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Rev. 0

River Corridor
Closure Contract

Decommissioning Plan for the In Situ Redox Manipulation (ISRM) Evaporation Pond

September 2013

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Washington Closure Hanford

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Assistant Manager for River Corridor

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Rev. 0

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Author:
W. S. Thompson

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ACRONYMS

ARAR	applicable or relevant and appropriate requirements
CHPRC	CH2MHill Plateau Remediation Company
COPC	contaminant of potential concern
DOE-RL	U.S. Department of Energy, Richland Operations Office
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant difference
FY	fiscal year
HDPE	high-density polyethylene
HEIS	Hanford Environmental Information System
IAMIT	Inter-Agency Management Integration Team
ICP	inductively coupled plasma
ISRM	in situ redox manipulation
QC	quality control
RDR/RAWP	remedial design report/remedial action work plan
ROD	record of decision
SAI	sampling and analysis instruction
TCLP	toxicity characteristic leaching procedure
VSP	visual sample plan
WAC	*Washington Administrative Code*
WCH	Washington Closure Hanford

METRIC CONVERSION CHART

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

1.0 INTRODUCTION

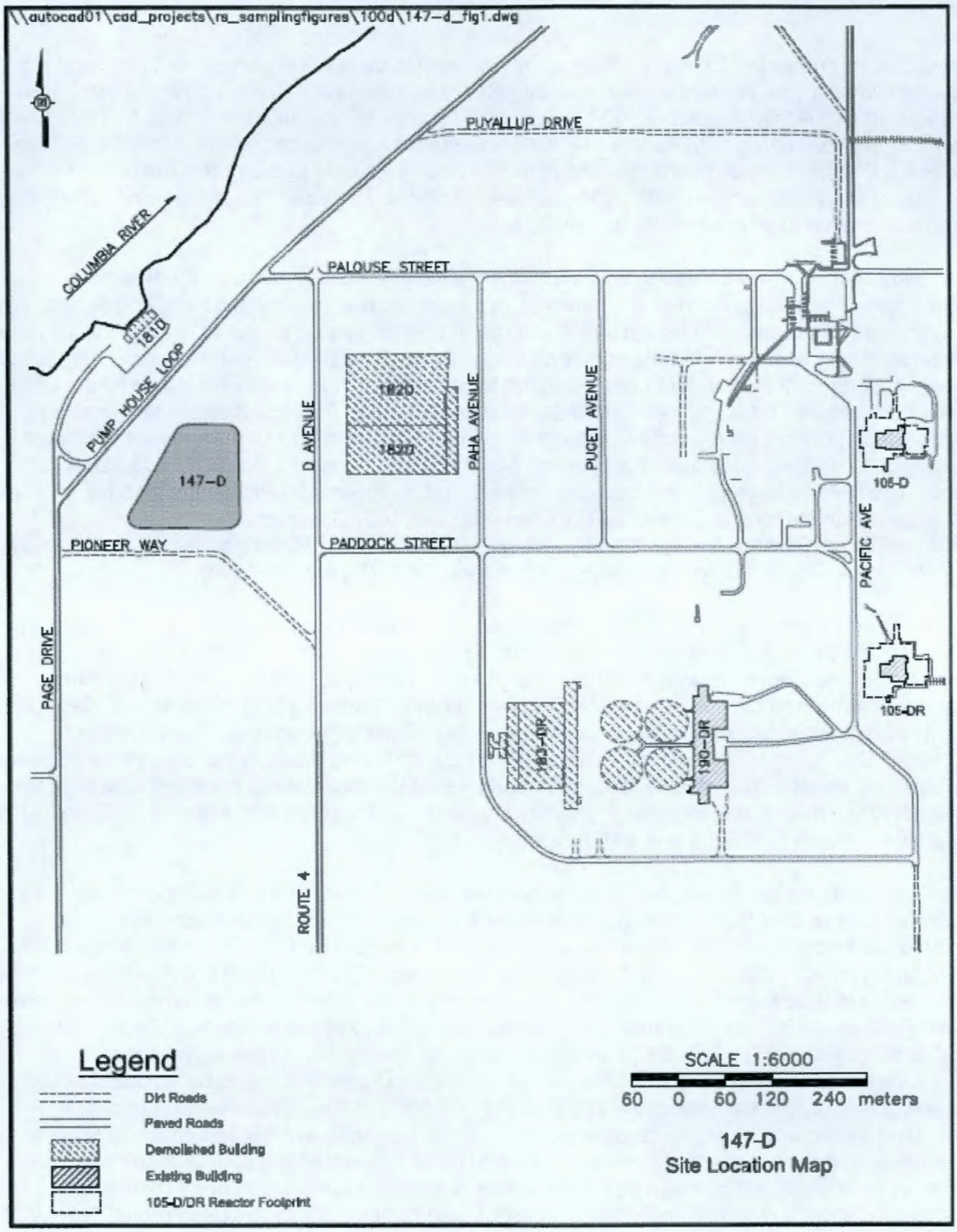
The U.S. Department of Energy, Richland Operations Office (DOE-RL) has directed Washington Closure Hanford (WCH) to remove the In Situ Redox Manipulation (ISRM) Evaporation Pond, also known as 147-D, located at 100-D (Figure 1). The pond was used to collect and evaporate groundwater containing high sulfate that was extracted during the operation of the ISRM Barrier (DOE-RL 2012). This decommissioning plan has been prepared to support removal and disposal of the pond components. The plan also provides the requirements for evaluation of the soil below the pond after removal is complete.

