221-T SAND FILTER PAD
ADDENDUM H
CLOSURE PLAN

CHANGE CONTROL LOG

Change Control Logs ensure that changes to this unit are performed in a methodical, controlled, coordinated, and transparent manner. Each unit addendum will have its own change control log with a modification history table. The "**Modification Number**" represents Ecology's method for tracking the different versions of the permit. This log will serve as an up to date record of modifications and version history of the unit.

Modification History Table

Modification Date	Modification Number

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ATTACHMENTS

TERMS

ASTM	American Society for Testing and Materials
BCSO	Benton County Sheriff's Office
CAA	Central Accumulation Area
CHPRC	CH2M HILL Plateau Remediation Company
CFR	Code of Federal Regulations
COC	Chain of Custody
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DWMU	Dangerous Waste Management Unit
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
HEIS	Hanford Environmental Information System
HHE	Human Health and the Environment
IQRPE	Independent Qualified Registered Professional Engineer
MTCA	*Model Toxics Control Act—Cleanup* (WAC 173-340)
PQL	Practical Quantitation Limit
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act of 1976
SAA	Satellite Accumulation Area
SAP	Sampling and Analysis Plan
SWOC	Solid Waste Operations Complex
VOA	Volatile Organic Analysis
VSP	Visual Sample Plan
WAC	Washington Administrative Code
WIDS	Waste Information Data System

H.1 Introduction

The purpose of this plan is to describe the Resource Conservation and Recovery Act (RCRA)/Hazardous Waste Management Act (HWMA), Chapter 70.105 Revised Code of Washington (RCW) closure process for the 221-T Sand Filter Pad Dangerous Waste Management Unit (DWMU), hereinafter called the 221-T Sand Filter Pad. The 221-T Sand Filter Pad is located in the northeast portion of the T Plant Complex in the 200 West Area of the Hanford Site (Figure H-1). The U.S. Department of Energy (DOE) and CH2M HILL Plateau Remediation Company (CHPRC), hereinafter called the Permittees, have agreed with the U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) through a Consent Agreement and Final Order (EPA Docket No. RCRA-10-2013-0113) to close this DWMU. The 221-T Sand Filter Pad is no longer used for storage of dangerous or mixed waste and will be clean closed.

This closure plan complies with closure requirements in Washington Administrative Code (WAC) 173-303-610(2) through WAC 173-303-610(6), and WAC 173-303-630(10).

Amendments to this closure plan must be submitted as a permit modification request in accordance with Permit Condition I.C.3.

Minor deviations from this closure plan must be addressed in accordance with Permit Condition II.K.6.

Closure requirements also follow Ecology guidance (Ecology Publication #94-111, *Guidance for Clean Closure of Dangerous Waste Units and Facilities*). This closure plan is designed to fulfill the elements of the Data Quality Objectives (DQO) Process, as defined in EPA Publication EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4)*. A site-specific DQO has been incorporated into this closure plan.

This closure plan describes in detail the closure activities necessary to achieve closure performance standards for the 221-T Sand Filter Pad. Closure activities include:

- Removal of all dangerous and mixed waste.
- Records review (i.e., container storage, operating, and inspection records) for documented spills or releases of dangerous or mixed waste and subsequent cleanup activities.
- Visual inspection to evaluate the likelihood of potential contamination of the soil.
- Sampling of soil to ensure closure performance standards are met.
- Transmit closure certification to Ecology.

Closure will be performed in accordance with the schedule provided in Section H.6.

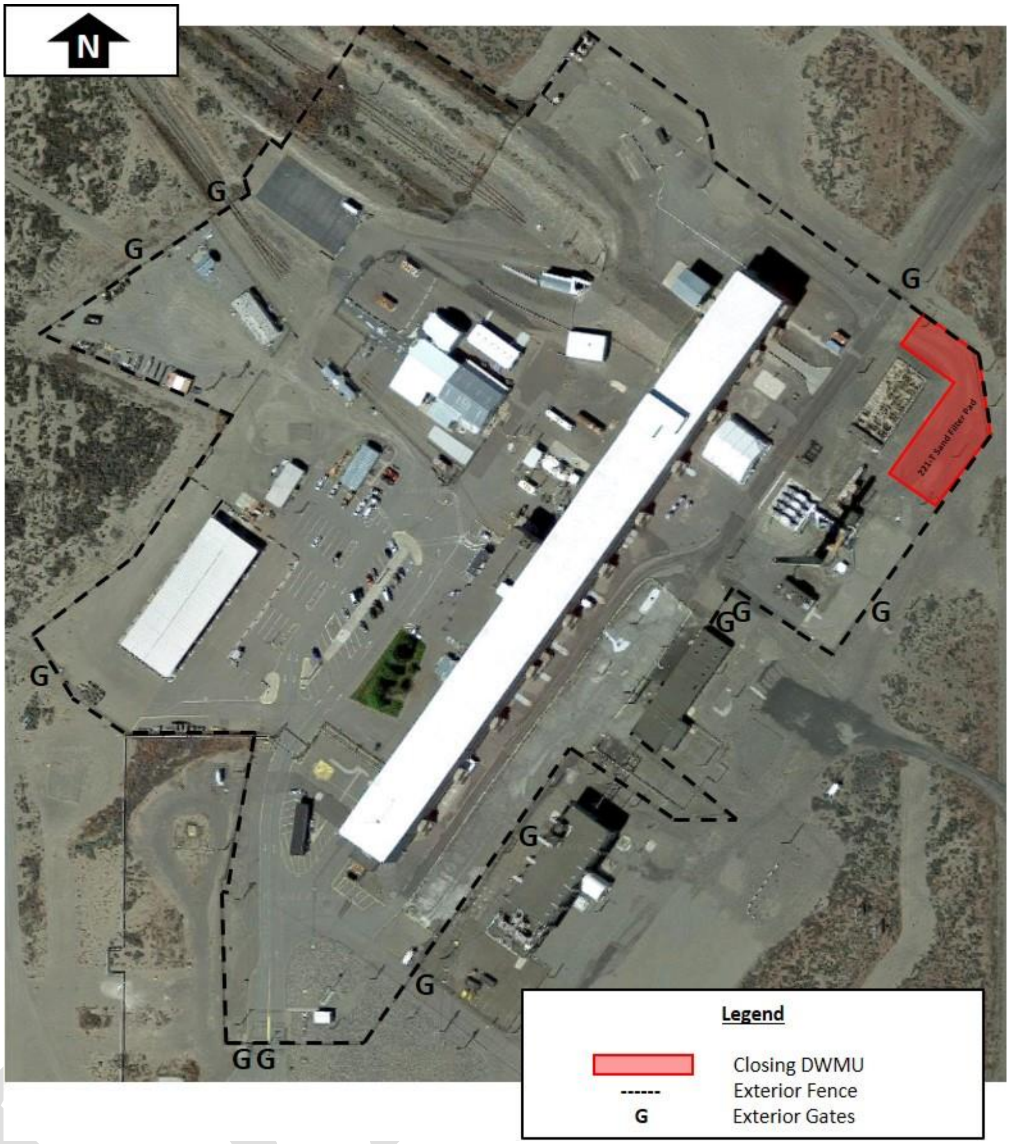

Figure H-1 T Plant Complex Overview, 221-T Sand Filter Pad Dangerous Waste Management Unit

H.1.1 Unit Description

The 221-T Sand Filter Pad is an uncovered gravel area located near the north end of the T Plant Complex, 221-T Canyon Building. The 221-T Sand Filter Pad was previously used for storing containers of various sizes and volumes, and a variety of waste streams to ensure adequate capacity and operational flexibility to support T Plant activities.

The 221-T Sand Filter Pad is approximately 55 m (180 ft) long by 18 m (60 ft) wide. Figure H-2 and Figure H-3 show the 221-T Sand Filter Pad.

The 221-T Sand Filter Pad was used to manage dangerous and mixed waste in a Central Accumulation Area (CAA) or Satellite Accumulation Area (SAA). The 221-T Sand Filter Pad does not currently store dangerous or mixed waste. Future storage of dangerous or mixed waste is not authorized within the 221-T Sand Filter Pad.

Figure H-2 T Plant Complex 221-T Sand Filter Pad (looking southeast) (March 2018)

Figure H-3 T Plant Complex 221-T Sand Filter Pad (looking northeast) (March 2018)

H.1.2 Maximum Waste Inventory

No dangerous waste permitted storage was identified at the 221-T Sand Filter Pad during the T Plant operating records review (Section H.3.2); therefore, no maximum waste inventory is presented. Weekly inspection records of the CAAs and SAAs identified that the 221-T Sand Filter Pad may have managed nondangerous, dangerous, and mixed waste.

H.1.3 Personnel Safety and Training Requirements

Closure will be performed in a manner to ensure the safety of Human Health and the Environment (HHE). Health and safety requirements are addressed in Section H.1.3.1, and training for facility and closure personnel is described in Section H.1.3.2.

H.1.3.1 Health and Safety Requirements

Personnel will be trained in the applicable safety and environmental procedures described in Table H-1. Personnel will be equipped with appropriate personal protective equipment. Personnel will perform all field operations and any necessary closure activities in compliance with applicable health, safety, and environmental procedures and requirements.

Pre-job briefings will be performed to evaluate activities and associated hazards by considering the following factors:

- Objective of the activities.
- Individual tasks to be performed.
- Hazards associated with the planned tasks.
- Environment in which the job will be performed.

- Facility where the job will be performed.
- Equipment and material required.
- Safety protocols applicable to the job.
- Training requirements for individuals assigned to perform the work.
- Level of management control.
- Proximity of emergency contacts.

H.1.3.2 Training Requirements

The Permittees have instituted training and qualification programs to meet training requirements imposed by regulations, DOE orders, and national standards such as those published by the American National Standards Institute/American Society of Mechanical Engineers. For example, the environmental, safety, and health training program provides workers with the knowledge and skills necessary to execute assigned duties safely. Permit Attachment 5, *Hanford Facility Personnel Training Program*, describes specific requirements for the Hanford Facility Personnel Training Program. The Permittees will comply with the training matrix shown in Table H-1, which provides training requirements for Hanford Facility personnel associated with the 221-T Sand Filter Pad.

Project-specific safety training will provide the knowledge and skills that personnel need to perform work safely and in accordance with Quality Assurance (QA) requirements. Training records are maintained for each employee in an electronic training record database. The Permittee's training organization maintains the training records system.

Table H-1 Training Matrix for the 221-T Sand Filter Pad Dangerous Waste Management Unit

Training Category Course Description[a]	Frequency of Training	Training Type[b]	Job Title/Position					
			Non-T Plant Personnel or Visitor	FWS	SPOC	ECO	BED	FS
General Training	Annual	GHFT, CPT	X	X	X	X	X	X
Building Emergency	Annual	ECT					X	X
ECO Training	Initial	OT				X		
Facility Health and Safety	Annual	GHFT, CPT	X	X	X	X	X	X
Sampler	Annual	GHFT, CPT						X

a. The T Plant Complex Dangerous Waste Training Plan provides a complete description of coursework in each training category.

b. Training types defined in Permit Attachment 5.

c. This training is required only if workers are unescorted in the facility.

BED = Building Emergency Director
CPT = Contingency Plan Training
ECO = Environmental Compliance Officer
ECT = Emergency Coordinator Training
FS = Field Sampler
FWS = Field Work Supervisor
GHFT = General Hanford Facility Training
OT = Operations Training
SPOC = Single Point of Contact

H.1.4 Maintenance and Security during Closure

To maintain the 221-T Sand Filter Pad in a compliant manner during closure, measures are taken to ensure inspections are performed and security and emergency preparedness activities are in place.

