points outside the whiskers. The y-axis displays the observed results of the data in the appropriate units. The area enclosed by the box shows the results range containing the middle half of the data; that is, the lower box edge is at the first or lower quartile of the data (Q1, also called the 25th percentile; 25 percent of the data fall below Q1), and the upper box edge is at the third or upper quartile of the data (Q3, the 75th percentile; 25 percent of the results fall above Q3). The height of the box (the interquartile range, Q3-Q1) is a measure of the spread of the results. The horizontal line

across the box represents the median (50th percentile or second quartile) of the data, a measure of the center of the results distribution. If the median line divides the box into two approximately equal parts, this indicates that the shape of the distribution of results is symmetric; if not, it indicates that the distribution is skewed or nonsymmetric. Frequently, the full set of results are plotted as points overlaying the box plot.

The format for large data sets, or data sets with much redundancy, results in an amount of overlap or multiplicity of results reported at a few values. Within each group (site or background), the points that represent individual observations are spread out laterally to reduce overlap. The random horizontal "jitter" has no significance; it is used strictly to improve the readability of the plot.

Differences between data groups depicted in box plots can be evaluated with parametric (t-test or analysis of variance based on an alpha of 5 percent) methods or with nonparametric methods (Wilcoxon rank sum test or Gehan test). Such tests will be selected based on the underlying statistical distribution of the data.

2.9.1.4 Outlier Box Plots

The purpose of this type of format is to display or draw attention to extreme values (Iglewicz and Hoaglin, 1993, *How to Detect and Handle Outliers*). The upper and lower "fences" enclose a range that extends beyond the box. The length of each fence is a multiple of the interquartile range, K*(Q3-Q1), K=1.5 is a standard choice. The fences are not plotted, per se, in the figure, but are implied by the whiskers. The whiskers (dashed line) extend beyond the box and terminate at "adjacent values". The upper adjacent value is the largest observed result within the upper fence. The lower adjacent value is the smallest observed result within the lower fence. The range enclosed by the fences is the equivalent of a nonparametric confidence interval around the median. Points beyond the whiskers, "outside points" (all points beyond the whiskers are outside the fences), represent data that may be evaluated for their potential to be outliers (extreme or unusual values).

2.9.1.5 Quantile Plots

Quantile plots provide a comparison of different data sets by plotting the results of each group in increasing order and evenly spread out. The y-axis displays the result scale, and the x-axis displays the quantiles (or percentiles) of the data. Each position along the x-axis displays the fraction or percent of the data that falls below the corresponding value. If the x-axis and the y-axis were reversed, the resulting plot would be called a cumulative probability distribution function.

2.9.1.6 Normal Quantile-Quantile Plots (Normal Probability Plot)

The normal quantile-quantile (q-q) plot is a particular type of quantile plot. The data set results are plotted in increasing order and are spread out in a manner that allows comparison of their distribution to that of a theoretical distribution, the standard normal distribution. The quantiles of the data set (y-axis) are plotted against the quantiles for a standard normal (x-axis). The quantiles of a standard normal (i.e., normal with mean=0 and standard deviation=1) are those for the theoretical distribution and can be found in tables of the cumulative normal distribution. For

example, the 50th quantile is 0, the 90th quantile is approximately 1.282, and the 95th quantile is about 1.645. In the normal q-q plot below, 0 corresponds to the 50th percentile (median), 1 corresponds to (approximately) the 84th quantile, 2 corresponds to (approximately) the 98th quantile, and 3 would correspond to (approximately) the 99.9th quantile. If the data set closely follows that of a normal distribution, the points in the plot will lie close to the diagonal straight line (q-q line) overlaying the plot. The subsets of the data set that differ the most from those expected from a normal distribution are seen as points straying from the q-q line. Often, the difference is seen in the extreme values of the data set (the largest or smallest data values at one or both ends of the plot), even for data sets that produce histograms that look rather "normal." Often, too, these plots are used to determine whether a data set looks more "normal" (all points fall closer to the q-q line) after a data transformation. Two different data sets (site and background) can be compared to each other, and to a normal distribution, by plotting a separate line for each data set in the same display. The viewer can see where, if anywhere, the two q-q plots follow the same line, overlap, or intersect, indicating that they have equal magnitude at that (those) associated quantile(s).

2.9.1.7 Bivariate Plots

Scatter plots are an example of a bivariate display used to look for a mutual relationship or correlation between two variables of interest in the same sample. Data relating to one variable (y-axis) are plotted against data from a second variable (x-axis). Each point represents the values of the two variables from the same sample. Two variables have a positive correlation if they have a tendency to increase together, and a negative correlation if an increase in one tends to produce a decrease in the other. The strength of the correlation between the two variables may be interpreted by the scatter of points around a sloped least squares fit line. The scatter of points typically follows the general pattern and is described as an ellipse. The shape of the ellipse reflects the strength of the correlation (i.e., the magnitude of r, the correlation coefficient). The shape of the ellipse ranges from circular when there is no correlation ($r=0$) to a thin ellipse that collapses into straight line (a degenerate ellipse) when the variables are perfectly correlated ($r=1$, or $r=-1$). The slope of the line or ellipse of points (positive or negative slope) indicates whether there is a positive or negative correlation. Both parametric and nonparametric methods are available to assess data for correlations; and a statistical model may be developed using tools like simple linear regression, using a predetermined alpha value (e.g., 5 percent).

A series of scatter plots for pairs of analytes from a set of samples often are used to explore potential (or expected) relationships among the data. For example, scatter plots of related isotopes provide a visual display of isotopic ratios to evaluate secular equilibrium or (for uranium isotopes) to evaluate evidence of depleted or enriched uranium.

2.9.1.8 Spatial Plots

Spatial plots present data in a given area or volume using a variety of techniques. The plots described here are bivariate plots, bubble plots, grayscale images, and contour lines suited for two-dimensional presentations.

2.9.1.9 Circle Plots

Circle plots provide simple graphical representations of the magnitude of results at each sample

location. For example, each concentration of a particular analyte is represented as a circle with an area proportional to the concentration value. The circles are centered at the locations from which the samples were collected, typically the lateral surface locations throughout an area.