The ISRM technology involved the creation of a permeable subsurface treatment zone to reduce hexavalent chromium in groundwater to an insoluble form. This was accomplished through the injection of sodium dithionite into the aquifer through a series of wells. The sodium dithionite reacts with the naturally occurring iron in the soil creating a treatment zone that results in the conversion of hexavalent chromium into trivalent chromium, a less toxic and less mobile form of chromium. After the injection of the sodium dithionite, unreacted agent and reaction by-products (predominantly sulfate) were then pumped out of the treated portion of the aquifer by extracting groundwater from the injection wells and transferred to the ISRM evaporation pond. The ISRM technology is described in the U.S. Environmental Protection Agency, interim remedial action Record of Decision (ROD) amendment, *U.S. Department of Energy Hanford Site – 100 Area Benton County, Washington, Amended Record of Decision Summary and Responsiveness Summary (100-HR-3 Operable Unit)* (EPA et al. 1999).

The ROD amendment (EPA 1999) originally planned for ISRM well purgewater to be discharged to the ground through a drip field. However, due to the greater than anticipated volume of purgewater, and concerns with residual sulfate levels in groundwater from the high volume estimates, a method other than the drip field was required for managing purgewater. Several alternatives were evaluated in the *Explanation of Significant Difference for the 100-HR-3 Operable Unit Record of Decision* (ESD) (EPA 2002), including trucking the water to a disposal facility. The construction of an evaporation pond was determined to be the most cost effective, minimizing the disposal of extracted groundwater to ground surface and allowing multiple simultaneous well injections and withdrawals.

The *Remedial Design Report/Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation* (RDR/RAWP) (DOE-RL 2000c) identified an action-specific applicable or relevant and appropriate requirement (ARAR) for the evaporation pond that was not included in the ROD amendment. This ARAR required the pond to be designed, constructed, and operated in accordance with the *Washington Administrative* Code (WAC) 173-304-430, "Surface Impoundment Standards"; this requirement is included in the 2003 ESD (EPA 2003). This ESD identified that at the completion of the project, the evaporation pond would be dismantled. Any remaining purgewater would be trucked to the Purgewater Storage and Disposal Facility or the Effluent Treatment Facility for disposal. Any remaining sediments or precipitants would be collected as solid wastes and characterized to determine waste disposal requirements. The ESD also noted that the sulfate in the precipitate is not an environmental concern because sulfate is neither a carcinogen nor a toxic waste. The "Dangerous Waste Regulations" (WAC 173-303) are identified as an ARAR in the RDR/RAWP (DOE-RL 2000c).

Figure 1. Location of the ISRM Evaporation Pond.



Accordingly, the solid wastes, including the pond liner and accumulated evaporation pond sediments will be evaluated to determine whether they are a characteristic dangerous waste, and disposed as appropriate to the Environmental Restoration Disposal Facility (ERDF) or other approved Hanford Site landfill.

2.0 BACKGROUND INFORMATION

2.1 FACILITY DESCRIPTION AND OPERATIONS

The ISRM evaporation pond, also known as the 147-D Pond, was a lined pond used to evaporate extracted groundwater (Figure 2). It consisted of a 60-mil high-density polyethylene (HDPE) liner above a 10-cm (4-in.) layer of sand. The interior of the pond above the liner was then filled with an additional 30 cm (12 in.) of sand bedding. A 0.6-m (2-ft)-high berm ran along the edge of the pond, which also provided a gas vent for the liner ("100 D Area In Situ Redox Manipulation Project Lined Evaporation Pond Civil Grading Plan" [DOE-RL 2000a] and "100 D Area In Situ Redox Manipulation Project Lined Evaporation Pond Civil Sections and Details" [DOE-RL 2000b]). The pond was located approximately 905 m (2,970 ft) west of the 105-D Reactor Building (Figure 1).