H.1.4.1 Inspections

The 221-T Sand Filter Pad will be closed in a manner that demonstrates that all steps to prevent threats to HHE have been met and will continue to be taken. After closure activities have been completed, the 221-T Sand Filter Pad will be inspected annually until Ecology approves the site closure certification. Table H-2 shows annual inspection requirements that will be performed.

Table H-2 221-T Sand Filter Pad Outdoor Storage Area Inspection Schedule

Requirement Description	Frequency	Dangerous Waste Management Unit Condition*
Signage	Annual	Warning signs are present and clearly legible.
Site – General	Annual	There is no evidence that unusual conditions exist at the closing DWMU site.

*The storage area is empty of dangerous and mixed waste. "No waste in storage" or equivalent words will be entered on the inspection log.

H.1.4.2 Facility Security

The following sections document security measures in effect at the T Plant Complex.

H.1.4.2.1 Security Provisions

Located within the 200 West Area of the Hanford Facility, the T Plant Complex complies with access control and warning sign requirements pursuant to WAC 173-303-310(1) and (2), *Security*.

Security measures are used to control access to the active portions of the Hanford Facility in accordance with Permit Condition II.M, Security.

The entire Hanford Facility is a controlled access area as described in Permit Attachment 3, *Security*.

The security measures in Permit Attachment 3 and the unit-specific security measures prevent the unknowing entry, and minimize the possibility for the unauthorized entry, of persons or livestock. [WAC 173-303-310(1)]

H.1.4.2.2 T Plant Complex Access Control

Unknowing entry and the possibility for unauthorized entry of persons or livestock onto the active portions of the T Plant Complex are minimized through implementation and maintenance of the following security measures.

Access to T Plant DWMUs is controlled by an approximate 2.4 m (8 ft) high chain-link fence encircling the operating boundary (Figure H-1). A two-part swinging chain link gate at the T Plant main entrance is open during operational hours to allow vehicle and personnel ingress to the parking lot and outdoor areas. Signs are posted at the main entrance instructing all visitors to check in at 271-T Building. This gate is closed and locked when personnel are away from T Plant. Alternate vehicle access gates, found about the fenced perimeter, are closed and locked except when in use. Keys to gates are controlled and accessible only by authorized personnel. [WAC 173-303-310(2)(c)]

Upon arrival at T Plant, visitors are required to sign in at the 271-T Building administration office, and must adhere to all personal protection requirements, and are subject to escorting protocols.

Section H.1.3.2 provides the personnel training requirements for T Plant Complex operators, workers, and visitors.

Access to the 221-T Sand Filter Pad is restricted by the T Plant Complex access controls described above.

H.1.4.2.3 Warning Signs

Warning signs stating "Danger-Unauthorized Personnel Keep Out" are posted near the entrance gate of the T Plant Complex. Identical signs are posted along the perimeter fence lines at distances not to exceed 250 ft (76.2 meters) between signs. Permittees must maintain warning signs at points described in this closure plan and ensure that signs are written in English, legible from a distance of 25 ft. (approximately 7.6 m) or more, and visible from all angles of approach. [WAC 173-303-310(2)(a)]

H.1.4.3 Preparedness, Prevention, Emergency Procedures

T Plant preparedness, prevention, and emergency procedures are described in the following subsections. Contingency information is contained in the Building Emergency Plan for the T Plant Complex, as well as Permit Attachment 4, *Hanford Emergency Management Plan.*

H.1.4.3.1 T Plant Building Emergency Plan

The T Plant Complex is within the Hanford Facility. The Building Emergency Plan for the T Plant Complex describes facility-specific hazards and emergency planning and response. This site-specific plan is intended to be used in conjunction with Permit Attachment 4, *Hanford Emergency Management Plan*. If an emergency occurs, the on-call Building Emergency Director will be notified, and the requirements associated with Permit Attachment 4, *Hanford Emergency Management Plan*, and the T Plant Complex Building Emergency Plan will be implemented. A copy of the T Plant Complex Building Emergency Plan is kept in the operating record.

H.1.4.3.2 Hanford Emergency Management Plan

Permit Attachment 4, *Hanford Emergency Management Plan*, addresses site emergency management and contingency plan requirements for the Hanford Facility.

H.1.4.4 Facility Recordkeeping

Historical records that describe dangerous and mixed waste management activities within the 221-T Sand Filter Pad are retained in the operating record, which ensures proper availability and retention periods. These records describe the source of the chemicals, quantity, and hazards associated with the chemicals.

Records will be stored in either electronic or hardcopy format. Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes to ensure the accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) will be managed in accordance with the requirements therein.

H.1.5 Facility Contact Information

221-T Sand Filter Pad Operator and Property Owner:

Doug S. Shoop, Manager
U.S. Department of Energy, Richland Operations Office
P.O. Box 550
Richland, WA 99352
(509) 376-7395

221-T Sand Filter Pad Co-Operator:

L. Ty Blackford, President and Chief Executive Officer
CH2M HILL Plateau Remediation Company
P.O. Box 1600
Richland, WA 99352
(509) 376-0556

H.2 Closure Performance Standards

The 221-T Sand Filter Pad will be closed in a manner that complies with the closure performance standards in WAC 173-303-610(2)(a) and (b) and, therefore, achieves clean closure. The objectives of closure activities for the 221-T Sand Filter Pad are as follows:

- Minimize the need for further maintenance.
- Control, minimize, or eliminate to the extent necessary to protect HHE, post-closure escape of dangerous waste, dangerous constituents, leachate, contaminated runoff, or dangerous waste decomposition products to the ground, surface water, groundwater, or atmosphere.
- Remove all waste and waste residues and properly dispose of them in a RCRA permitted disposal facility.
- Perform soil sampling and analysis to ensure soils in the 221-T Sand Filter Pad meet standard Model Toxics Control Act (MTCA) cleanup levels, and remove any soils contaminated above these levels.
- Return the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity.

H.3 Closure Activities

The 221-T Sand Filter Pad will be clean closed.

The following closure activities are required to achieve and verify clean closure:

- Remove all dangerous and mixed waste inventory (completed; Section H.3.1).
- Review dangerous and mixed waste container storage, operating, and inspection records for documented spills or releases of dangerous, or mixed waste during periods of waste storage and subsequent cleanup (completed; Section H.3.2).
- Perform a visual inspection of the soil and gravel surface to identify dangerous or mixed waste related staining to identify potential for focused sample locations (completed; Section H.3.2).
- Perform soil sampling (H.4.4).
- Confirm analytical results from soil samples meet closure performance standards (Section H.3.8).
- Identify and manage contaminated environmental media (Section H.3.5).

- Identify and manage waste generated during closure (Section H.3.6).
- Transmit closure certification to Ecology (Section H.5.3).

H.3.1 Removal of Wastes and Waste Residues

No dangerous or mixed waste is currently stored at the 221-T Sand Filter Pad. The 221-T Sand Filter Pad will not be used for storage of dangerous or mixed waste in the future.

It is unknown if dangerous or mixed waste residues are present at this DWMU. There are no containers or structures in the 221-T Sand Filter Pad where dangerous or mixed waste could be present. If dangerous or mixed waste residues are found during clean closure activities, then the residues will be removed and managed as newly generated waste in accordance with Section H.3.6.

H.3.2 Operating Records Review and Visual Inspection

To support the development of this closure plan and the Sampling and Analysis Plan (SAP), a review of the T Plant Complex container storage, operating, and inspection records was completed and submitted to the operating record. The records review included the following operating record documents: facility operating logbooks (including spill reports), and waste management inspection and surveillance records. The operating records that were reviewed focused on the period during active waste storage for the T Plant Complex (i.e., January 1985 through June 2013) including:

- 271-T Cage.
- 211-T Pad.
- 221-T Sand Filter Pad.
- 277-T Outdoor Storage Area.
- 277-T Building.
- 221-T Railroad Cut.
- 2706-TB Tank System.
- 221-T Pipe Gallery Storage.
- 221-T R5 Waste Storage Area.
- 221-T Tank System.

The records review extended past the active waste storage period to June 2013. The records review indicated no releases of dangerous or mixed waste in the 221-T Sand Filter Pad. Table H-3 provides a summary of the records review.

Waste management records reviewed in Table H-3 indicate that dangerous or mixed waste may have been previously managed in the 221-T Sand Filter Pad under CAA or SAA storage areas. Since the 221-T Sand Filter Pad was not permitted for dangerous or mixed waste storage, this area lacks sufficient documentation to clearly define the dangerous waste codes associated with the waste in storage at the CAAs and SAAs. Therefore, as a conservative measure, the target analytes for the 221-T Sand Filter Pad (shown in Table H-4) were derived from the collective list of all dangerous waste codes identified during the records review of the T Plant Complex DWMUs.

Table H-3 Operating Records Review Summary

Document Title	Document Type	Timeframe of Records Reviewed		Items of Concern Noted
		Start Date	End Date	
T Plant Daily Operating Logbook	Logbook	01/02/1985	06/22/2010	No
T Plant Operation Logbook	Logbook	07/27/2010	04/07/2011	No
Waste Management Area Daily Inspection Data Sheet	Data Sheet	08/29/2005	12/01/2005	No
Waste Management Area Daily Inspection Data Sheet	Data Sheet	10/01/2007	04/22/2013	No
Weekly Surveillance Log, ≤90-day Storage Areas and Satellite Accumulation Areas	Log Sheet	06/07/1991	12/20/1999	No
Treatment Facility Waste Management Area Weekly Inspection Log Sheet Treatment Facility Waste Management Area Daily Inspection Log Sheet Treatment Facility Waste Management Area Weekly Inspection Data Sheet Treatment Facility Waste Management Area Daily Inspection Data Sheet Weekly Waste Area Surveillance T Plant Daily Waste Management Area Inspection Data Sheet	Inspection, Data and Log Sheets	01/2000 01/2005	12/2002 12/2007	No
Waste Management Area Daily Inspection Report Weekly Waste Area Surveillance	Inspection Sheets	01/2003	12/2004	Yes*
T Plant Weekly Waste Management Area Inspection Data Sheet	Data Sheet	10/18/2007	06/12/2013	No

*Item of concern was a container of Insulkote® leaking in 271-T Cage. Product was determined to be nonregulated material.

®Insulkote is a registered trademark of Industrial Insulation Group, LLC, Brunswick, Georgia.

For the purposes of focused sampling, a visual inspection was performed on August 15, 2013, to identify whether any staining was present that could be related to dangerous or mixed waste storage. No unusual or suspect staining was identified during the visual inspection; therefore, only confirmation sampling and analysis to verify clean closure will be performed.

Supporting documentation for the visual inspection is included in Attachment A, T Plant 221-T Sand Filter Pad Visual Inspection Supporting Documentation.

H.3.3 Unit Components, Parts, and Ancillary Equipment

The 221-T Sand Filter Pad consists of gravel surfaces and does not have any unit components, parts, or ancillary equipment identified for removal as part of closure.

H.3.4 Decontamination

Soil decontamination activities are not planned for the 221-T Sand Filter Pad. Equipment used during sampling will be decontaminated for re-use or disposed of and managed as newly generated waste in accordance with Section H.3.6. A small temporary decontamination area (approximately 10 by 20 feet) may be established near the 221-T Sand Filter Pad. This area will be constructed of Visqueen™ or an equivalent material, and will be used for decontamination of sampling equipment, personal protective equipment, and other miscellaneous small equipment used during sampling efforts. When decontamination of equipment is completed, the Visqueen™ or equivalent material and rinsate will be removed and managed as newly generated waste in accordance with Section H.3.6.