2.9.1.10 Multivariate Analyses

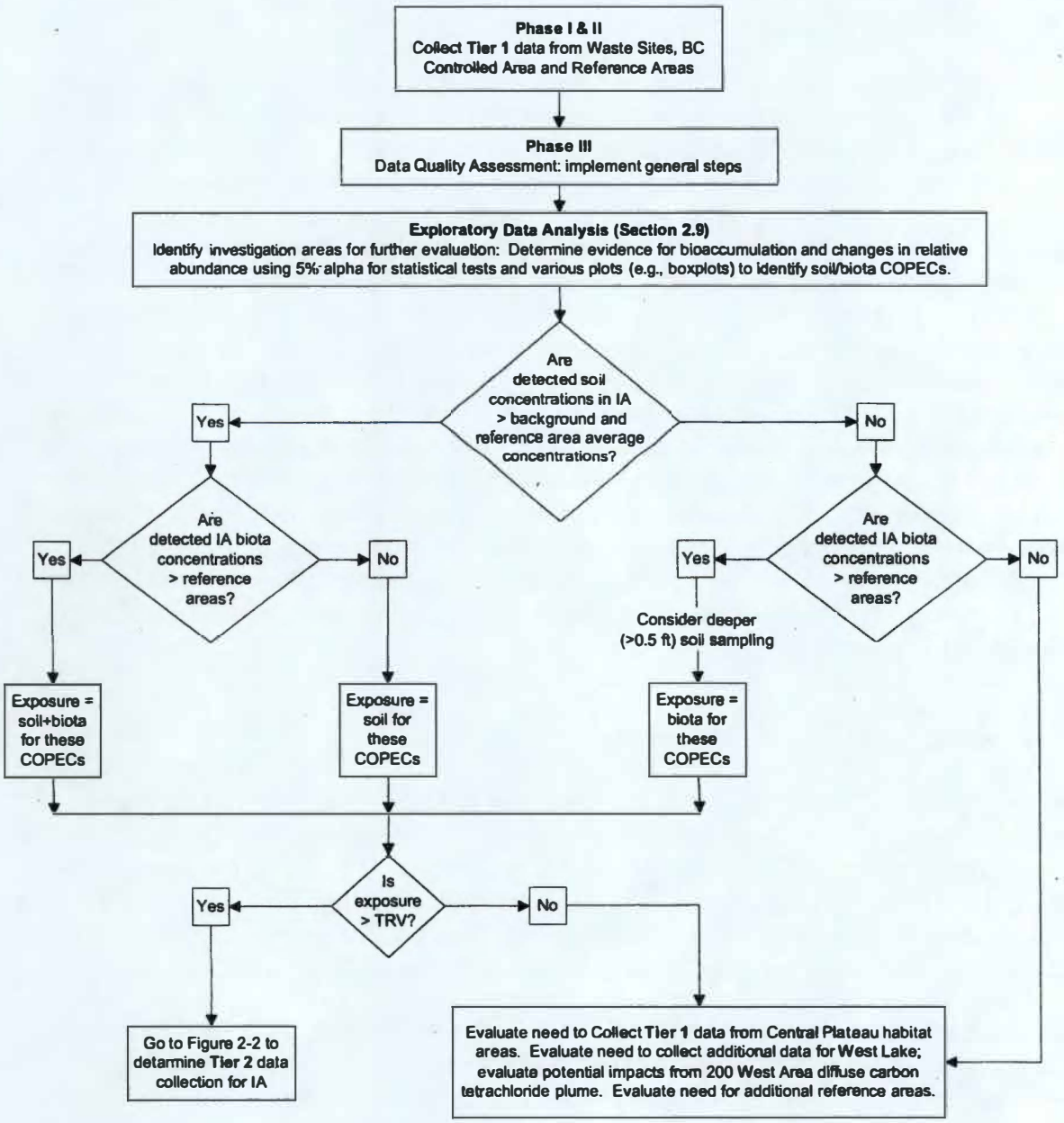
When multiple environmental and ecological measurements are taken in an attempt to avoid overlooking any that may have relevance, the subsequent analyses of individual responses may become unmanageable and difficult to study. The solution is to condense the data information, or reduce the dimensionality of the data, by using multivariate analysis. Data reduction is summarization, and summarization can result in categories or quantitative variables. Multivariate analysis is designed in such a way that a small number of variables have discriminating power similar to that of the full set of original variables. The multivariate approaches most useful to an ecological community setting include discriminate analysis, canonical-correlation analysis, and principal-components analysis. Discriminate analysis produces the best linear combination of the original variables that will classify a sample location into one of k groups (e.g., control area, minimally contaminated site, highly contaminated site). Canonical-correlation analysis determines the linear combination(s) of predictor variables (e.g., sediment-contaminant concentrations) and associated linear combination(s) of outcome measures (e.g., species abundance) that produce the strongest relationship (correlation) between the predictor set and the outcome set. Principal-components analysis determines the linear combination(s) of the set of original variables that explain the maximum amount of variability or differences between the samples taken. The results of multivariate analyses can be displayed graphically using bivariate plots.

2.9.2 Data Analysis/Risk Characterization

Figure 2-1 shows the decision logic associated with the DQA activities for Phase II. The DQA will make use of existing literature information relevant to the Hanford Site. The DQA process is initiated after Phases I and II are completed. For example, the Tier 1 data collected in Phases I and II will be evaluated through the DQA to assess whether collecting Tier 2 data for Core Zone waste sites or the BC Controlled Area is warranted in Phase III. Similarly, sampling of soils below 15 cm (0.5 ft) will occur in Phase III if warranted by the DQA (Table 1-1).

Data analysis of the Phase I/II ecological data starts with various exploratory data analysis approaches as described in Section 2.9.1. Data analysis will evaluate results from all 11 investigation areas, including six Phase I waste sites areas, the bunchgrass reference site, the three BC Controlled Area locations, and the shrub reference site.

Figure 2-1. Decision Logic for Phase II Data Quality Assessment to Support the Phased Sampling Approach and Tiered Data Collection for the Ecological Data Quality Objective Sampling and Analysis Plan.



NOTE:

Tier 1 data include:
- Field radiological data on soil, ant mounds, burrows
- 0-0.5 ft soil samples for metals, rads, and organics
- Biota (insect, lizard, mammal) samples
- Note abnormalities in collected wildlife
- Relative animal abundance
- Plant cover

Tier 2 data may include:
- Deeper soil sampling (>0.5 ft)
- Plant tissue analytical samples
- Population measures for mammals and lizards
- Field verification for middle trophic-level birds
- Litterbag studies and toxicity tests for plants/inverts
- Note abnormalities in collected wildlife

COPEC = contaminant of potential ecological concern
IA = investigation area
TRV = Toxicity Reference Value

The data from the investigation areas will be assessed for outliers and for differences in concentration between the potentially impacted areas and the reference areas. While many statistical approaches will be used, not all data are equally valid for all analyses[2]. Among the relationships explored with these various statistical analyses are differences in the relative density of invertebrates, lizards, and mammals based on variation in plant cover. Data also will be evaluated for statistically increased tissue concentrations versus soil concentrations (i.e., transfer factors or more complex bioaccumulation models). Contaminant transfer or bioaccumulation factors are an empirical ratio of contaminants in soil to contaminants in biota, which are used in exposure modeling. Adverse effects are inferred by the ratio of exposure to effects levels (toxicity reference values). It is assumed that the dose received orally for terrestrial wildlife can be described mathematically as one of the two following equations.

$$E_{oral} = [C_{soil} \cdot I_{food} \cdot fs + C_{food}] \cdot AUF,$$

where

E_{oral} is the estimated oral daily dose for a COPEC (mg-COPEC/kg-body weight/day)

C_{soil} is the concentration of chemical constituent x in soil (mg/kg dry weight)

I_{food} is the normalized daily dietary ingestion rate (kg-dry weight/kg-body weight/day)

fs is the fraction of soil ingested, expressed as a fraction of the dietary intake

C_{food} is the concentration of COPEC in food (mg/kg-dry weight)

AUF is the area use factor for the receptor (ratio of the investigation area to the home range, but no larger than 1.0).

$$E_{oral} = C_{soil} \cdot I_{food} \cdot [fs + TF_{food}] \cdot AUF,$$

where

E_{oral} is the estimated oral daily dose for a COPEC (mg-COPEC/kg-body weight/day)

C_{soil} is the concentration of COPEC in soil (mg/kg dry weight)

I_{food} is the normalized daily dietary ingestion rate (kg-dry weight/kg-body weight/day)

fs is the fraction of soil ingested, expressed as a fraction of the dietary intake

TF_{food} is a transfer factor from soil to food (mg/kg food dry weight per mg/kg soil dry weight)

AUF is the area use factor for the receptor (ratio of the investigation area to the home range, but no larger than 1.0).

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[2] The evaluation of the abundance of waste-site plant species in multivariate analyses is inappropriate, because these sites are highly managed systems, seeded with a finite number of targeted plants – the flora present consequently is more reflective of management decisions than of a subtle interplay among environmental variables.

The two equations assume that a single food type is ingested and that exposure modeling must be specific for herbivores, omnivores, insectivores, and carnivores. This model is the same as the one used in WAC 173-340-900, Table 749-4, "Wildlife Exposure Model for Site-Specific Evaluations," for evaluation of ecological effects of contaminants on terrestrial wildlife (WAC 173-340-7492, "Simple Terrestrial Ecological Evaluation Procedures").