The pond was constructed to allow collection of extraction water from ISRM barrier wells following injection of sodium dithionite. The sodium dithionite reacts with the naturally occurring iron in the soil creating a treatment zone that results in the conversion of hexavalent chromium into trivalent chromium, a less toxic and less mobile form of chromium. After the injection of the sodium dithionite, unreacted agent and reaction by-products (predominantly sulfate) were then pumped out of the treated portion of the aquifer by extracting groundwater from the injection wells and transferred to the ISRM evaporation pond. The pond was sized for an upper limit of 2 million gallons to minimize the cost of leak detection and sampling required for a larger capacity pond. The purpose of the pond was to evaporate the water to reduce the cost of trucking and to eliminate the need to dispose of the water via a drain field (*Addendum to Insitu Redox Manipulation Evaluation of Potential Radionuclide Air Emissions* [BHI 2001]). The pond construction was completed in June 2000.

Originally, 10 wells were identified as treatment wells in fiscal year (FY) 2000 with 24 wells planned for FY 2001. However, in late FY 2000, the number of wells to be treated increased from 24 to 28 wells. A 3-year, three-phase emplacement schedule was developed for the ISRM barrier, coinciding with FY 2000, 2001, and 2002. The 680-m (2,231-ft)-long permeable reactive treatment barrier was completed in the fall of 2004 (*In Situ Redox Manipulation [ISRM] Annual Report - Fiscal Year 2007* [DOE-RL 2008]). The ISRM pond was maintained for use as needed for disposal of extracted ISRM process groundwater. Decontamination fluids from the ISRM project were also discharged, if needed, to the evaporation pond.

Figure 2. Aerial Photograph of the ISRM Evaporation Pond (April 2008).

In 2004, a new pump-and-treat system was installed in the 100-D Area to address the high chromium contamination in the groundwater northeast of the ISRM barrier. Rinsate and filtrate from the DR-5 groundwater treatment system was also discharged to the ISRM pond (*Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units* [DOE-RL 2005]). During this time, it was determined that the high-sulfate solution that was injected into the ISRM barrier no longer needed to be withdrawn from the injection wells and there was, therefore, no longer a future need for the ISRM pond as an evaporation basin (*Inter-Agency Management Integration Team (IAMIT) Meeting Minutes* [Ecology et al. 2008] and *100/300 Area Unit Managers Meeting Minutes* [Ecology et al. 2009]). However, the effluent stream from the DR-5 pump and treat system, which was treating about 40 gallons per minute, continued to discharge to the ISRM pond. Beginning in 2008, DOE-RL and the Washington State Department of Ecology (Ecology) discussed ending DR-5 pump and treat system discharges to the ISRM pond and dismantling the pond by December 31, 2011 (Ecology et al. 2009). In January 2009, all discharges to the pond were stopped and the pond was allowed to start drying out. In July 2009, a fixative was applied to the outer 1/3 to 1/2 of the pond area, but the inner portions were noted to contain a soupy residue covered by a salty crust (DOE-RL 2009a).

Originally, planning had included removal of the ISRM pond in FY 2012, but due to budget constraints and priorities, decommissioning of the ISRM pond was deferred. Further discussion concerning disposition of the pond occurred on November 17, 2011, at the Inter-Agency

Management Integration Team (IAMIT) meeting (Ecology et al. 2011). It was decided that decommissioning of the pond would be added to the WCH contract (DOE-RL 2012).

3.0 PROCESS INFORMATION

3.1 WASTE SOURCES AND DESCRIPTION

The ISRM technology involves the creation of a permeable subsurface treatment zone to reduce mobile hexavalent chromium in groundwater to trivalent chromium, an insoluble form. This is accomplished through injection of sodium dithionite into the aquifer through a series of wells. The emplacement process is conducted in three stages: injection, reaction, and withdrawal. During the reaction stage, sodium dithionite is converted to sulfites, sulfates, and thiosulfates. During the withdrawal phase, which lasts approximately 7 to 14 days, groundwater containing reaction products and unreacted agents is extracted from the injection/withdrawal wells. The post-treatment extraction purgewater was collected and disposed of at the ISRM evaporation pond. In addition, decontamination fluids for the ISRM project were also acceptable for disposal to the pond. The requirements for wastewater management and disposal are described in the *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units*, DOE-RL-97-01 (DOE-RL 2005).