H.3.5 Identifying and Managing Contaminated Environmental Media

The records review and visual inspection outlined in Section H.3.2 did not identify any releases of dangerous or mixed waste or the presence of staining that could be related to dangerous or mixed waste. Contaminated environmental media (soil) removal is not anticipated. However, contaminated soil will be remediated at grid sampling locations where analytical results indicate contamination.

If contamination above closure performance standards is identified, then the nature and extent of contamination will be evaluated. Soil surrounding the grid sampling node that identified soil contamination will be removed up to a maximum of 4.6 m (15 ft) below the surface, and up to the adjacent sampling node location. Contaminated soil will be removed using equipment capable of removing the quantity of material required to complete removal. If contamination exists in the soil deeper than 4.6 m (15 ft), the Permittees will collaborate with Ecology for a path forward on closure.

Contaminated soil will be managed as a newly generated waste stream. Contaminated soil will be managed in accordance with all applicable requirements of WAC 173-303-170, *Requirements for generators of dangerous waste*, through 173-303-230, *Special conditions.* [WAC 173-303-610(5)]

The contaminated soil will be containerized, labeled, and sampled for waste characterization. Contaminated soil will be placed in U.S. Department of Transportation-compliant containers and sent to a RCRA permitted disposal facility or staged at central accumulation areas in accordance with all applicable requirements of WAC 173-303-200, *Conditions for exemption for a large quantity generator that accumulates dangerous waste*. Contaminated soil subject to the requirements of WAC 173-303-140, *Land Disposal Restrictions* (which incorporates by reference 40 Code of Federal Regulations [CFR] 268, *Land Disposal Restrictions*) will be characterized, designated, and stored or treated, as applicable, prior to disposal in a RCRA permitted disposal facility.

H.3.6 Identifying and Managing Waste Generated During Closure

There are no newly generated waste streams anticipated for the 221-T Sand Filter Pad. However, in the unlikely event that waste is generated, newly generated waste will be managed in accordance with all applicable requirements of WAC 173-303-170 through WAC 173-303-230. Once waste characterization results are received, all waste will be designated and shipped to a RCRA permitted facility for treatment, storage, or disposal. Dangerous and mixed waste will be treated, if necessary, to meet land disposal restrictions in WAC 173-303-140 (which incorporates by reference 40 CFR 268), then ultimately disposed in a RCRA permitted waste disposal facility.

Management and disposal of waste generated during closure will be documented and included as part of the clean closure certification documentation (Section H.5.3).

H.3.7 Closure Performance Standards for Soil

The presumed exposure pathways that are considered for the 221-T Sand Filter Pad are:

- WAC 173-340-740(3), Model Toxics Control Act (MTCA)—Cleanup, *Unrestricted land use soil cleanup standards*, Method B (cancer and noncancer), that considers human health based on direct soil contact.
- WAC 173-340-740(2), Table 740-1, *Method A Soil Cleanup Levels for Unrestricted Land Uses (WAC 173-340-900)*, which includes closure performance standards for human health based on unrestricted land use. MTCA Method A is only used if MTCA Method B is not available in the Cleanup Levels and Risk Calculation tables.
- WAC 173-340-747, *Deriving soil concentrations for groundwater protection,* that notes soil concentrations protective of groundwater.
- WAC 173-340-7493, *Site-specific terrestrial ecological evaluation procedures,* that considers ecological indicators (plants, biota, wildlife) in Table 749-3, *Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals (WAC 173-340-900)*.
- WAC 173-340-750, *Cleanup standards to protect air quality,* that describes human health risks due to fugitive vapors and dust.

Of the exposure pathways listed above, MTCA Method B direct soil contact, or Method A as applicable, is always considered a complete and viable exposure pathway for all soil samples. The exposure pathway for soil protective of groundwater assumes that water or rainwater on a surface has an avenue to percolate through the surface and underlying soil to groundwater. The scenario for ecological indicators requires that vegetation, biota, and wildlife be present in order for the pathway to be complete. The exposure scenario for inhalation of fugitive vapors and dust assumes a complete pathway, which would begin with a source of contaminated media and end with a receptor.

Of the viable exposure pathways, the most conservative closure performance standard is selected. Per WAC 173-340-740(5)(c), the closure performance standard value cannot be below the following:

- Hanford Site background.
- Laboratory practical quantitation limit (PQL) found in the CHPRC laboratory contracts.

If a closure performance standard is below both values, the higher of these two values is selected.

Two exposure pathways were considered complete pathways at 221-T Sand Filter Pad—direct soil contact and soil levels protective of groundwater. The ecological indicator pathway and the inhalation exposure pathway were excluded when determining 221-T Sand Filter Pad closure performance standards. Areas where grid sampling will be conducted are treated to prevent growth of vegetation, so the ecological indicator pathway was excluded. As evidenced by the site inspection and record review (Section H.3.2), there was no known source of waste-contaminated media so the inhalation exposure pathway was also excluded.

Soil grab samples will be collected following the grid sampling design described in Section H.4.4.1. Soil sampling and analysis will be conducted in accordance with the closure plan SAP located in Section H.4. Analytical results of grid samples will be evaluated in the Visual Sample Plan (VSP[1]) data analysis function to generate the Data Analysis Report and follow the MTCA three-part test (also described in Section H.4.4.1) to determine if closure performance standards (Table H-4) have been met. A copy of the VSP Data Analysis Report is to be provided to Ecology within 30 days of receipt of the final laboratory analytical report.

[1] Visual Sample Plan is a product of Pacific Northwest National Laboratory (PNNL), Richland, Washington.

If target analytes are found above closure performance standards, then the contaminated soil will be remediated and confirmatory sampling will be conducted in accordance with Section H.4.4.3 to ensure the closure performance standards are met for the remaining soil. If failed constituents of concern remain above closure performance standards after soil remediation, then the Permittees will meet with Ecology to determine a path forward for closure. The sample design for grid soil samples is discussed in Section H.4.4.1.

H.3.8 Development of Closure Performance Standards

The target analytes considered for evaluation during closure sampling and analysis were derived from a list of all waste codes identified at other T Plant Closure DWMUs. Table H-4 provides the closure performance standards for soil for each individual target analyte associated with the dangerous waste codes identified. A list of closure performance standard values for all exposure pathways was provided to Ecology in July 2017 as correspondence from DOE (17-AMRP-0217, "Dangerous Waste Management Unit [DWMU] 277-T Building Closure Plan Comment Disposition and Performance Standards for Future Solid Waste Operations Complex [SWOC] Closure Plans") which Ecology acknowledged (17-NWP-100, "Dangerous Waste Management Unit [DWMU] 277-T Building Closure Plan Comment Disposition and Performance Standards for Future Solid Waste Operations Complex [SWOC] Closure Plans"). Values in Table H-4 have been adjusted to remove nonviable pathways as noted above.

Table H-4 Closure Performance Standards for Soil and Analytical Performance Requirements

CAS Number	Waste Code(s)[a]	Analyte	Closure Performance Standards		PQL[b] (mg/kg)
			Value (mg/kg)	Basis	
SW-846 Method 6010			**Accuracy Requirement ±20% Recovery[c] Precision Requirement ≤35 RPD[d]**		
7440-38-2	D004	Arsenic[e]	2.00E+01	Background	1.00E+01
7440-39-3	D005	Barium	1.32E+02	Background	5.00E+00
7440-43-9	D006	Cadmium	6.90E-01	Groundwater Protection	5.00E-01
7439-92-1	D008	Lead	5.00E+01	Ecological – Plants	5.00E+00
7782-49-2	D010	Selenium	1.00E+01	PQL	1.00E+01
7440-22-4	D011	Silver	2.00E+00	Ecological – Plants	1.00E+00
1314-62-1 (7440-62-2)	(P120)	Vanadium pentoxide (analyzed as vanadium)	8.51E+01	Background	5.00E+00
SW-846 Method 6020			**Accuracy Requirement ±20% Recovery[c] Precision Requirement ≤35 RPD[d]**		
7440-38-2	D004	Arsenic[e]	2.00E+01	Background	1.00E+00
SW-846 Method 7196			**Accuracy Requirement ±20% Recovery[c] Precision Requirement ≤35 RPD[d]**		
18540-29-9	D007	Chromium (Hexavalent)	5.00E-01	PQL	5.00E-01
SW-846 Method 7471			**Accuracy Requirement ±20% Recovery[c] Precision Requirement ≤35 RPD[d]**		
7439-97-6	D009	Mercury[f]	2.00E-01	PQL	2.00E-01
SW-846 Method 8015			**Accuracy Requirement ±30% Recovery[c] Precision Requirement ≤30 RPD[d]**		
67-56-1	F003	Methanol	6.43E+01	Groundwater Protection	5.00E+01

Table H-4 Closure Performance Standards for Soil and Analytical Performance Requirements

CAS Number	Waste Code(s)[a]	Analyte	Closure Performance Standards		PQL[b] (mg/kg)
			Value (mg/kg)	Basis	
SW-846 Method 8260			**Accuracy Requirement ±30% Recovery[c] Precision Requirement ≤20 RPD[d]**		
67-64-1	F003	Acetone	2.89E+01	Groundwater Protection	2.00E-02
71-43-2	D018, F005	Benzene	2.82E-02	Groundwater Protection	5.00E-03
71-36-3	(U031), F003	*n*-Butyl alcohol (1-Butanol)	3.31E+00	Groundwater Protection	2.50E-01
75-15-0	F005, (P022)	Carbon disulfide	5.65E+00	Groundwater Protection	5.00E-03
56-23-5	D019, F001, F002	Carbon tetrachloride	4.60E-02	Groundwater Protection	5.00E-03
108-90-7	F002	Chlorobenzene	8.74E-01	Groundwater Protection	5.00E-03
67-66-3	D022	Chloroform	7.50E-02	Groundwater Protection	5.00E-03
108-94-1	F003	Cyclohexanone	1.74E+02	Groundwater Protection	1.00E-01
123-91-1	(U108)	1,4-Dioxane	1.00E+01	Human Health-Direct Contact (cancer)	5.00E-01
141-78-6	F003	Ethyl acetate	2.97E+01	Groundwater Protection	5.00E+00
100-41-4	F003	Ethylbenzene	2.28E+00	Inhalation (cancer)	5.00E-03
60-29-7	F003, (U117)	Diethyl ether [ethyl ether, ethoxyethane, or 1,1'-oxybis-ethane]	6.85E+00	Groundwater Protection	1.00E-02
78-83-1	F005	Isobutanol	9.70E+00	Groundwater Protection	5.00E-01
78-93-3	D035, F005	Methyl ethyl ketone (MEK) (2-Butanone)	1.96E+01	Groundwater Protection	2.00E-02
108-10-1	F003	Methyl isobutyl ketone (4-Methyl-2-Pentanone)	2.73E+00	Groundwater Protection	2.00E-02
75-09-2	F001, F002	Methylene chloride	2.18E-02	Groundwater Protection	5.00E-03
127-18-4	D039, F001, F002	Tetrachloroethylene	5.30E-02	Groundwater Protection	5.00E-03
109-99-9	(U213)	Tetrahydrofuran	3.00E+01	Groundwater Protection	1.00E+1
108-88-3	F005	Toluene	4.65E+00	Groundwater Protection	5.00E-03
71-55-6	F001, F002, (U226)	1,1,1-Trichloroethane	1.58E+00	Groundwater Protection	5.00E-03
79-00-5	F002	1,1,2-Trichloroethane	2.78E-02	Groundwater Protection	5.00E-03
79-01-6	D040, F001, F002	Trichloroethylene	2.64E-02	Groundwater Protection	5.00E-03
76-13-1	F002	1,1,2-Trichloro-1,2,2-trifluoroethane	1.11E+04	Groundwater Protection	1.00E-02
75-69-4	F002	Trichlorofluoromethane	2.82+E01	Groundwater Protection	1.00E-02
75-01-4	D043	Vinyl chloride	1.00E-02	PQL	1.00E-02
1330-20-7	F003	Xylenes (total)	1.46E+01	Groundwater Protection	1.00E-02