Exposure modeling will be based on site-specific soil COPEC data and on COPECs detected in the three taxonomic representatives of middle trophic-level species (invertebrates, lizards, and small mammals) sampled for tissue analyses (Figure 2-1). Food ingestion rates and home ranges for Central Plateau receptors are provided in the Phase I EcoDQO (WMP-20570). Avian and mammalian toxicity reference values for the COPECs being evaluating in this plan also are provided in the Phase I EcoDQO (WMP-20570). Soil ingestion values will be obtained from the literature for the receptors considered in the Central Plateau or from appropriate surrogate receptors (Beyer et al. 1994, "Estimates of Soil Ingestion by Wildlife"). A framework for considering uncertainties in exposure-related (e.g., ingestion rate) and toxicity-related parameters is described in LA-UR-04-8246, *Screening-Level Ecological Risk Assessment Method*, as well and will be adopted for evaluating uncertainty in this SAP.

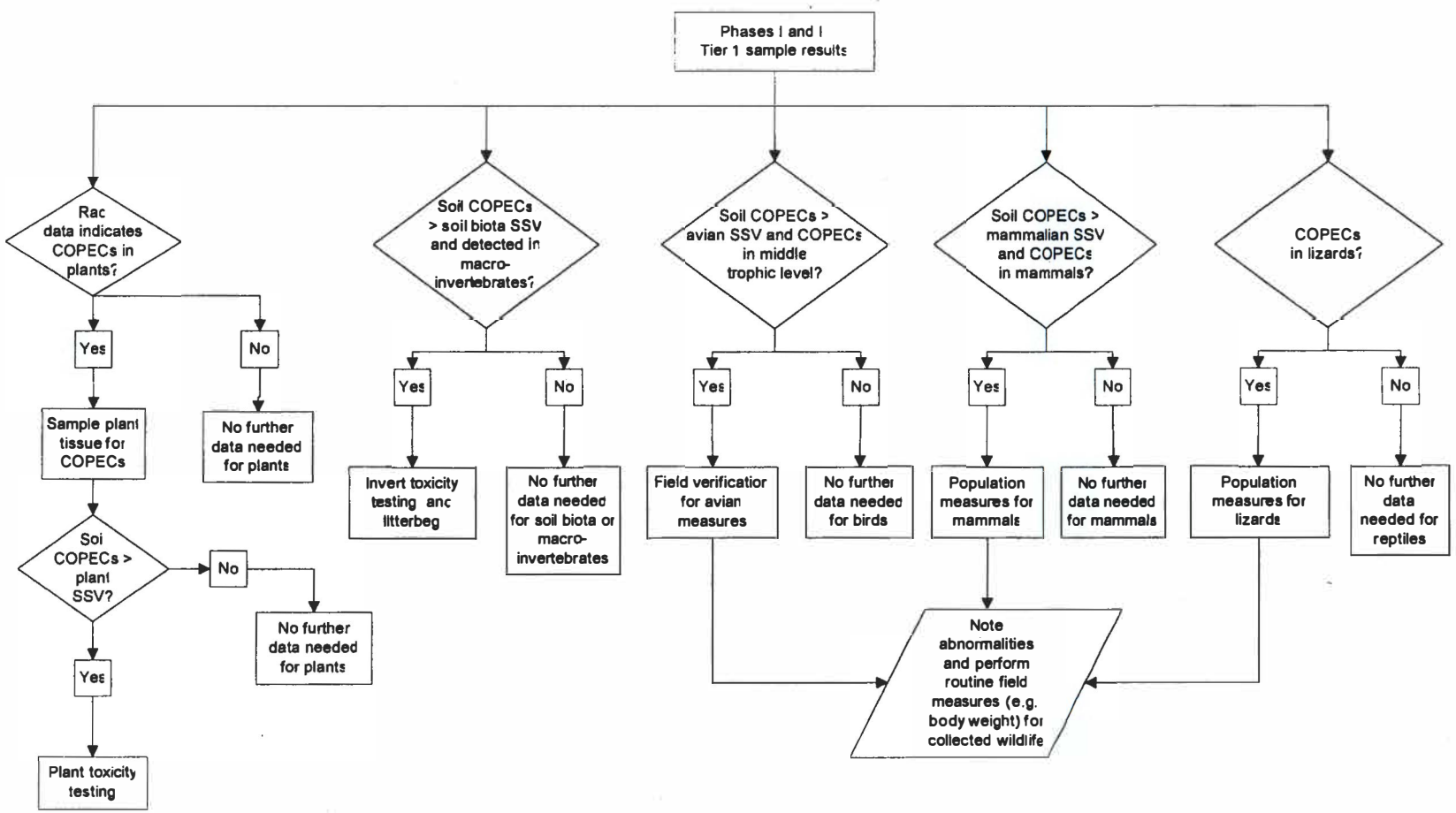
Given that Phase II only includes radionuclides, exposure modeling of the nonradionuclides will not be performed using Phase II data. The DQA will provide the basis for selecting from among four possible outcomes for each COPEC (Figure 2-1):

1. COPECs are in soil and in biota
2. COPECs are in soil only
3. COPECs are in biota only (potentially triggering deep soil sampling or additional lateral sampling in Phase III and an evaluation of the need for receptor-specific Tier 2 data)
4. COPECs are not in soil or in biota (indicating that no additional data are needed to characterize risk to biota for the geographic areas sampled for Tier 1).

For outcomes 1-3, exposure is compared to effect levels to determine if additional data should be collected. Figure 2-2 is used to identify the types of data needed for Tier 2. The last outcome is the clearest case for not proceeding to Tier 2 sampling. The second outcome of detecting COPECs in BC Controlled Area soil and not in biota likely would suggest that Tier 2 data collection for the BC Controlled Area is unnecessary. Thus, outcome #2 indicates that no further data are needed to determine if COPECs are affecting biota.

- The possibility of not detecting COPECs in biota could be attributed to sampling transient animals. This possibility, however, is thought to be unlikely for the Phase II data, because the BC Controlled Area zones are large spatially and thought to be relatively homogeneous with regard to radioactivity levels (see Figure 1-6); unlike a small waste site, the animals sampled in an investigation area likely will be exposed to similar contaminant levels. Therefore, even transient animals from outside an investigation area should be representative of the investigation area.

Figure 2-2. Data Quality Assessment Logic for Determining Data Requirements for Specific Ecological Receptors.



COPEC = Contaminant of potential ecological concern
SSV = Soil screening value

- Detection limits for biotic tissues (Table 2-2) are based on no-effect levels and are therefore an appropriately protective measure of biotic effects.

Figure 2-2 shows the DQA activities associated with data collected for specific ecological receptors in Phases I and II and how these data assist with the development of DQOs and the Phase III SAP. The five decision logic components in Figure 2-2 represent the receptors considered for Tier 2 characterization.

1. Plants: The field radiological data and analytical data are used to evaluate the potential for bioaccumulation of COPECs into plants. The results of this evaluation will be reviewed to determine the characteristics of potential contaminants that may be present to establish surrogate ratios with other COPECs (e.g., cesium to strontium). Line transects will be used to assess cover of dominant plants, bare ground, and cryptogams. This information will be used to evaluate the comparability of the investigation areas in terms of plant cover and, therefore, the expected abundance and types of other receptors. Existing data on vegetation will be overlain with existing data from radiation surveys to address observations of stressed vegetation in the area of highest radiation in the BC Controlled Area. These data are in the form of existing aerial photographs that cover the entire BC Controlled Area and the existing radiation field data, thus enhancing the ability to assess potential effects over a greater expanse of land. By spatially comparing these data, it is envisioned that a correlation between radiation levels and observations of stressed vegetation can be evaluated. Other stressors also may be evident from these aerial surveys. Additional field work may undertaken in Phase III, based on the results of the vegetation and radiation-field data assessment.

2. Invertebrates: Toxicity tests and litterbag assessments are planned if COPECs are measured in soil at greater than invertebrate soil-screening values, and these COPECs also are measured in soil macroinvertebrates. This evaluation will include exploratory data analysis of the macroinvertebrate and soil COPEC concentrations to look for bioaccumulation trends. These results also will be compared to relationships documented in the literature or from other relevant sites. The DQA also will evaluate the diversity and relative abundance of invertebrates by measuring the biomass of invertebrates in major taxonomic groups (predominantly beetles and crickets; biomass of lesser fractions will be noted as "other"). A measure of relative abundance is obtained by tabulating the trap days of capture activity at each investigation area.