The waste management plan (DOE-RL 2005) also allowed liquid waste, consisting of rinsate and/or filtrate from the 100-D pump and treat system and the 100-K treatability test to be disposed at the ISRM pond.

3.2 WASTE CHARACTERIZATION INFORMATION

All waste associated with the ISRM project is designated in accordance with WAC 173-303, "Dangerous Waste Regulations," using process knowledge, historical analytical data, and/or analyses of samples identified in project documents or sampling and analysis plans, as appropriate (DOE-RL 2005). Several years of characterization data and pump-and-treat system operation data were used as the basis for waste designation. The ISRM-treated groundwater did not designate as a dangerous waste and was only required to be collected in the evaporation pond due to increases in groundwater sulfur concentrations above drinking water standards (1,580 mg/L) resulting from the treatment process (*Waste Designation: Hanford Site Groundwater Contacted Wastes* [BHI 2000b] and *Waste Designation: ISRM Pond Water* [BHI 2002]).

In July 2009, six sediment samples were collected by the CH2MHill Plateau Remediation Company (CHPRC) to support planning and disposal decisions associated with decommissioning the pond. The samples were collected at the corners of the ISRM pond that were accessible from outside the pond and where the sediment was dry. The inner portion of the pond was still wet and not accessible for sampling. Information concerning this sampling is provided in the sampler's field logbook (CHPRC 2009). The samples were analyzed for hexavalent chromium, inductively coupled plasma (ICP) metals, anions, toxicity characteristic leaching procedure (TCLP) metals, gamma-emitting radionuclides, gross alpha activity, and gross beta activity. The sample results are reported in the Hanford Environmental Information System (HEIS) and are available in the Tri-Party Administrative Record (*Data Package*

Summary Analytical Laboratory F09-053 In Process Sampling and Analysis of the ISRM Pond Soil Sampling [MSA 2009]). Concentrations of sulfate and chromium (total) were elevated above background, but not at levels that would result in designation of the sediment as a dangerous waste. This data will be used by WCH to support waste designation of the ISRM pond sediment and debris.

3.3 GROUNDWATER MONITORING DATA

The 100-HR-3 and 100-KR-4 Operable Units have an extensive groundwater well sampling network. Groundwater monitoring data for the ISRM wells is summarized in annual performance reports for the 100-HR-3 Operable Unit ISRM remedial action (e.g., DOE-RL 2009a). A total of 72 wells are sampled as treatment, monitoring, and compliance wells. This monitoring data is available in the HEIS database.

3.4 DECOMMISSIONING WASTE DISPOSAL

The "Dangerous Waste Regulations" (WAC 173-303) are identified as an ARAR in the RDR/RAWP (DOE-RL 2000c). Accordingly, the solid wastes, including the pond liner and accumulated evaporation pond sediments, will be evaluated to determine whether they are a characteristic dangerous waste, and disposed as appropriate to the ERDF or other approved Hanford Site landfill.

The waste management plan (DOE-RL 2005) identifies the ERDF for disposal of contaminated debris associated with decommissioning the ISRM evaporation pond. Debris identified for disposal includes the HDPE pond liner, the sand bedding material located above and below the liner, bird chase wiring, ecology blocks, and any other wood, concrete, metal, or plastic that might be integral to the pond. Contaminated soil located below the pond will also be disposed to ERDF. Debris that is nondangerous and radiologically released or materials that have not contacted potentially contaminated materials (e.g., ecology blocks, perimeter fence) may be disposed off site at a solid waste landfill, an onsite demolition landfill, or recycled, as appropriate.

4.0 DECOMMISSIONING ACTIVITIES

The ISRM evaporation pond will be decommissioned in accordance with the Inter-Agency Management Integration Team decision, documented in the October 2008 meeting minutes (Ecology et al. 2008). The RDR/RAWP (DOE-RL 2005) identified an action-specific ARAR for the evaporation pond that was not included in the ROD amendment. This ARAR required the pond to be designed, constructed, and operated in accordance with WAC 173-304-430, "Surface Impoundment Standards"; this requirement is included in the 2003 ESD (EPA 2003). This ESD identified that at the completion of the project, the evaporation pond would be dismantled. Any remaining purgewater, if present, would be trucked to the Purgewater Storage and Disposal Facility or the Effluent Treatment Facility for disposal. Any remaining sediments or precipitants would be collected as solid wastes and characterized to determine waste disposal requirements. The requirements for closure of surface impoundments (WAC 173-304-430 [2][g]) require that the ISRM evaporation pond "be closed in a manner which removes all solid

wastes including liners, etc. to another permitted facility and the site returned to its original or acceptable topography."