Table H-4 Closure Performance Standards for Soil and Analytical Performance Requirements

CAS Number	Waste Code(s)[a]	Analyte	Closure Performance Standards		PQL[b] (mg/kg)
			Value (mg/kg)	Basis	
SW-846 Method 8270			**Accuracy Requirement ±30% Recovery[c] Precision Requirement ≤30 RPD[d]**		
95-48-7	F004	*o*-Cresol, reported as total cresols[f]	2.33E+00	Groundwater Protection	3.33E-01
121-14-2	D030	2,4-Dinitrotoluene	3.33E-01	PQL	3.33E-01
95-50-1	F002	1,2-Dichlorobenzene (Ortho-dichlorobenzene)	7.03E+00	Groundwater Protection	3.33E-01
111-44-4	(U025)	bis (2-chloroethyl) ether (dichloroethyl ether)	3.33E-01	PQL	3.33E-01
67-72-1	D034	Hexachloroethane	3.33E-01	PQL	3.33E-01
98-95-3	F004,	Nitrobenzene	3.33E-01	PQL	3.33E-01
87-86-5	D037	Pentachlorophenol	6.60E-01	PQL	6.60E-01
110-86-1	F005	Pyridine	6.60E-01	PQL	6.60E-01
SW-846 Method 9012			**Accuracy Requirement ±20% Recovery[c] Precision Requirement ≤35 RPD[d]**		
57-12-5	(P030)	Cyanides, Total[g] (soluble cyanides salts)	1.92E+01	Inhalation (noncancer)	1.00E+00
SW-846 Method 9056			**Accuracy Requirement ±20% Recovery[c] Precision Requirement ≤35 RPD[d]**		
64-18-6	(U123)	Formic Acid (measured as Formate)	7.20E+04	Human Health – Direct Contact (noncancer)	2.00E+00
Not Analyzed			**Not Analyzed**		
CAS Numbers	**Waste Code(s)**	**Analyte**	**CAS Numbers**	**Waste Code(s)**	**Analyte**
75-07-0	(U001)	Acetaldehyde[i]	1338-23-4	(U160)	MEK peroxide[j] (2-Butanone peroxide)
75-36-5	(U006)	Acetyl chloride[j]	79-46-9	F005	2-Nitropropane[i]
107-20-0	(P023)	Chloroacetaldehyde[k]	1314-80-3	(U189)	Phosphorus pentasulfide[j]
110-80-5	F005, (U359)	2-Ethoxyethanol[l]	N/A	F001, F002	Chlorinated fluorocarbons[m]

References:

17-AMRP-0217, "Dangerous Waste Management Unit (DWMU) 277-T Building Closure Plan Comment Disposition, and Performance Standards for Future Solid Waste Operations Complex (SWOC) Closure Plans."

17-NWP-100, "Dangerous Waste Management Unit (DWMU) 277-T Building Closure Plan Comment Disposition and Performance Standards for Future Solid Waste Operations Complex (SWOC) Closure Plans."

DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*.

ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*.

Ecology, 2013, "Issues associated with Establishing Soil Cleanup Levels for arsenic."

Ecology, 2019, *Cleanup Levels and Risk Calculation (CLARC) Data Tables, Toxics Cleanup Program*.

Howard et al., 1991, *Handbook of Environmental Degradation Rates*.

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, Third Edition; Final Update V.

Table H-4 Closure Performance Standards for Soil and Analytical Performance Requirements

CAS Number	Waste Code(s)[a]	Analyte	Closure Performance Standards		PQL[b] (mg/kg)
			Value (mg/kg)	Basis	

WAC 173-340, *Model Toxics Control Act—Cleanup*.

173-340-740, *Unrestricted land use soil cleanup standards*.

173-340-747, *Deriving soil concentrations for groundwater protection*.

Notes: Screening levels considered when developing closure performance standards were drawn from the following:

- MTCA (WAC 173-340-740, *Model Toxics Control Act–Cleanup, Unrestricted land use soil cleanup standards*) (Ecology, 2019, *Cleanup Levels and Risk Calculations (CLARC) Tables*, May 2019 data tables are most recent). MTCA Method B values represent both cancer and noncancer human health risk values from direct soil contact. The most conservative value of the two Method B published values will be used. Method A values are substituted when MTCA Method B values are not provided in the CLARC tables.
- WAC 173-340-747. Section 4 describes the fixed parameter three-phase partitioning model. Where applicable, these values were used. Values selected were from the 25°C vadose zone. If values were not listed for 25°C, values from the 13°C vadose zone were used.
- Background levels as published in ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*, and DOE/RL-92-24, *Hanford Site Background: Soil Background for Nonradioactive Analytes*. Background values were used at the 90th percentile of calculated Hanford background values.
- Closure performance standard values for all exposure pathways were provided to Ecology in July 2017 correspondence from DOE (17-AMRP-0217) and which values Ecology acknowledged (17-NWP-100). Values in this table have been adjusted to remove nonviable pathways.
- Values taken from the above resources that fell below background levels were not considered.

a. Many of the chemicals listed in this table also have P and U waste codes associated with them (WAC 173-303-9903, *Discarded chemical products lists*). (1) These codes are listed in the table because it is unknown whether or not the waste container had a “discarded chemical product” (per WAC 173-303-081) or if it was a chemical contaminant of the waste. (2) The P and U code designations do play a part in the determination of dangerous waste criteria (WAC 173-303-100), as they indicate that chemical as either acutely hazardous (P) or dangerous (U) waste based on toxicity and/or persistence calculations. For these reasons, the P and U codes are listed in parentheses.

b. Highest allowable PQL will be defined in the individual laboratory contract with CHPRC. In practice, the laboratory PQL values have the potential to be lower.

c. Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation based on statistical control of laboratory control samples is also performed. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analyses.

d. Precision is determined by the laboratory based on historical data or statistically derived control limits. Limits are reported with the data. Where specific acceptance criteria are listed, those acceptance criteria may be used in place of statistically derived acceptance criteria.

e. Arsenic – the Hanford Site closure performance standard is 20 mg/kg based on a letter (Ecology, 2013, “Issues Associated with Establishing Soil Cleanup Levels for Arsenic”) indicating that the Method A soil closure performance standard of 20 mg/kg can be used to define natural background levels when developing Method B soil closure performance standards for the Hanford Site. One of the two methods (SW-846 6010 or 6020) may be used.

f. Mercury – Equation 740-1 and Equation 740-2 from WAC 173-340-740(3)(b) are used to calculate the MTCA Direct Contact Human Health soil closure performance standards. The MTCA human health direct contact soil closure performance standard for mercury is calculated to be 24 mg/kg.

g. Cresols – the closure performance standard for *o*-cresol will be reported as total cresols: a total of the three isomeric forms: *o*-cresol, m-cresol, and *p*-cresol.

h. Cyanides – Copper (P029), potassium (P098), and sodium cyanides (P106), as well as other cyanide salts not specified will be analyzed as total cyanide.

i. Acetaldehyde and 2-nitropropane are listed with inhalation values in the CLARC Tables. However, because the inhalation pathway is not being addressed as part of this closure plan, they will not be analyzed.

j. Acetyl chloride, MEK peroxide, and phosphorus pentasulfide are not listed in the CLARC Tables. They would most likely be inhalation hazards if present (based on NIOSH chemical hazard data), so they are not being calculated as closure performance standards and will not be analyzed.

Table H-4 Closure Performance Standards for Soil and Analytical Performance Requirements

CAS Number	Waste Code(s)[a]	Analyte	Closure Performance Standards		PQL[b] (mg/kg)
			Value (mg/kg)	Basis	

k. Chloroacetaldehyde – No previous records of analysis on the Hanford Site. CAS is not listed in the CLARC tables. Chloroacetaldehyde is not listed in the CLARC Tables. It would most likely be an inhalation hazard if present, so it is not being calculated as a closure performance standard and will not be analyzed.

l. 2-Ethoxyethanol – Due to the extremely short half-life of 2-ethoxyethanol (between 168 hours and 672 hours), its presence in soil samples is highly unlikely; therefore, samples will not be analyzed for this constituent. Degradation rates from Howard et al., 1991, *Handbook of Environmental Degradation Rates*, p. 420.

m. A CFC is an organic compound that contains only carbon, chlorine, and fluorine, produced as a volatile derivative of methane, ethane, and propane. Examples of CFCs include 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-133) and trifluoromethane (CFC-11).

CAS = Chemical Abstract Services
CFC = chlorofluorocarbon
CHPRC = CH2M HILL Plateau Remediation Company
CLARC = Cleanup Levels and Risk Calculation
MTCA = *Model Toxics Control Act—Cleanup*
N/A = not applicable
PQL = Practical Quantitation Limit
RPD = relative percent difference

H.3.9 Conditions that will be Achieved when Closure is Complete

Upon completion of the closure activities, the 221-T Sand Filter Pad will remain in an "as-is" state with the gravel remaining in place. Once Ecology accepts the clean closure certification, a permit modification request will be submitted to remove the 221-T Sand Filter Pad DWMU from the Permit.

H.4 Sampling and Analysis Plan

Sampling and analysis of the 221-T Sand Filter Pad soil will be conducted to confirm whether closure performance standards have been met. Sampling includes 21 grid (area-wide) soil samples (Section H.4.4.1). Analysis will be performed in accordance with the sampling and quality standards established in this closure SAP.

H.4.1 Sampling and Analysis Plan Requirements

Sampling and analysis activities were designed using the EPA guidance document EPA/240/R-02/005, *Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan* (EPA QA/G-5S) and Ecology Publication #94-111, and will be conducted via this SAP. The objective of the sampling described in this section is to determine if the closure performance standards (Table H-4) established in this closure plan pursuant to WAC 173-303-610(2)(b)(i) and WAC 173-303-610(2)(b)(ii) have been satisfied, demonstrating clean closure of the 221-T Sand Filter Pad.

The closure SAP details sampling and analysis procedures in accordance with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods,* Third Edition; Final Update V; the American Society for Testing and Materials (ASTM) *Annual Book of ASTM Standards* (ASTM International 2017); and applicable EPA guidance. Sampling and analysis activities will meet applicable requirements of SW-846, ASTM standards, and EPA-approved methods at the time of closure. This SAP was also developed using guidance from Ecology Publication #94-111, Section 7.0, Sampling and Analysis for Clean Closure, and EPA/240/R-02/005.

H.4.2 Sampling and Analysis Schedule

Closure sampling and analysis will be performed in accordance with the closure plan schedule located in Section H.6.

H.4.3 Project Management

The following subsections address project management and ensure that the project has defined goals, participants understand the goals and approaches used, and planned outputs are appropriately documented. Project management roles and responsibilities discussed in this section apply to the major activities covered under this SAP.