3. Birds: Further evaluation of the avian receptors will be based on measuring COPEC concentrations in soil at levels greater than avian soil-screening values and based on exposure modeling with Hanford Site-specific dietary data (see the detection limit calculations in the Phase I EcoDQO [WMP-20570] for the form and parameters of the exposure model) and also by detecting COPECs in mammals and/or lizards. Mammal and lizard data are relevant in that these species are in the same middle trophic level as the bird species under consideration for Tier 2 data collection.

4. Mammals: Small mammal population studies are planned if COPECs are measured in soil at greater than mammalian soil-screening values and based on exposure modeling with Hanford Site-specific dietary data (see the detection limit calculations in the Phase I

EcoDQO [WMP-20570] for the form and parameters in the exposure model). These COPECs also are measured in small mammals.

This evaluation will include exploratory data analysis of the mammal and soil COPEC concentrations to look for bioaccumulation trends. These results also will be compared to relationships documented in the literature or from other relevant sites. The DQA also will evaluate the relative abundance of small mammals by measuring the biomass of each animal captured. A measure of relative abundance is obtained by tabulating the trap days of capture activity at each investigation area.

5. Lizards: Lizard population studies are planned if COPECs in lizards are measured. This evaluation will include exploratory data analysis of the lizard and soil COPEC concentrations to look for bioaccumulation trends. These results also will be compared to relationships documented in the literature or from other relevant sites.

The DQA also will evaluate the data to determine if an indicator model for ecological risk or ecological effects can be developed. Data analysis will determine if exposure levels are comparable between any of the investigation areas and, therefore, will be able to use results from sites with comparable exposure levels as something similar to field duplicates of analytical results.

2.10 FIELD SPECIFIC COLLECTION

Additional details regarding field-specific collection requirements are provided below.

2.10.1 Sample Location

Sample locations will be staked and labeled before the activity is started. After the locations have been staked, minor adjustments to the location may be made to mitigate unsafe conditions, avoid structural interferences, or bypass utilities. Locations will be identified as part of the work planning process for the collection of samples. Changes in sample locations that do not affect the DQOs will require approval of the project manager. However, changes to sample locations that result in impacts to the DQOs will require U.S. Environmental Protection Agency concurrence.

2.10.2 Sample Identification

The FH *Sample Data Tracking* database will be used to track the samples through the collection and laboratory analysis process. The HEIS database is the repository for the laboratory analytical results. The HEIS sample numbers will be issued to the sampling organization for this project. The radiological and physical properties of each sample will be identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS numbers will be documented in the sampler's field logbook.

Each sample container will be labeled with the following information using a waterproof marker on firmly affixed, water-resistant labels:

- Sampling Authorization Form number
- HEIS number
- Sample collection date and time
- Name of person collecting the sample
- Analysis required
- Preservation method (if applicable).

2.10.3 Field Sample Log

All information pertinent to field sampling and analysis will be recorded in field checklists and bound logbooks in accordance with existing sample collection protocols. The sampling team will be responsible for recording all relevant sampling information. Entries made in the logbook will be dated and signed by the individual who made the entry. Program requirements for managing the generation, identification, transfer, protection, storage, retention, retrieval, and disposition of records within FH also will be followed.

2.10.4 Sample Custody

Sample custody will be maintained in accordance with existing Hanford Site protocols. The custody of samples will be maintained from the time the samples are collected until the ultimate disposal of the samples, as appropriate. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples (in a cooler) shipped to any laboratory. Wire or laminated waterproof tape will be used to seal the coolers. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. Each time the responsibility for the custody of the sample changes, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and transmit the copy to FH Sample and Data Management within 48 hours of shipping. A custody seal (i.e., evidence tape) will be affixed to the lid of each sample jar. The container seal will be inscribed with the sampler's initials and the date.

2.10.5 Sample Containers and Preservatives

Level I U.S. Environmental Protection Agency precleaned sample containers will be used for soil samples collected for radiological analysis. Container sizes may vary depending on the laboratory-specific volumes needed to meet analytical detection limits. If, however, the dose rate on the outside of a sample jar or the curie content within the sample exceeds levels acceptable to an offsite laboratory, the sampling lead can send smaller volumes to the laboratory after consultation with FH Sample and Data Management to determine acceptable volumes. Preliminary container types and volumes are identified in Tables 2-3 through 2-6. The final container type and volumes will be provided on the Sampling Authorization Form. Tables 2-3 through 2-6 also list the priority for the analyses, with gamma spectroscopy being the highest

analytical priority, because it is a nondestructive analysis. The order for the remaining analyses is based on their importance for potential ecological risks, based on DOE-Headquarters analysis documented in WMP-20570.

2.10.6 Sample Shipping

The RCT will measure both the contamination levels on the outside of each sample jar and the dose rates on each sample jar. The RCT also will measure the radiological activity on the outside of the sample container (through the container) and will document the highest contact radiological reading in millirem per hour. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork in accordance with U.S. Department of Transportation regulations (49 CFR, "Transportation"), and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's acceptance criteria. The sampler will send copies of the shipping documentation to FH Sample and Data Management within 48 hours of shipping.

As a general rule, samples with activities of <1 mR/h will be shipped to an offsite laboratory. Samples with activities between 1 mR/h and 10 mR/h may be shipped to an offsite laboratory, although samples with dose rates within this range will be evaluated on a case-by-case basis by the FH Sample and Data Management. Samples with activities of >10 mR/h will be sent to an onsite laboratory arranged for by Sample and Data Management.

2.10.7 Radiological Field Data

Alpha and beta/gamma data collection in the field will be used to support the characterization described in this SAP, as appropriate. The following information will be disseminated to personnel performing work in support of this SAP, as appropriate:

- Instructions to the RCTs on methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, as appropriate. This will include direction to allow RCTs to calculate a number of quantities supporting sample analysis

- Information regarding the Geiger-Mueller (GM) portable instrument, to include a physical description of the GM, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The GM instrument is a beta/gamma instrument commonly used on the Hanford Site when removable surface contamination measurements and direct measurements of the total surface contamination are made

- Information regarding the portable alpha meter (PAM), to include a physical description of the PAM, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The PAM is an alpha instrument commonly used on the Hanford Site when removable surface contamination measurements and direct measurements of the total surface contamination are made

- Information regarding the sodium iodide (NaI) detector, to include a physical description of the NaI detector, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The NaI detector is a gamma detector commonly used on the Hanford Site for performing direct measurements

- Information on the characteristics associated with the hand-held probes to be used in the performance of direct radiological measurements include a physical description of the probe, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The hand-held probe is an alpha instrument commonly used on the Hanford Site when removable surface contamination measurements and direct measurements of the total surface contamination are made.

3.0 FIELD SAMPLING PLAN

The Field Sampling Plan (FSP) addresses the study scope defined through the DQO process and implements an iterative approach to characterizing ecological risks for the BC Controlled Area. This sampling design uses a tiered sample-collection framework. A screening-level approach is used to match COPECs with the medium that has the greatest potential of occurrence. In some sampling zones, the occurrence of a COPEC in an abiotic exposure medium may trigger future sampling in biota. Tables presented in this FSP contain a complete suite of analyses for easy comparison between media and sampling zones.

The FSP defines sampling objectives (Section 3.1), sampling design (Section 3.2), and descriptions of the different sampling media including soil (Section 3.3) and biota (Section 3.4). Administrative matters include sample handling (Section 3.5), environmental measurements (Section 3.6), sample management (Section 3.7), and management of investigation-derived waste (Section 3.8).

3.1 SAMPLING OBJECTIVES

The objective of the FSP is to provide information that will be used to support BC Controlled Area remedial decision making and to provide information to evaluate ecosystem health across habitats. A secondary benefit is that the collected data also may help the Hanford Natural Resources Trustees in understanding the condition of the ecosystem.

3.2 SAMPLING DESIGN

As discussed in DOE/RL-2004-42, the approach for Phase I was to classify sites within the Central Plateau based on waste disposal processes and COPECs, the cover depth, and the habitat. To accomplish these goals, sample locations were selected that represented a potential gradient of COPEC concentrations. This approach is repeated in Phase II. As discussed in Section 1.5, a reference location will be selected that is distant from the waste site. The soil and biota will be sampled between 0 and 15 cm (6 in.) to determine if the biota are taking up COPECs from this interval. The study area for ecological risk investigations will be a 1 ha area (100 x 100 m). A surface radiation assessment will be performed over the selected investigation areas and reference areas on a 10 x 10 m (32.8 x 32.8 ft) grid. The surface radiation assessment will be conducted by a qualified RCT in accordance with specific task instructions and other applicable approved procedures that will provide direction to the RCTs on how the areas under consideration are to be surveyed to meet the requirements as stated in this SAP.

A variety of sampling methods are required to ensure that the proper characterization data are collected from these diverse areas and media. The sampling methods considered for the BC Controlled Area include the following.

- **Reconnaissance Surveys** – Reconnaissance surveys (visual observations, radioactivity measurements, and mapping) will be conducted to determine locations, abundance, and availability of soil and biotic sampling populations. These surveys are to be conducted

by ecologists experienced in the Central Plateau ecology. Obvious ecological effects (e.g., distressed vegetation) will be noted during reconnaissance and other field collection activities; these notes will be communicated to the project team for evaluation and to solicit recommendations on changes in sampling or analytical activities. The reconnaissance surveys will provide information for the locations of the investigation areas in the BC Controlled Area zone. Criteria for selecting reference sites were discussed in Section 1.5; one reference site will be identified for detailed complementary sampling and evaluations of ecological health. To the extent possible, all media sampled in the investigation areas will be sampled in the reference site. Line transects will be used to assess cover of dominant plants, bare ground, and cryptogams. This information will be used to evaluate the comparability of the investigation areas in terms of plant cover and, therefore, the expected abundance and types of other receptors.

- **Systematic Grid Surveys** – Systematic grid surveys are based on a specified pattern, with samples taken at regular intervals along a defined pattern. The field radiological data collection will be performed following the grid surveys. Surveys may be designed for one, two, or three dimensions if the population characteristic of interest have any of the following spatial components:

  - Surveys along a line or transect represent sampling in one dimension

  - Surveys at every node on a grid laid over an area of interest represent sampling in two dimensions

  - Surveys representative of a depth profile at a node represent three-dimensional sampling.

  To ensure that the systematic surveys have a probability-based design, the initial unit for the first survey point of size n is chosen at random, and then the remaining (n-1) units are chosen so that all n are located according to the pattern.

- **Random Sampling** – This method is used for soil sampling and is intended to ensure that the investigation area soils are fully and uniformly represented in the multi-increment samples. The random assignment of locations to the multi-increment sample provides assurance that the sample truly represents the overall characteristics of the target population, which leads to an unbiased estimate of the mean.

- **Opportunistic Collections** – In some cases, biological samples can be collected opportunistically at locations within the investigation area. In such cases, the animal will be collected and the notes will be recorded on the specific location by referencing a grid node. An example is collecting a lizard in a pitfall trap intended for collecting invertebrates. Another example is hand-collecting invertebrates observed on the investigation area.

The sample design objectives, methods, features, and basis presented in Table 1-4 are discussed in the following subsections; additional detail is provided in Table 3-1.

Table 3-1. Methods for Field Data Collection.

Targeted Field Data	Description
Soils	Use direct-reading radiological survey instrumentation for measuring on a systematic survey grid. Collect samples for a multi-increment by soil corer or hand shovels, using a random start location in the systematic sampling grid.
Ant mounds	Characterize selected ant mounds at locations marked within the investigation area using direct-reading radiological instrumentation.
Burrow spoils	Characterize selected burrow spoils at locations marked within the investigation area using direct-reading radiological instrumentation.
Plants	Use direct-reading radiological instrumentation for measuring on a systematic survey grid. Use line transects to assess cover of dominant plants, bare ground, and cryptogams.
Invertebrates	Use pitfall traps along transects within the investigation area and opportunistic collections.
Small mammals	Use live traps systematically placed along transects within the investigation area.
Lizards	Collect lizards, make measurements, and submit whole animal.

3.3 SOIL-SAMPLING PROCEDURES

One of the primary objectives of the soil sampling in the BC Controlled Area is to locate and sample a gradient or range of COPEC concentrations.

As discussed in WMP-20570, the sampling design was based on the scale of middle trophic-level biota. The species used as measures of exposure (e.g., small mammals) reflect relevant scales for BC Controlled Area impacts. The investigation area of 1 ha reflects the home range and dispersal distance of these species. Existing radiological field data are used to establish the COPEC concentration gradients for locating the hectare investigation areas in the BC Controlled Area. The use of the characterization techniques identified in this SAP is expected to yield meaningful radiological characterization data. Additionally, the reference area will be sampled in the same manner that the investigation areas are sampled. Surface soils (the top 15 cm [6 in.]) will be characterized by collecting multi-increment samples that are representative of the entire 1 ha investigation area. The multi-increment samples will be a mixture of 50 samples taken at 0-15 cm (0-6 in.). The samples will be collected at 50 of the hectare grid locations, using systematic sampling with a random start.

3.3.1 Field Sampling Implementation Process Examples

3.3.1.1 Soil Surface

- Identify the investigation area based on existing radiological field data.

- Identify the grid pattern.
- Develop Environmental Radiological Survey Task Instructions (ERSTI) for the RCTs – these are specialized surveys that will be performed by RCTs, based on specific guidance to the RCTs. The task instruction will instruct the RCTs on what to survey, how to survey a particular area, and what instrumentation/equipment to use. For example, this may include information on both NaI detectors (to perform an evaluation for Cs-137 contamination levels) and GMs (to perform an evaluation for gross beta/gamma contamination levels), as needed, for the area under consideration.
- Survey the surface of the site by implementing the ERSTI, and produce a survey record that documents its implementation.
- Identify the soil samples that are needed within the grid boundary (i.e., a work instruction that says where to collect the soil samples).
- Biologists will identify areas of interest (e.g., ant nests, animal burrows, areas where soil has been disturbed and/or removed) for surveys to be conducted (gross beta/gamma measurements with handheld instrumentation).
- Samplers will collect the individual soil samples and mix the increments ("containerize and label" the soil samples) –RCTs will use standard radiological field instrumentation for these samples to measure the gross contamination levels directly within the soil samples under consideration both for radiological safety/job control purposes and to measure the contamination levels associated with each sample.
- Perform sample preparation activities for transfer to the lab.
- The samples will be stored in chain-of-custody conditions until submitted to the lab for COPEC analyses. The lab will receive the multi-increment samples for additional processing.

3.3.1.2 Animals (Lizards, Small Mammals, and Insects)

- Identify the site.
- Identify the grid pattern.
- Place the traps and collect insects, lizards, and mammals – the work instruction for this process will follow existing programs and procedures that will be implemented via existing processes.
- Collect the animals via the traps (this process will use existing radiological controls for health and safety purposes).
- Following collection, the RCTs will use field instrumentation to measure the contamination levels on the exterior of the animals both for health and safety purposes and for documenting measured contamination levels on the exterior of the animals

(e.g., standard GM hand-held field instrumentation and/or NaI detector measurements per the survey task instructions).

- Record species-specific information, weight, and other information.
- "Containerize and label" the samples.
- Store samples in a custody-controlled freezer before they are submitted to the lab.
- The lab will prepare the samples for analysis, including a deionized water rinse to be analyzed for the COPECs.
- The results that are provided from the lab will constitute analytical data for the animals.