H.4.3.1 Project/Task Organization

The Permittees are responsible for planning, coordinating, sampling, preparing, packaging, and shipping samples to the contract analytical laboratory. The project has the following key positions.

Regulatory Representative. Ecology will assign an Ecology employee as Project Manager responsible for oversight of the 221-T Sand Filter Pad closure.

Project Manager and Technical Lead. The CHPRC Project Manager provides oversight of closure activities and coordinates with the U. S. Department of Energy, Richland Operations Office (DOE-RL), Ecology, and contract management. In addition, support is provided to the project technical lead to ensure that work is performed safely and cost effectively.

The Project Manager (or designee) for the 221-T Sand Filter Pad closure sampling is responsible for direct management of sampling documents and requirements, field activities, and subcontracted tasks. The Project Manager is responsible for ensuring that project personnel are working to the approved version of the 221-T Sand Filter Pad Closure Plan in the Permit and for providing updates to field personnel.

The Project Manager works closely with QA, Health and Safety, and the Field Work Supervisor (FWS) to integrate these and other lead disciplines in planning and implementing the work scope. The Project Manager also coordinates with DOE-RL and the primary contractor management on all sampling activities. The Project Manager supports DOE-RL in coordinating sampling activities with the Regulatory Representative.

Environmental Compliance Officer. The Environmental Compliance Officer provides technical oversight, direction, and acceptance of project and subcontracted environmental work, and develops appropriate mitigation measures with a goal of minimizing adverse environmental impacts.

Health and Safety. The Health and Safety organization is responsible for coordinating 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 internal primary contractor work requirements.

Waste Management Lead. The Waste Management Lead communicates policies and protocols, and ensures project compliance for storage, transportation, disposal, and waste tracking.

Field Work Supervisor. The FWS is responsible for planning and coordinating field sampling resources. The FWS ensures that samplers are appropriately trained and available. Additional related responsibilities include ensuring that the sampling design is achievable, understood, and can be performed as specified.

The FWS must document all deviations from procedures or other problems pertaining to sample collection, chain of custody (COC) protocols, analytes, sample analysis, sample transport, or noncompliant monitoring. As appropriate, such deviations or problems will be documented in the field logbook or in nonconformance report forms in accordance with internal corrective action procedures. The FWS is responsible for communicating field corrective actions to the Project Manager and for ensuring that immediate corrective actions are applied to field activities.

Sample Management and Reporting. The Permittee's sampling organization coordinates field sampling as well as laboratory analytical work, ensuring that laboratories conform to the specifications of SW-846 analytical methodology at the time of closure. The sampling organization receives the analytical data from the laboratories, performs the data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation. The sampling organization is responsible for informing the Project Manager of any issues reported by the contract analytical laboratory.

Contract Laboratories. The contract laboratories analyze samples in accordance with established procedures and provide necessary sample reports and explanation of results in support of data validation.

The roles described above make up the project organization structure (regarding sampling and analysis) and interact in a manner shown graphically in Figure H-4.**Error! Reference source not found.**

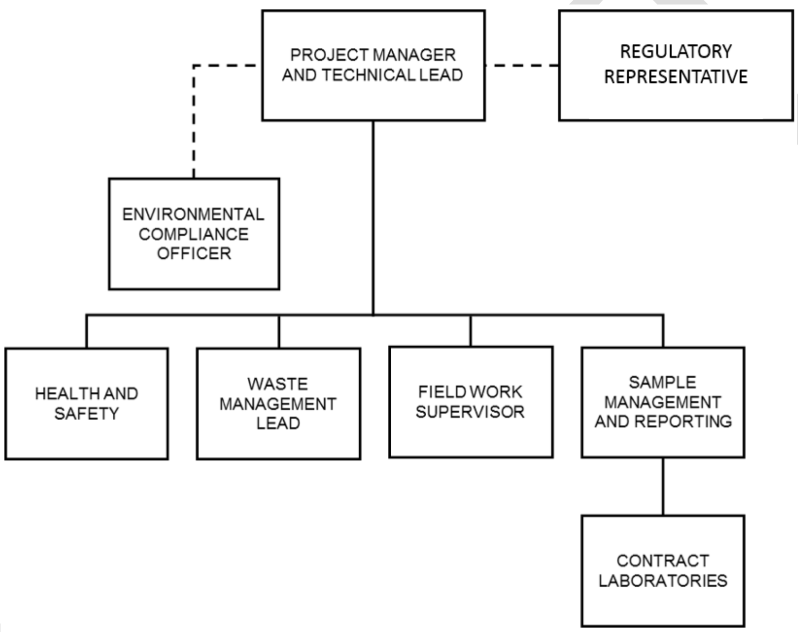

Figure H-4 Sampling and Analysis Plan Project Organization

H.4.3.2 Field Sampler Training/Certification

Training records of field samplers are maintained by the sampling organization, retained in the electronic training record database, or archived with operating records. Field samplers will be collecting grab soil samples of the soil for analysis to determine if closure performance standards have been met.

H.4.3.3 Sampling Documents and Records

The Project Manager is responsible for ensuring that the current version of the SAP is being used and providing any updates to field personnel. Version control is maintained by the administrative document control process. Changes to the SAP affecting the data needs will be submitted as a permit modification request.

Logbooks are required for field activities. A logbook must be identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook and only authorized persons may make entries in logbooks. After review, logbooks will be signed by the field manager, supervisor, cognizant scientist/engineer, or other responsible individual. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

The Project Manager is responsible for ensuring that a project file is properly maintained. The project file will contain the records or references to their storage locations. The following items will be included in the project file, as appropriate:

- Field logbooks or operational records.
- Global positioning system data.
- Sample authorization forms.
- Data forms.
- COC forms.
- Sample receipt records.
- Inspection or assessment reports and corrective action reports.
- Interim progress reports.
- Final reports.
- Laboratory data packages.
- Data verification and validation reports.

The contract analytical laboratory is responsible for maintaining, and having available upon request, the following items:

- Analytical logbooks.
- Raw data and Quality Control (QC) sample records.
- Standard reference material or proficiency test sample data.
- Instrument calibration information.

Records may be stored in either electronic or hard copy format. Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes to ensure the accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) will be managed in accordance with the requirements therein.

H.4.4 Sampling Design and Analysis

The sampling design includes input parameters used to determine the number and location of samples. The primary purpose of sampling the soil is to determine if analytical results meet closure performance standards (Table H-4).

H.4.4.1 Sampling Process Design

This SAP takes guidance from Ecology Publication #94-111, Section 7.0, to determine the type of sampling design that will be used to demonstrate clean closure. When designing the sampling plan, area-wide (grid or random) sampling methods were considered. The basis for grid (area-wide) sampling is described in the following paragraphs.

Grid (Area Wide) Soil Sampling. Ecology Publication #94-111, Section 7.2.1, Area Wide Sampling, identifies that grid sampling is appropriate when the spatial distribution of contamination at or from the closure unit is uncertain. Ecology Publication #94-111, Section 7.3, Sampling to Determine or Confirm Clean Closure, identifies the grid sampling approach as generally appropriate for sampling to determine or confirm whether closure performance standards are met.

In grid sampling, grab samples are collected at regularly-spaced intervals (called sample node locations) over an area. An initial location or time is chosen at random, and then the remaining sample node locations are defined so that locations are at regular intervals over an area (grid). Grid sampling is used to search for hot spots and to infer means, percentiles, or other parameters and is useful for estimating spatial patterns or trends over time. This design provides a practical method for designating grab sample node locations and ensures uniform coverage of a site, unit, or process.

The quantity and location of sample nodes for the soil and gravel areas within the 221-T Sand Filter Pad were determined using the VSP software. VSP is a tool used throughout Washington State and nationally that statistically determines the quantity of samples required to accept or reject the null hypothesis based on input parameters specific to the unit or area. A null hypothesis is generally assumed true until evidence indicates otherwise. The null hypothesis, as defined in WAC 173-340-200, *Definitions*, for the 221-T Sand Filter Pad is that soil is assumed to be above closure performance standards as defined in Sections H.3.7 and H.3.8. Therefore, the soil is presumed to be contaminated. Rejection of the null hypothesis means results of field sampling and laboratory analysis indicated that soil meets closure performance standards.

Should sampling and analysis provide a basis that the null hypothesis can be accepted, such an event will be considered an unexpected event during closure, and the soil would then be identified as contaminated environmental media and managed in accordance with Section H.3.5.

For grid sampling determination in VSP, both parametric and nonparametric equations rely on assumptions about the data population. Typically, however, nonparametric equations require fewer assumptions and allow for more uncertainty about the distribution of data. Alternatively, if parametric assumptions are valid, the required number of samples is usually less than if a nonparametric equation was used.

For the 221-T Sand Filter Pad, data assumptions were based on a DQO process performed in accordance with EPA/240/R-02/005. VSP parameter inputs, which are based on the DQO process, are detailed in Table H-5.

The decision rule for demonstrating compliance with the MTCA (WAC 173-340) Method B closure requirements includes a three-part test that compares sample results to the closure performance standards:

- The 95% upper confidence limit on the true data mean must be less than the MTCA Method B closure performance standard.
- No sample concentration can be more than twice the closure performance standards.
- Less than 10% of the samples can exceed the closure performance standards.

Using a nonparametric test and the input parameters identified in Table H-5, VSP calculated that 25 samples would adequately describe the population. With this level of confidence in the population description, the null hypothesis could be rejected with 95% confidence and ensure that a site would not be mistakenly released as clean (uncontaminated). The VSP software compares the site mean to a fixed threshold in order to accept or reject the null hypothesis. Data will be evaluated to ensure that less than 10% of the individual values exceed MTCA (WAC 173-340) Method B closure performance standards and that no values are more than twice the closure performance standard.

Grid sample node locations were determined using the grid with a random start sampling method run in the VSP software. Statistical analysis of systematically collected data is valid if a random start to the grid is used. The dimensions of the 221-T Sand Filter Pad were entered into VSP to determine the locations of the sample nodes. The triangular grid sampling layout was determined to have an even distribution over the soil and gravel areas within the 221-T Sand Filter Pad; thus, providing the most representative data set including coverage of the middle portion of the sampling area. The 25 samples will be taken from the node locations indicated by the VSP software (shown in Figure H-5) and will be assigned sample location identifications and sample numbers using the HEIS database.

The first node location is chosen at random by the VSP software, and the subsequent 24 sample locations are assigned by the VSP software using a triangular grid sampling method to achieve an even distribution.

Supporting documentation for the VSP software sampling designations is provided in Attachment B, T Plant 221-T Sand Filter Pad Visual Sample Plan Supporting Documentation.

Table H-5 Visual Sample Plan Parameter Inputs for Grid (Area-Wide) Soil Sampling

Parameter	Value	Basis
Primary Objective of the Sampling Design	Null hypothesis	Compare a site mean or median to a fixed threshold. The basis is that the null hypothesis is true (site is contaminated). Clean closure requires rejection of the null hypothesis.
Type of Sampling Design	Nonparametric	Data are not assumed to be normally distributed.
Working Null Hypothesis	The mean value exceeds the threshold	The null hypothesis assumes that the site is dirty requiring the sampling and analysis to demonstrate through statistical analysis that the site is clean (MTCA [WAC 173-340] Method B closure performance standards).
Grid Sampling Pattern	Triangular	A triangular pattern provided an even distribution of sample locations over soil and gravel areas within the 221-T Sand Filter Pad.
Standard Deviation (S)	45%	This is the assumed standard deviation value relative to a unit action level for the sampling area. The value of 45% is conservative, based on consideration of past verification sampling. (Number of samples calculated increases with higher standard deviation values relative to a unit action level.)
Delta (Δ)	40%	This is the width of the grey region. It is a user-defined value relative to a unit action level. The value of 40% balances unnecessary remediation cost with sampling cost. A Type II error with the grey region would result in cleanup of a site that is already clean.
Alpha (α)	5%	This is the acceptable error of deciding a dirty site is clean when the true mean is equal to the action level. It is a maximum error rate since dirty sites with a true mean above the action level will be easier to detect. A value of 5% was chosen as a practical balance between health risks and sampling cost.
Beta (β)	20%	This is the acceptable error of deciding a clean site is dirty when the true mean is at the lower bound of the gray region. A value of 20% was chosen during the DQO process as a practical balance between unnecessary remediation cost and sampling cost.
MARSSIM sampling overage	20%	MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of *n*.