3.3.1.3 Plants

- Identify the site.
- Identify the grid pattern.
- Within each grid, identify plants based on the characteristic of the species being evaluated. Collect and analyze the radiological information associated with the species per the work package instructions and the ERSTI requirements in the task instructions.

Detailed sampling techniques are described further in the following subsections.

3.3.2 Field Radiological Data Collection

Radiological instrumentation for field data collection that may be used is shown in Table 3-2.

Table 3-2. Field-Screening Methods.

Measurement Type	Emission Type	Method/Instrument or Equivalent[a]	Detection Limit
Contamination levels	Alpha/beta-gamma	SHP380-A/B scintillation probe or equivalent	100 dpm α 1,921 dpm[b] β–γ
Gamma measurements NaI detector field data (must be used for site surveys for assessment of variance)	Gamma isotopic emissions	NaI detector	~3 pCi/g for Cs-137

[a] SHP380-A/B scintillation probe is a trademark of Eberline Instruments, a subsidiary of Thermo Electron Corporation, Waltham Massachusetts.
[b] Detection limit rating is for 100 cm^2 at a scan rate of 2 in./s.

Existing radiological data will be used to locate the BC Controlled Area investigation areas; one investigation area will be based in each of Zones A, B, and C, identified in Figure 1-3. The field team will have the latitude to vary the aspect ratio of the investigation area, but the area is to be kept at 1 ha unless this is not feasible. Process knowledge also may be used to locate the investigation area and determine its dimensions.

Once the hectare investigation area is located, radiological field data will be collected in the

areas between grid nodes that are staked with flags or wood posts containing the location numbers. A total of 121 nodes are located in each hectare plot.

Surface soil and plant radiological readings will be measured in a 1 m^2 area surrounding each flag and located within the 1 ha study site. The results from implementing the ERSTI will be documented on a radiological field record, as per the task instructions. The plant nearest to the radiological field data location will be selected. If more than one plant is equidistant from the survey location, the tallest specimen will be selected for the plant radiological field data. The species and dimensions (height and width) of the plant will be noted, as well as the radiological measurement used. Both beta and gamma measurements will be taken on the surface soil as well as on the plant material.

The investigation area will be surveyed for burrowing animal activity and ant mounds, with the objective of marking and making surface radiological measurements at these locations. From 30 to 50 locations with burrow spoils should be surveyed, and 15 to 20 ant mounds should be surveyed, subject to availability. One-quarter of the investigation plot initially should be inspected, and large ant mounds and burrow spoils should be marked. If more than enough of each type is located in the first 0.25 ha, then the radiation measurements will be made in this 0.25 ha, and the locations will be marked. The ambient radiological background levels and the radiation measurements for both ant mounds and burrow spoils will be recorded as per the ERSTI, and the locations will be recorded using the node identification number. In addition, the location will be flagged for future reference. If additional measurements are needed for ant mounds or for burrows, then the next 0.25 ha section of the investigation plot will be surveyed, and ant mounds and/or burrows will be marked until the desired minimum numbers of each are obtained. The field team leader may select additional areas for radiological measurements that are outside the study site, either to meet the desired minimum survey locations or to obtain a more representative survey of the investigation area (with consultation of the radiological controls supervisor). If sufficient numbers cannot be obtained, this deviation will be documented in the radiological field data documentation.

3.3.3 Soil Screening

An assessment population of small mammals will be exposed to contamination within a spatial area of approximately 1 ha (Ryti et al. 2004, "Preliminary Remediation Goals for Terrestrial Wildlife"). Animals range freely over the hectare and, as a result, integrate exposure from multiple locations. The parameter of interest is therefore the average soil concentration for the hectare. As such, the samples will be field screened for evidence of radioactive contamination by the RCT. Surveys of these materials will be conducted with field instruments for both beta and gamma radiation. Potential screening methods and instruments are listed in Table 3-2 with their respective detection limits.

Before sampling begins, a local area background reading will be taken with the field-screening instruments at a background site to be selected in the field per established procedures. Field screening of the soil and visual observations of the soil (e.g., sediment/clay layer, organic debris) will be used to support worker health and safety monitoring.

Field-screening instruments will be used, maintained, and calibrated in accordance with the

manufacturer's specifications and other approved procedures. The RCT will record field-screening results on the radiological survey record associated with the survey area.

3.3.4 Multi-Increment Soil Sampling and Analysis

An assessment population of small mammals will be exposed to contamination within a spatial area of approximately 1 ha (Ryti et al. 2004). Animals range freely over the hectare and, as a result, integrate exposure from multiple locations. The parameter of interest is therefore the average soil concentration for the hectare. As such, the soil-sampling plan is based on multi-increment sampling procedures that are designed to control the fundamental error (FE) for an average, based on collecting an adequate sample mass (Pitard 1993, *Pierre Gy's Sampling Theory and Sampling Practice: Heterogeneity, Sampling Correctness, and Statistical Process Control*; Ramsey, 2004, *Sampling for Environmental Activities*, DQO Training Course). The following steps are involved in determining an adequate sample mass to collect in the field and the proper particle size for the analytical laboratory to measure for radiological analysis.

1. The investigation area is 1 ha. The systematic grid used for radiological surveys provides 100 grid boxes. Of these, 50 grid box locations will be sampled, beginning with a random start.

2. Select or measure a reasonable maximum sample particle size in the field. Because soils typically are defined as comprising particles of ≤ 2 mm, an assumption is made that the maximum particle size is 2 mm or 0.2 cm. This will be achieved by sieving the soil samples to exclude the > 2 mm size particles.

3. Select the desired FE, which has been specified as 10 percent. This corresponds to a standard error of 10 percent on the mean concentration. This value was selected to be low relative to other sources of error (analytical measurement error typically is 30 percent).

4. Calculate the mass of sample (M) needed based on the FE and particle size (d, in cm) as

$$M = 22.5\frac{d^3}{FE^2}.$$

   If d=0.2 cm and FE=0.1 (10%), then M=18 g.

5. Using a scoop large enough to capture the maximum particle size, collect enough sample increments (k=50) to equal at least the mass calculated in step #4 and place them in a container, combining increments into one "sample" (m). Be sure to obtain consistent and representative samples for the desired sample depth, and form the multi-increment sample such that the material is representative of the particle size fractions that are of less than 2 mm. Collect sufficient sample mass for all laboratory analyses.

6. Repeat step #5 within the investigation area to obtain two field QC samples (as specified in Table 3-3) that will be used as a field duplicate, by sampling from two additional sets of 50 systematic locations, each with a different random start.

7. Deliver the samples and QC samples to the lab.

8. Because sufficient sample mass of <2 mm screened soil will be collected for all laboratory analyses, the laboratory is expected to analyze the entire mass for each test method. According to item #4, this is a minimum of 18 g per analysis.

9. Calculate the concentration from the sample.

10. The concentration represents average concentration or activity in the investigation area.

The multi-increment soil sampling will be based on the grid pattern used for radiological field data collection. Of the 100 grid boxes in each hectare plot, 50 grid boxes will be used for soil sampling. The soil sample increments will be collected from each investigation area to provide a single multi-increment sample representing the 0-15 cm (6-in.) depth.

If the results of the gamma field data indicate that the investigation area is heterogeneous in COPEC concentrations, then the Field Team Lead may elect to subdivide the investigation area into more equal contaminant levels. Within each subarea, the multi-increment sample strategy will be employed. Each multi-increment sample will be submitted to the analytical laboratory for analysis of radionuclides (Cs-137 and Sr-90).

Information regarding the samples will be recorded in the sampler's field logbook. The sampling field logbook includes, but is not limited to, the soil description, sample depths, sample locations, HEIS database sample numbers, relevant and/or pertinent events, general information about the sample or locations, and any other information that may be useful to meet the objectives of the FSP.

The investigation-derived waste generated during this activity will be handled according to applicable procedures in Section 3.8 of this SAP.