References: EPA 402-R-97-016, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*.

WAC 173-340, *Model Toxics Control Act—Cleanup*.

DQO = data quality objective

MTCA = *Model Toxics Control Act—Cleanup*

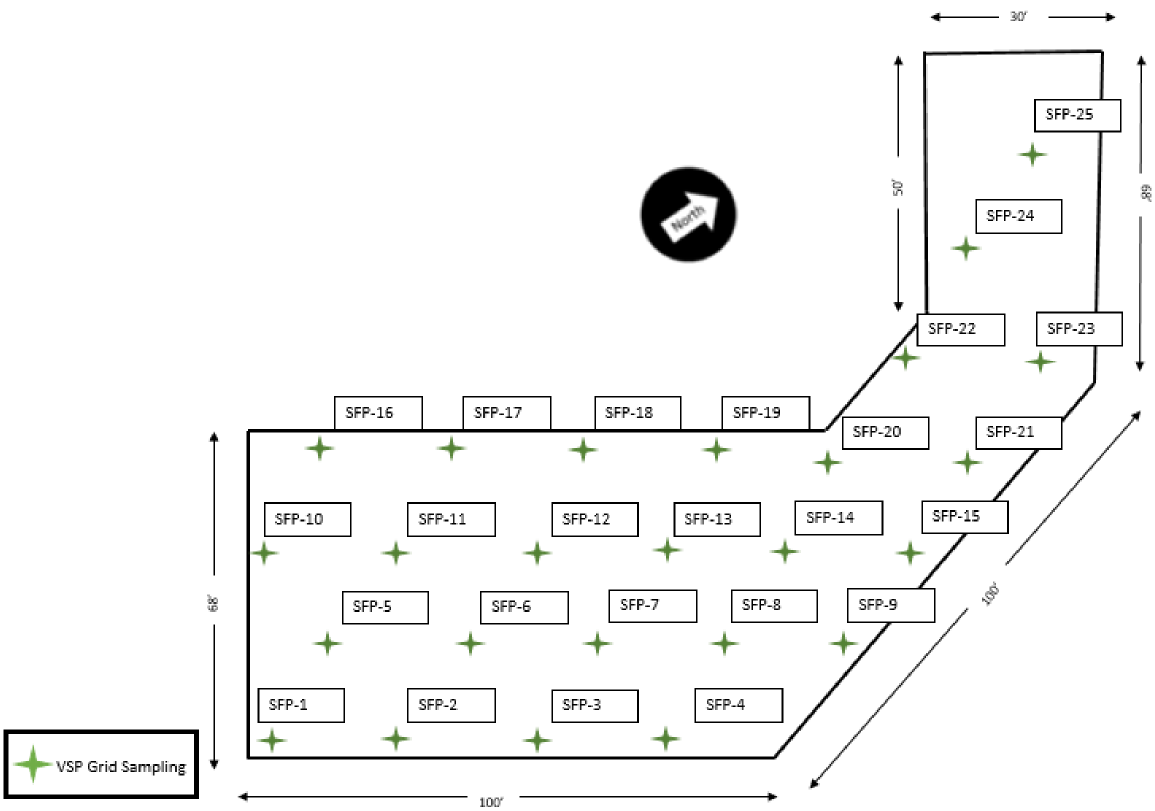

Figure H-5 Grid Sampling Locations

H.4.4.2 Sampling Methods and Handling

The grab sample matrix will consist of soil collected in clean sample containers. Soil will be collected at a depth of no more than 6 in. (approximately 15 cm) below ground surface, unless staining or discoloration indicates contamination is below that depth. For the purpose of this SAP, ground surface is defined as the exposed surface layer once loose gravel has been removed. Once the soil is collected, the sampled media will be screened to remove material larger than approximately 0.08 in. (2 mm) in diameter, which allows for a larger surface area-to-volume ratio. This ratio increases the likelihood of identifying any potential contamination in the sample.

To ensure sample and data usability, sampling will be performed in accordance with established sampling practices, procedures, and requirements pertaining to sample collection, collection equipment, and sample handling. Sampling includes the following:

- Preparation and review of sampling paperwork such as COC or labels.
- Sample container and equipment preparation.
- Field walkdown of sample area (includes locating and marking sample locations).
- Sample collection.
- Sample packaging and shipping.

Sample preservation and holding time requirements are specified in Table H-6. These requirements are in accordance with the analytical method specified. The final container type and volumes will be identified on the sampling authorization form and COC form.

Table H-6 Preservation, Container, and Holding Time Requirements for Soil Samples

EPA Method	Analysis (Analytes)	Preservation Requirement	Holding Time	Bottle Type
6010	ICP-AES (Metals)	None	180 days	G/P
6020	ICP-MS (Metals)	None	180 days	G/P
7196	Colorimetric (Hexavalent Chromium)	Cool ≤6°C	30 days prior to extraction; 7 days after extraction	G/P
7471	Cold Vapor atomic absorption (Mercury)	Cool ≤6°C	28 days	G/P
8015	GC/Flame Ionization Dectector (Non-halogenated Organics [Methanol])	Cool ≤6°C	14 days	G
8260	GC/MS (Volatile Organic Compounds)	Frozen*	14 days	G
8270	GC/MS (Semivolatile Organic Compounds)	Cool ≤6°C	14 days prior to extraction; 40 days after extraction	Amber Glass
9012	Colorimetric (Total Cyanide)	Cool ≤6°C	14 days from sampling to extraction; 40 days from extraction to analysis	G/P
9056	Ion Chromatography (Inorganic anions [Formic acid as Formate])	Cool ≤6°C	28 days	G/P

Reference: SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, Third Edition; Final Update V.

*Preservation techniques for soil samples collected include refrigeration immediately following collection (placing on ice) and freezing overnight prior to shipping. Holding times are from sampling to analysis unless specified otherwise.

AES = atomic emission spectrometry
EPA = U.S. Environmental Protection agency
GC = gas chromatography
ICP = inductively coupled plasma
MS = mass spectrometry
G/P = glass/plastic

A sampling and data-tracking database (e.g., HEIS) is used to track the samples from the point of collection through the laboratory analysis process. HEIS sample numbers are issued to the sampling organization for the project. Each sample is identified and labeled with a unique HEIS sample number.

To prevent potential contamination of the samples, clean equipment will be used for each sampling activity. Equipment used during sampling will be decontaminated or disposed of and managed as newly generated waste in accordance with Section H.3.6. Level I EPA pre-cleaned sample containers will be used for samples collected for chemical analysis. Container sizes may vary, depending on laboratory-specific volumes/requirements for meeting the PQL.

The date and time of sample collection, and the sample location, depth, and corresponding HEIS numbers will be documented in the sampler's field logbook. A custody seal (e.g., evidence tape) will be affixed to each sample container (except for Volatile Organic Analysis [VOA] sample containers) or the sample collection package in such a way as to indicate potential tampering. The custody seal will be inscribed with the sampler's initials and date. Custody tape is not applied directly to VOA sample containers based on the potential for affecting analyte results or fouling of laboratory equipment. Alternatively, VOA vials are placed in a sealable plastic bag affixed with custody seals and any other required labels/documentation.

Data verification and validation will also note any issues with sample collection and analysis. Each sample container will be labeled with the following information on firmly affixed, water-resistant labels:

- Sample authorization form and form number.
- HEIS number.
- Sample collection date and time.
- Sampler identification (e.g., initials).
- Analysis required.
- Preservation method (if applicable).
- COC identification number.

In addition to the container label information, sample records must include:

- Sample location.
- Matrix (e.g., soil).

Sample custody will be maintained in accordance with existing Hanford Facility protocols to ensure maintenance of sample integrity throughout the analytical process. COC protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A COC record is initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory. At a minimum, the following information must be identified on a completed COC record:

- Collector(s) names.
- Project designation.
- Unique sample numbers.
- Date, time, and location (or traceable reference thereto) of sample collection.
- Chain of possession information (i.e., signatures/printed names of all individuals involved in the transfer of sample custody and storage locations, dates of receipt and relinquishment).

Additional information regarding the sample and specific analytical instructions may also be documented.

Discrepancies with the sample material (unusual color, texture, or odor), collection techniques, containers, or transfer packages are noted in the field logbook, communicated with the Project Manager, and corrective actions are initiated. For example, where a custody seal is damaged or missing, each case is individually reviewed for usability of the sample. The damaged or missing seal and action taken will be documented in the final data package. Data verification and validation will also note any issues with sample collection and analysis.

Contaminated environmental media and newly generated waste resulting from sampling activities will be handled in accordance with all applicable requirements of WAC 173-303-170 through WAC 173-303-230 as outlined in Sections H.3.5 and H.3.6.

H.4.4.3 Sampling and Analysis Requirements to Address Removal of Contaminated Soil

In the event that grid sample results based on the MTCA Method B (WAC 173-340) three-part test (Section H.4.4.1) indicate contamination above clean closure performance standards, then the contaminated soil from the node locations(s) that indicated contamination will be removed and managed in accordance with Section H.3.5.

Following remediation of the contaminated soil, VSP will be used to generate a new grid sampling design. The new grid sampling design will use a new random start point and new grid-node sampling locations, in accordance with the same model parameters established in Section H.4.4.1. Grab samples collected from the new grid-node locations will be analyzed for the constituents that previously did not meet closure performance standards. The new sample results will be analyzed to confirm clean closure as described in Section H.5.1. If the new sample results meet the closure performance standards, the site will be considered clean. If the new sample results do not meet the closure performance standards, then the Permittees will meet with Ecology to determine a path forward for closure.

The new grid sampling design, analytical results, and corresponding VSP report documentation will be provided as supporting information with the closure certification as described in Section H.5.3.

H.4.4.4 Analytical Methods

All analyses and testing will be performed consistent with this closure plan, laboratory contracts, and laboratory analytical procedures at the time of closure. The contracted analytical laboratory must achieve the lowest PQLs consistent with the selected analytical method (identified in Table H-4) in order to confirm that the closure performance standards are met.

H.4.4.5 Quality Control

QC procedures must be followed in the field and laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability. Field QC samples include the collection of:

- Field trip blanks.
- Field transfer blanks.
- Equipment rinsate blanks.
- Field duplicates.

Laboratory QC samples estimate the precision and bias of the analytical data. Laboratory QC samples include:

- Method blanks.
- Laboratory duplicates.
- Matrix spikes.
- Matrix spike duplicates.
- Surrogates.
- Laboratory control samples.

Field and laboratory QC samples are summarized in Table H-7.