3.3.5 Summary of Soil Sampling Activities

A summary of the number and types of soil samples to be collected is presented in Table 3-3.

Table 3-3. Summary of Projected Soil Sample Collection Requirements.

Site Identification	Primary Samples	Quality Control Samples
BC Controlled Area, Zone A	1 sample from 50 locations	-
BC Controlled Area, Zone B	1 sample from 50 locations	-
BC Controlled Area, Zone C	1 sample from 50 locations	-
Reference site	1 sample from 50 locations	-
Field replicate	-	2 additional samples, each from another 50 random locations. Field team will select investigation area
Equipment blank	-	1 sample of clean soil/sand or water
Laboratory quality control	-	2 additional samples, laboratory triplicate performed on primary multi-increment sample from field quality control site
Total	4	5
Total samples to analyze	9	

3.4 BIOTA SAMPLING PROCESS

For each type of biological data collected, the activity required to collect the target number of organisms or sample mass will be recorded. This information will provide a semiquantitative measure of the abundance of biota at each investigation area. This semiquantitative measure of abundance is similar to that used in wildlife or fisheries studies where catch is related to population density. For example, the number of trap days will be recorded (where applicable), or the number of man-hours will be recorded for each data type. Animals caught opportunistically during other activities also will be noted in the sampling checklists or logbook. To the extent practicable, data will be recorded in a consistent manner. This may be most easily accomplished through use of a standardized data entry form or forms (e.g., checklists).

3.4.1 Plant Cover Surveys

It is proposed to use line transects to estimate canopy cover of dominant plant species, bare ground, and cryptogam cover. The following vegetation attributes typically are monitored using the line transect method: canopy cover, frequency, and composition by canopy cover. The canopy cover only will be estimated visually. It is important that the same investigators collect these data to minimize differences in observer bias. The data will be consistently recorded to ensure that all pertinent information is noted in all areas sampled.

Each investigation area will be divided into 0.25 ha sections. Within each 0.25 ha subarea, four line transects will be placed using a systematic sampling array with a random start. Thus, cover information will be recorded at 16 transects that encompass the entire investigation area. In addition, photographs will be taken at the start of each transect.

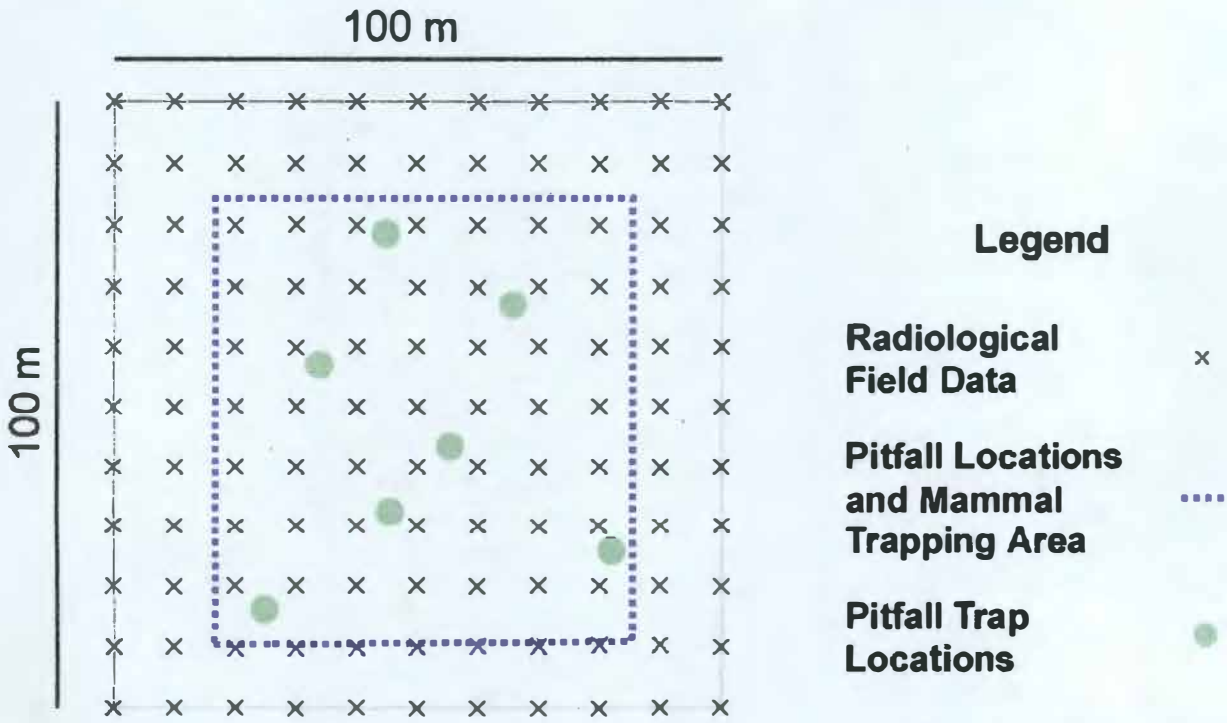
3.4.2 Insects

Pitfall traps will be used to capture invertebrates for COPEC analysis. The pitfall traps will be located within a 70 x 70 m grid in the center of the 100 x 100 m grid (Figure 3-1).

Ground-dwelling invertebrates such as darkling beetles, harvester ants, and spiders represent the soil biota guild specified in WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures." Individual pitfall traps or drift fences with traps at each end will be used within the grid at each of the investigation areas to collect invertebrates. Pitfall traps consist of 3.8 L (1-gal) metal or plastic containers buried at grade.

Pitfall traps will be left open for at least five nights at each sampling area. Invertebrates caught during trapping will be collected and composited for each sampling area for contaminant analysis. A trained entomologist will identify the invertebrate orders and/or families represented in the traps, and each fraction will be weighed. Pitfall trapping will continue until sufficient sample mass is obtained (to be determined by the field team leader). The number of trap days will be recorded for a relative measure of invertebrate abundance.

Figure 3-1. Schematic Used to Illustrate Phase II Sampling of BC Controlled Area.



If insufficient sample mass is obtained from the pitfall traps, then invertebrates can be manually collected or collected by other means (e.g., sweep nets). If alternate methods are used for invertebrate collection, then each fraction will be sorted, weighed, and separated, and an approximate effort (person-days) will be recorded for each collection method. Coordinates for pitfall trap locations will be recorded to the nearest grid marker. The insects will be analyzed for radionuclides (Cs-137 and Sr-90). Invertebrates will not be depurated, because these data are used mainly to assess risks to upper trophic levels, and depuration does not occur before predation. The invertebrate sample will be rinsed with deionized water at the analytical laboratory to remove any exterior contamination, to minimize any bias introduced from soil potentially accumulating in the pitfall traps.

3.4.3 Lizards

The field team will note the presence of lizards on their visits to the investigation areas when the radiological data are collected, when soil samples are collected, and during the installation of the pitfall traps. Lizards will be captured in the pitfall traps or by alternate methods, such as using a noose or other resource-effective methods like stunning them with a rubber band. After capture, the entire lizard will be used as the sample. Only lizards that are located within the inner 70 x 70 m part of the investigation area will be captured. Within each grid, they will be analyzed for Cs-137 and Sr-90. Each lizard sample will be rinsed with deionized water at the analytical laboratory to remove any exterior contamination. Lizard tissues are to be analyzed exclusive of external concentrations so that these data will be better suited to developing bioaccumulation models. In addition, the exposure models incorporate incidental soil ingestion, and rinsing the

lizards prevents double counting soil ingestion in exposure model calculations. Coordinates for each lizard location will be recorded based on the nearest grid marker. At least six lizards will be captured and analyzed for COPECs at each investigation area. The number of trap days required to get at least six lizards per species will be recorded. This will provide a relative measure of animal density. Captured lizards will be examined for physical abnormalities, and data on total length, snout-vent length, and gender will be recorded. Abnormalities, which include coloration (e.g., albino), extra or missing digits, or two heads, and the animals – both normal and abnormal – should be photographed. Causes of abnormalities include disease, contaminants, missed predation, ultraviolet radiation, or a combination of these stressors (Blaustein and Johnson, 2003, "The Complexity of Deformed Amphibians").