Table H-7 Project Quality Control Sampling Summary

QC Sample Type	Frequency	Characteristics Evaluated
Field QC		
Field Trip Blanks	One per 20 samples, minimum of one per decision unit	Field trip blanks are used to assess contamination from sample containers or during transportation and storage procedures.
Field Transfer Blanks	One per day that volatile organic compounds are sampled	Field transfer blanks are used to assess contamination from surrounding sources during sample collection.
Equipment Rinsate Blanks	One per 20 samples per analytical method	Equipment rinsate blanks are used to measure the cleanliness of sampling equipment and effectiveness of equipment decontamination procedures. Equipment rinsate blanks are not required if only disposable equipment is used, or if rinsing between samples is not practical (e.g., core drilling equipment).
Field Duplicates	One per 20 samples with a minimum of one per decision unit	Field duplicates are used to assess the precision of the entire data collection activity, including sampling, analysis, and site heterogeneity.
Laboratory QC*		
Method Blanks	One per batch	Method blanks measure contamination associated with laboratory sample preparation and analysis.
Laboratory Duplicates	One per laboratory analytical batch	Laboratory duplicates measure laboratory reproducibility and precision.
Matrix Spikes	One per laboratory analytical batch	The matrix spike recovery measures the effects of interferences in the sample matrix and reflects the accuracy of the determination.
Matrix Spike Duplicates	One per laboratory analytical batch	The relative percent difference between matrix spikes and matrix spike duplicates measures the precision of a given analysis.
Surrogates	Added to each sample and QC (laboratory and field) sample	Surrogate standards are added prior to extraction of the sample to evaluate accuracy, method performance, and extraction efficiency.
Laboratory Control Samples	One per laboratory analytical batch	The laboratory control samples measure the accuracy of the analytical methods.

*Batching across projects is allowed for similar matrices.

H.4.5 Data Review, Verification, Validation, and Usability Requirements

Analytical results will be received from the contract analytical laboratory, loaded into a database (e.g., HEIS), and verified in accordance with Section H.4.5.1. A total of 5% of the data will be validated as described in Section H.4.5.2. Grid soil sample results will be evaluated to ensure VSP model assumptions were correct (Section H.4.5.3) and a data quality assessment (DQA) will be conducted to ensure the output of the DQO process provided appropriate values (Section **Error! Reference source not found.**).

H.4.5.1 Data Verification

Verification activities ensure analytical data in the database were properly uploaded and reflect the contract laboratory program equivalent data packages. The steps outlined below will consider both the primary and QC samples. Activities will include, but are not limited to, the following:

- Amount of data requested matches the amount of data received (number of samples for requested methods of analytes).
- Correct procedures/methods are used.
- Issues with sample collection and analysis are noted.
- Documentation/deliverables are complete.
- Hard copy and electronic versions of the data are identical.
- Data is reasonable based on analytical methodologies.

H.4.5.2 Data Validation

The contract analytical laboratory supplies the equivalent of contract laboratory program analytical data packages intended to support data validation by the third party. These data packages are supported by QC test results and raw data. Data validation includes both primary and QC samples, and considers issues with sample collection and analysis.

Controls are in place to preserve the data sent to the validators, such as allowing only additions to be made, not changes to the raw data. The format and requirements for data validation activities are based on the most current version of EPA-540-R-08-01, *National Functional Guidelines for Superfund Organic Methods Data Review* (OSWER 9240.1-48), and EPA-540-R-10-011, *National Functional Guidelines for Inorganic Superfund Data Review* (OSWER 9240.1-51). As defined by the validation guidelines, 5% of the analytical results will undergo Level C validation.

H.4.5.3 Verification of Visual Sample Plan Input Parameters

Analytical data from grid soil sampling will be entered back into the VSP data analysis function to generate the Data Analysis Report. If all analytical data for a particular analyte are nondetectable at levels below the closure performance standard, then verification of VSP input parameters is not required for that analyte. VSP software uses the analytical data to determine if the user input parameters were estimated appropriately.

Once analytical data are entered into VSP, the software will calculate the true standard deviation and determine if the null hypothesis can be rejected (Section H.4.4.1). If the calculated standard deviation is smaller than the estimated user input standard deviation, then no additional sampling will be required. If the calculated standard deviation is larger than the estimated standard deviation, then additional sampling may be required.

Verification of the null hypothesis through VSP will determine if the mean value of the site analytical data supports rejection of the null hypothesis (Section H.4.4.1). If additional statistical tools are identified, such as EPA's ProUCL[2], then they will be used, as appropriate, to augment evaluation of the data set.

H.4.5.4 Data Quality Assessment

A DQA will be performed on the final data using the guidance in EPA/240/B-06/002, *Data Quality Assessment: A Reviewer's Guide* (EPA QA/G-9R), and implementing the specific requirements in Sections H.4.5.1 through H.4.5.3.

H.4.6 Revisions to the Sampling and Analysis Plan and Constituents to be Analyzed

Changes to the SAP may be necessary due to unexpected events during closure. An unexpected event would be an event outside the scope of the SAP or a condition that inhibits implementation of the SAP as written. Revisions to the SAP will be submitted no later than 30 days after the unexpected event as a permit modification request. [WAC 173-303-610(3)(b)]

H.5 Confirmation and Certification of Closure Activities

Confirmation of closure will be performed using methods defined in Section H.5.1. Closure certification is performed by an Independent Qualified Registered Professional Engineer (IQRPE) (Section H.5.2). Certification will be submitted to Ecology as described in Section H.5.3, and the conditions of the DWMU after closure are described in Section H.3.9. The timing of closure is described in Section H.6.

H.5.1 Confirmation of Clean Closure

The 221-T Sand Filter Pad will be confirmed clean closed through sampling of soil. Soil sample results from the contract analytical laboratory will be reviewed to confirm that target analytes meet closure performance standards (Sections H.3.7 and H.3.8). Once it has been determined that the soil sample results have met closure performance standards, the soils and gravel in the 221-T Sand Filter Pad will be considered clean.

Once clean closure has been confirmed for the 211-T Sand Filter Pad DWMU, a closure certification will be prepared in accordance with Section H.5.3.

H.5.2 Role of the Independent Qualified Registered Professional Engineer

An IQRPE will be retained to provide certification of the closure as required by WAC 173-303-610(6). The IQRPE will be responsible for observing field activities and reviewing documents associated with clean closure of the 221-T Sand Filter Pad DWMU. At a minimum, the following field activities will be completed:

- Review 221-T Sand Filter Pad visual inspection documentation.
- Verify that the locations of soil samples are as specified in the SAP.
- Observe and/or review soil sampling activities.
- Review sampling procedures and results.
- Observe and/or review contaminated environmental media removal (as applicable).
- Observe and/or review newly generated waste management and disposition records.
- Verify that closure activities were performed in accordance with this closure plan.

The IQRPE will record observations and reviews in a written report that will be retained in the operating record. The resulting report will be used to develop the clean closure certification, which will then be submitted to Ecology.

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[2] ProUCL Software is a comprehensive statistical software package developed and maintained by EPA.

H.5.3 Closure Certification

Within 60 days of completion of closure of the 221-T Sand Filter Pad DWMU, a certification that the DWMU has been closed in accordance with the specifications in this closure plan will be submitted to Ecology by registered mail. The certification will be signed by the Permittees and by the IQRPE.

At the time of the closure certification submittal, the Permittees will submit to Ecology information to support the closure certification. [WAC 173-303-610(6)]

The supporting information will include at least the following:

- All field notes and photographs related to closure activities.
- A description of any minor deviations from this closure plan and justification for these deviations.
- Documentation of the removal and final disposition of any unanticipated contaminated environmental media.
- Documentation of the removal and final disposition of any newly generated waste.
- All laboratory and/or field data, including sampling procedures, sampling locations, QA/QC samples, and COC procedures for all samples and measurements, including samples and measurements taken to determine background conditions and determine or confirm clean closure.
- A summary report that identifies and describes the data reviewed by the IQRPE and tabulation of the analytical results of samples taken to determine and confirm clean closure performance standards were met.
- Description of the 221-T Sand Filter Pad DWMU appearance at completion of closure, including what parts of the former unit, if any, will remain after closure.

H.6 Closure Schedule and Time Frame

Closure activities will be completed no more than 180 days after the effective date of the approved permit modification incorporating this closure plan. [WAC 173-303-610(4)(b)]

Should an unexpected event occur and an extension to the 180-day closure activity expiration date be deemed necessary, a permit modification request will be submitted to Ecology for approval at least 30 days prior to the expiration of the 180 days. [WAC 173-303-610(4)(c)]

The permit modification request will include the statement that closure activities, will of necessity, take longer than 180 days to complete, including the supporting basis for the statement. The permit modification request will also include necessary information demonstrating that all steps to prevent threats to HHE have been and will continue to be taken, including compliance with all applicable permit requirements. [WAC 173-303-610(4)(b)]

The closure certification will be submitted to Ecology within 60 days following completion of closure activities at the 221-T Sand Filter Pad DWMU (Table H-8 and Figure H-6).

Table H-8 221-T Sand Filter Pad Dangerous Waste Management Unit Closure Schedule

Closure Activity Description		
Activity	**Description**	**Duration**
Closure Activities		
Remove All Waste	Package and ship dangerous and mixed waste to a RCRA permitted facility for treatment, storage, or disposal.	Completed (Section H.3.1)
Records Review	Perform review of 221-T Sand Filter Pad container storage, operating, and inspection records.	Completed (Section H.3.2)
Perform Visual Inspection of 221-T Sand Filter Pad	Inspect for dangerous or mixed waste-related staining. Identify focused sampling locations (as applicable).	Completed (Section H.3.2
Perform Soil Sampling and Analysis of the 221-T Sand Filter Pad	Perform grid sampling and analysis in accordance with SAP (Section H.4).	170 Days
	Perform data verification and validation of VSP input parameters, and data quality assessment, as applicable (Section H.4.5).	
	If necessary, remove contaminated environmental media, and resample and analyze (Section H.4.4.3).	
Confirm Clean Closure	Review soil sample results from contract analytical laboratory. Ensure closure performance standards were met (Section H.5.1).	10 Days
Complete Closure of the 221-T Sand Filter Pad	Complete closure activities within 180 days after the date on which the closure plan is effective. Request extension if necessary.	180 Days
Closure Certification		
Permittees and IQRPE Submit Closure Certification	Within 60 days of completion of closure activities; submit certification to Ecology that the DWMU has been closed in accordance with the specifications in this closure plan (Section H.5.3).	60 Days

Reference: WAC 173-303-610, Dangerous Waste Regulations, *Closure and post-closure*.

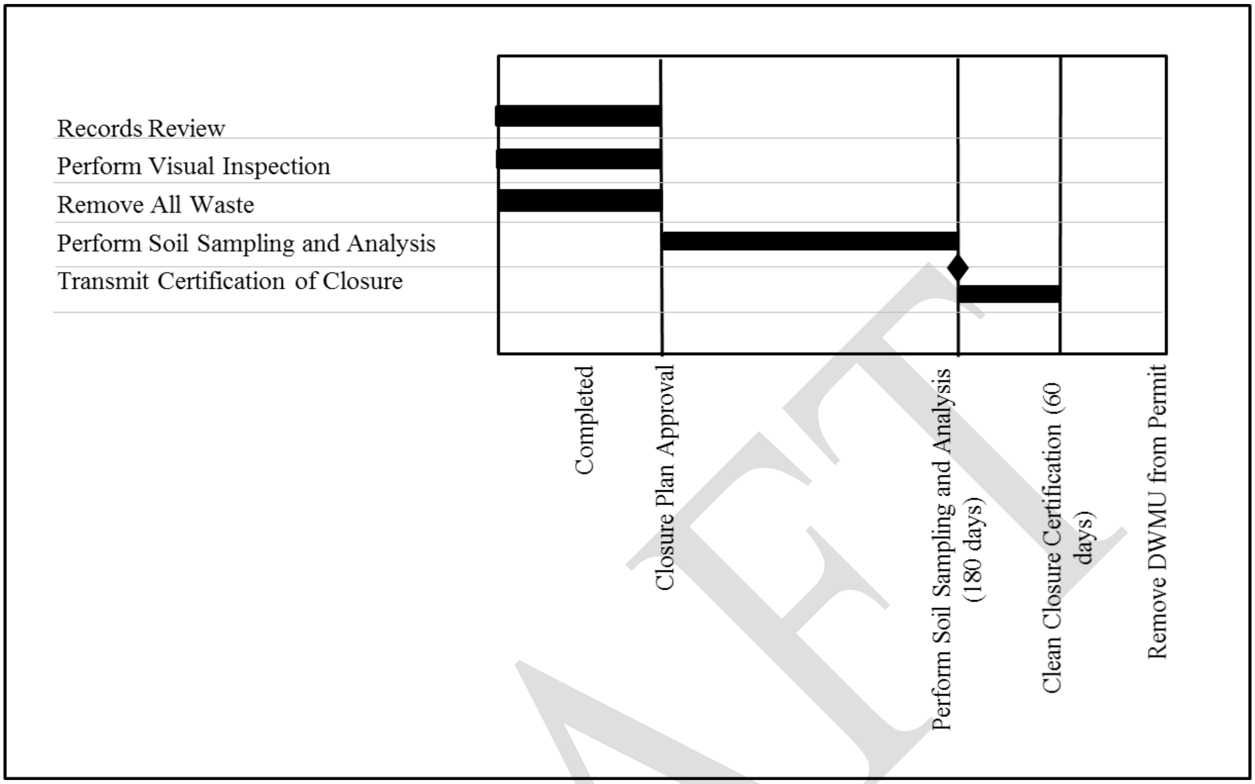

Figure H-6 221-T Sand Filter Pad Closure Schedule Activities

H.7 Closure Costs

An annual report outlining updated projections of anticipated closure costs for the Hanford Facility treatment, storage, and disposal units is not required per Permit Condition II.H.

H.8 References

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ATTACHMENT A

T PLANT 221-T SAND FILTER PAD
VISUAL INSPECTION SUPPORTING DOCUMENTATION

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T Plant Complex 221-T Sand Filter Pad Container Storage Area

Purpose:

A visual inspection walkdown of the T Plant Complex outdoor 221-T Sand Filter Pad container storage area was performed to determine if there is any evidence of spills and/or leaks from waste packages containing dangerous waste that was stored at this location from past operations. The inspection was to identify and document by photographing any waste related staining of the storage area surface (i.e., gravel and soil), and to denote any remaining waste related items.

The inspection was performed on August 15, 2013 by Brett M. Barnes (CHPRC) Environmental Compliance Officer.

Results:

No staining of any kind was identified on the storage area surface. Area was thoroughly photographed. A few debris items were observed (e.g., small pieces of lumber, bricks, and Jersey barriers).

Housekeeping will be performed on the area prior to closure.

Signature/Date:

Brett M. Barnes: Brett M. Barnes 9/3/13

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ATTACHMENT B

T PLANT 221-T SAND FILTER PAD
VISUAL SAMPLE PLAN SUPPORTING DOCUMENTATION

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Systematic sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

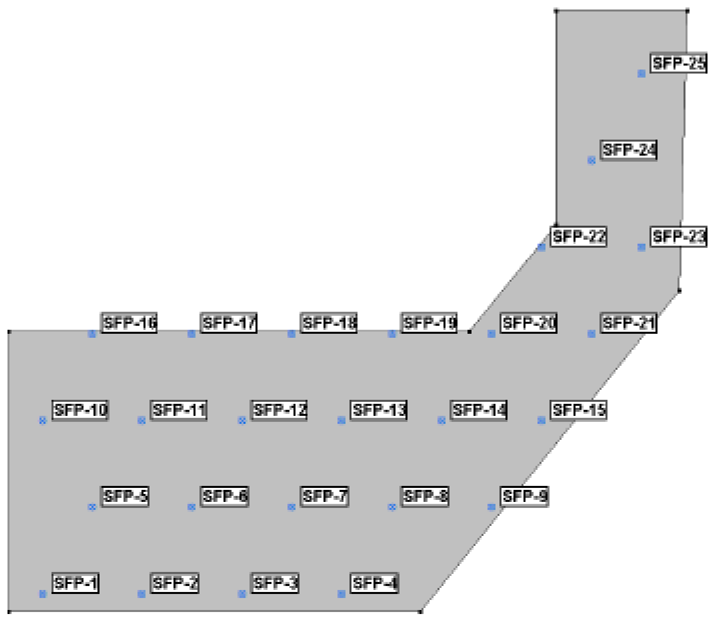
Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated number of samples	16
Number of samples adjusted for EMC	16
Number of samples with MARSSIM Overage	20
Number of samples on map [a]	25
Number of selected sample areas [b]	1
Specified sampling area [c]	11308.00 ft^2
Size of grid / Area of grid cell [d]	24.2737 feet / 510.273 ft^2
Grid pattern	Triangular

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.



(0, 0) South Corner
(-119.61688, 46.56135)

Area: 221T SFP						
X Coord	Y Coord	Label	Value	Type	Historical	Sample Area
8.2131	4.3807	SFP-1		Systematic		
32.4868	4.3807	SFP-2		Systematic		
56.7605	4.3807	SFP-3		Systematic		
81.0342	4.3807	SFP-4		Systematic		
20.3500	25.4023	SFP-5		Systematic		
44.6237	25.4023	SFP-6		Systematic		
68.8974	25.4023	SFP-7		Systematic		
93.1711	25.4023	SFP-8		Systematic		
117.4448	25.4023	SFP-9		Systematic		
8.2131	46.4240	SFP-10		Systematic		
32.4868	46.4240	SFP-11		Systematic		
56.7605	46.4240	SFP-12		Systematic		
81.0342	46.4240	SFP-13		Systematic		
105.3079	46.4240	SFP-14		Systematic		
129.5817	46.4240	SFP-15		Systematic		
20.3500	67.4456	SFP-16		Systematic		
44.6237	67.4456	SFP-17		Systematic		
68.8974	67.4456	SFP-18		Systematic		
93.1711	67.4456	SFP-19		Systematic		
117.4448	67.4456	SFP-20		Systematic		
141.7185	67.4456	SFP-21		Systematic		
129.5817	88.4673	SFP-22		Systematic		
153.8554	88.4673	SFP-23		Systematic		
141.7185	109.4889	SFP-24		Systematic		
153.8554	130.5106	SFP-25		Systematic		

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

VSP offers many options to determine the locations at which measurements are made or samples are collected and subsequently measured. For this design, systematic grid point sampling was chosen. Locating the sample points systematically provides data that are all equidistant apart. This approach does not provide as much information about the spatial structure of the potential contamination as simple random sampling does. Knowledge of the spatial structure is useful for geostatistical analysis. However, it ensures that all portions of the site are equally represented. Statistical analyses of systematically collected data are valid if a random start to the grid is used.

Nuclides
The following table summarizes the analyzed nuclides.

Nuclides Analyzed by Study		
Nuclide	$DCGL_W$	$DCGL_{EMC}$
Analyte 1	1	

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

For each nuclide in the **Nuclides Analyzed by Study** table, the values of these inputs that result in the calculated number of sampling locations are:

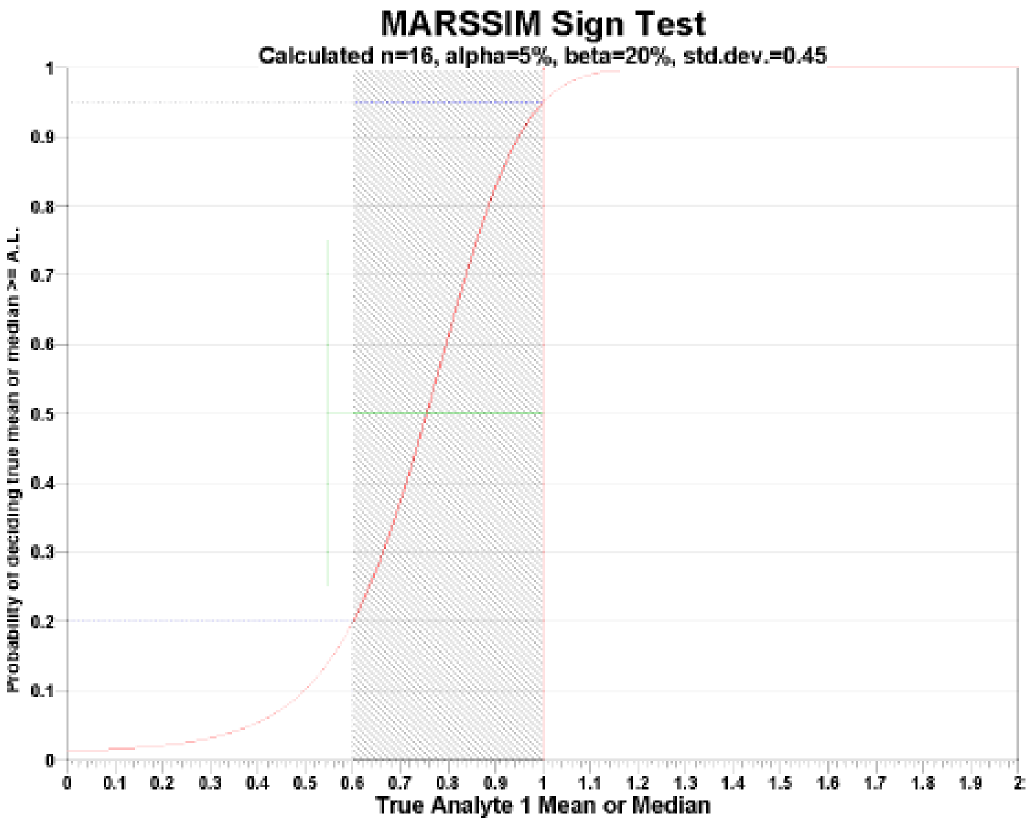
Nuclide	n[a]	n[b]	n[c]	Parameter					
				S	Δ	α	β	$Z_{1-\alpha}$ [d]	$Z_{1-\beta}$ [e]
Analyte 1	16	16	20	0.45	0.4	0.05	0.2	1.64485	0.841621

[a] The number of samples calculated by the formula.
[b] The number of samples increased by EMC calculations.
[c] The final number of samples increased by the MARSSIM Overage of 20%.
[d] This value is automatically calculated by VSP based upon the user defined value of α.
[e] This value is automatically calculated by VSP based upon the user defined value of β.

Performance

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at $1-\alpha$. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=1		α=5		α=10		α=15	
		s=0.9	s=0.45	s=0.9	s=0.45	s=0.9	s=0.45
LBGR=90	β=15	1103	280	825	209	659	167
	β=20	948	240	692	176	542	138
	β=25	826	209	587	149	449	114
LBGR=80	β=15	280	75	209	56	167	45
	β=20	240	64	176	47	138	36
	β=25	209	56	149	40	114	30
LBGR=70	β=15	128	36	95	27	77	22
	β=20	110	32	81	23	63	18
	β=25	95	27	69	20	52	15

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Note: values in table are note adjusted for EMC