3.4.4 Small Mammals

Deer mice and pocket mice likely are present in the BC Controlled Area, particularly where adequate vegetation exists. These mice are omnivores and granivores, respectively, and are considered the best representatives for the mammalian predator guild (as recommended in WAC 173-340-7490 et seq., "Terrestrial Ecological Evaluation Procedures"). Deer mouse and pocket mouse sampling will be accomplished using live traps laid in the 70 x 70 m array in the center of the 100 x 100 m investigation area. Small mammal trapping will be conducted between April and September, when animals are most likely to be active.

Typically, two trap lines, each consisting of approximately seven Sherman live traps[3] 7.6 cm wide by 8.9 cm high by 23 cm long (3 in. wide by 3.5 in. high by 9 in. long) will be placed parallel with the edges of the 70 x 70 m array. Identical trapping methods will be employed in similar habitats at the reference locations. The number of trap lines, number of traps per line, line spacing, and trap spacing may be varied to maintain comparable trapping efforts between sites and to ensure that results are comparable between the waste areas and reference locations. Adjustments will be made, such as function of the size of the area and type of the plant community in the vicinity. The grid location for the trap where the animal was captured will be noted in the field logbook.

Trapping arrays will be limited to one habitat type, if possible. The animals will be trapped over enough nights to obtain at least six small mammals from each investigation area; to the extent possible, the same species will be sampled at all Phase I and Phase II investigation areas. The number of trap days required to get at least six animals for a species will be recorded. This will provide a relative measure of animal density. Individuals of other species may be collected if insufficient numbers of one species are captured, to meet the minimum of six small mammals per investigation area. The team members consistently will record information on all animals captured by use of standardized data-entry procedures. Data recorded will include animal condition (e.g., species, sex, weight, reproductive class) and deformities. Because the habitat of the BC Controlled Area is relatively undisturbed, it is expected that pocket mice will be more common than deer mice. It would, however, be ideal to collect six deer mice from each trapping array, so that mammal data are consistent with what is expected to be collected in the Phase I

[3] Sherman trap is a trademark of the H. B. Sherman Company, Tallahassee, Florida.

investigation areas. The relative density estimates will be interpreted with regard to field notes and weather conditions to make inferences about comparability of results among different investigation areas.

The mammals (whole animal) will be analyzed for Cs-137 and Sr-90. The mammals will be rinsed with deionized water at the analytical laboratory to remove any exterior contamination. Small mammal tissues are to be analyzed exclusive of external concentrations so that these data will be better suited to developing bioaccumulation models. In addition, the exposure models incorporate incidental soil ingestion, and rinsing the mammals prevents double counting soil ingestion in exposure model calculations.

3.4.5 Summary of Biota Sampling Activities

A summary of the number and types of biota samples to be collected is presented in Table 3-4.

Table 3-4. Summary of Projected Biota Sample Collection Requirements in the BC Controlled Area.

Site Identification[a]	Invertebrate Samples[b]	Small Mammal	Lizards
Zone A	3	6	6
Zone B	3	6	6
Zone C	3	6	6
Reference Site	3	6	6
Total	**12**	**24**	**24**

[a] Sites will be selected during initial reconnaissance activities.
[b] Assume sufficient mass for three samples.

3.4.6 Potential Sample Design Limitations

The sample design developed for this SAP has several potential limitations that may affect the sampling results. Some of the factors that have the potential to affect the outcome of this sampling activity include the following:

- Ability to collect sufficient sample mass for analytical measurements of biota
- Timing of data collection to maximum abundance of biota.

3.4.7 Sampling Contingencies

This SAP includes an assessment of the possible contingency considerations to offset the possible limitations encountered during sampling in the Central Plateau. The FH task lead will evaluate the need to implement these contingencies on a case-by-case basis.

The current climatological conditions may impede the field collection of biota samples because of drought-suppressed population levels. A greater trapping effort would necessarily extend the field schedule, and this could push sampling into a suboptimal collection season. For these

reasons, fewer animals may be available to address analytical uncertainties (e.g., detection limits) than currently planned.

If insufficient mass of invertebrates is obtained from the pitfall traps, then additional duration will be added or other methods will be used. Such methods include hand picking large insects to collect invertebrates. If the target numbers of small mammals or lizards cannot be obtained, then additional sampling will be considered.

If sample volumes from the biotic sampling still are not sufficient to meet analytical needs, analyses will be performed in accordance with the priority listed in Tables 2-3 to 2-6. Detection limits higher than the levels in Table 2-2, or reduced analyte lists, are significant deviations and must be documented and communicated to the project team.

If there are difficulties in locating an analytical laboratory to successfully complete steps 8-11 in Section 3.3.3, then the analytical laboratory will be directed to run triplicate analyses on each original sample. In addition, the field team will instruct the analytical laboratory to run triplicate analysis on two of the QC samples.

The small mammal trapping from some arrays may not yield a sufficient number of animals of the target species. If this should be the case, then the first six small mammals captured (regardless of species) should be submitted for analysis from each trapping array. However, the decision on what species to submit for tissue analysis should be made after an array has been trapped for at least four nights, based on consultation with the project task lead.

During the radiological field data collection, the sampling locations may not correspond to the locations of vegetation. The radiological field data locations may be moved slightly to accommodate the plant spacing. If this is not feasible because of lack of vegetation at the grid location, then the closest plant will be surveyed for radiation. This and/or other deviations will be noted in the radiological field data record associated with the implementation of the task instruction and will be conveyed to the task lead.

3.5 SAMPLE HANDLING, SHIPPING, AND CUSTODY REQUIREMENTS

All field-sample handling, shipping, and custody requirements will be consistent with established procedures. Sample transportation will be in compliance with the applicable regulations for packaging, marking, labeling, and shipping hazardous materials, hazardous substances, and hazardous waste that are mandated by the U.S. Department of Transportation (49 CFR 171-177, Chapter 1, "Research and Special Programs Administration, Department of Transportation," Part 171, "General Information, Regulations, and Definitions," through Part 177, "Carriage By Public Highway") in association with the International Air Transportation Authority, DOE requirements, and applicable program-specific implementing procedures. Sample custody during laboratory analysis is addressed in the applicable laboratory standard operating procedures. Laboratory custody procedures will ensure that sample integrity and identification are maintained throughout the analytical process.

3.6 SAMPLING AND ONSITE ENVIRONMENTAL MEASUREMENT PROCEDURES

Procedures for field measurements are specified in the subcontractor's or manufacturer's manuals. The sampling and onsite environmental measurement procedures to be implemented in the field will be consistent with established procedures.

3.7 SAMPLE MANAGEMENT

Sample management activities will be consistent with established procedures. Any laboratory performing work will be compliant with SW-846 requirements.

3.8 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Waste generated by sampling activities will be managed consistent with an established waste management plan. Unused samples and associated laboratory waste for analysis will be dispositioned in accordance with the laboratory contract and agreements for return to the Hanford Site. In accordance with 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," task lead approval is required before unused samples or waste are returned from offsite laboratories.

4.0 HEALTH AND SAFETY

All field operations will be performed in accordance with Duratek Federal Services of Hanford, Inc., health and safety requirements, and applicable portions of the *Washington Administrative Code* and RCW 43.21C, "State Government – Executive," "State Environmental Policy," (State Environmental Policy Act). In addition, work control documents will be prepared that will further control site operations. The safety documentation will include an activity hazard analysis and applicable FH radiological work permits.

The sampling procedures and associated activities will implement ALARA practices to minimize the radiation exposure to the sampling team, consistent with the requirements defined in 10 CFR 835. All field operations will be performed in accordance with FH health and safety requirements. Duratek Federal Services of Hanford, Inc., will comply with the FH Radiological Protection Program.

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