4.1 DEMOLITION OF STRUCTURE AND REMOVAL

Decommissioning of the ISRM pond includes removal and disposal of the accumulated pond sediment, pond structure (sand bedding material, 60-mil HDPE liner), and bird chase wire. The ecology blocks and perimeter fence will be removed and if appropriate made available for reuse or recycled. The pond berm will either be removed for disposal or will be stockpiled, sampled, and evaluated for reuse as clean backfill material. In addition, a minimum 0.3-m (1-ft) layer of soil below the pond structure will be removed for disposal to ERDF.

4.2 VERIFICATION SAMPLING

Upon completion of removal of the ISRM pond and contaminated soils, sampling will be performed to verify that contaminant removal is complete and that the berm material may be used as backfill. The sampling and analysis requirements for verification sampling are described in Section 5.0 of this decommissioning plan.

4.3 BACKFILL EXCAVATION AND GRADE

Once the verification sampling indicates that contaminant removal is complete, the site will be surveyed, backfilled/recontoured, graded compatible with the surrounding terrain, and then revegetated.

5.0 VERIFICATION SAMPLING AND ANALYSIS PLAN

This section describes the requirements for sampling and analysis to verify adequate removal of the ISRM pond and suitability of the berm material for use as clean backfill.

Sampling and analysis will be performed in accordance with the following requirements:

- DOE O 414.1C, *Quality Assurance*
- *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 2001)
- *Hanford Analytical Services Quality Assurance Requirements Documents* (DOE-RL 1997).

5.1 CONTAMINANTS OF CONCERN

A list of contaminants of potential concern (COPCs) for the ISRM pond was developed by reviewing process knowledge and historical data for the ISRM project. The COPCs associated

with verification sampling after removal of the pond and associated analytical methods and data quality requirements are specified in Table 1.

Table 1. Data Quality Requirements Summary.

Analytical Parameter	Analytical Method	Preliminary Action Level [a]	Detection Limit	Precision (% Relative Percent Difference)	Accuracy (% Recovery)
Chromium (total)	EPA Method 6010 [b]	18.5 mg/kg	0.2 mg/kg	±30%	70%-130%
Hexavalent chromium	EPA Method 7196	2.0 mg/kg	0.5 mg/kg	±30%	70%-130%
Chloride	EPA Method 300.0	25,000 mg/kg	2.0 mg/kg	±30%	70%-130%
Sulfate	EPA Method 300.0	25,000 mg/kg	5.0 mg/kg	±30%	70%-130%
Sulfide	EPA Method 9030	--	5.0 mg/kg	±30%	70%-130%
Nitrate	EPA Method 300.0	1,000 mg/kg	0.75 mg/kg	±30%	70%-130%
Nitrate/nitrite	EPA Method 353.2	100 mg/kg	0.75 mg/kg	±30%	70%-130%
pH	EPA Method 9045	NA	0.1 pH unit	±30%	70%-130%

[a] Value provided is the most restrictive action level for direct exposure, groundwater protection, and river protection soil cleanup criteria (DOE-RL 2009b).
[b] Analysis will be performed for the expanded ICP metals to include antimony, arsenic, barium, beryllium, boron, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, vanadium, and zinc.
– = no cleanup criteria
EPA= U.S. Environmental Protection Agency
ICP = inductively coupled plasma
NA = not applicable

5.2 TRAINING REQUIREMENTS

The training or certification requirements needed by personnel are described in BSC-1, *Business Services and Communications*, BSC-1-2.4, "Training Requirements," and ENV-1, *Environmental Monitoring & Management,* ENV-1-2.36, "River Corridor Quality Assurance Program Plans."

5.3 VERIFICATION SAMPLING

Once the ISRM pond is removed, verification soil samples will be collected within the footprint of the remediated pond. The stockpiled berm material will also be sampled to evaluate suitability of the material for use as backfill.

The decision rule for demonstrating compliance with the action level criteria requires comparison of the true population mean, as estimated by the 95% UCL on the sample mean, with the action level. Therefore, a statistical sampling design is the preferred verification sampling approach for this site because the distribution of residual contamination over the investigation area is uncertain. Ecology publication *Guidance on Sampling and Data Analysis Methods* (Ecology 1995) recommends that systematic sampling with sample locations distributed over the entire study area be used.

5.3.1 Verification Sampling of the ISRM pond

A statistical systematic sampling design using a random-start systematic triangular grid was used for verification sampling of the footprint of the remediated ISRM pond. A triangular grid was selected for this investigation based on studies that indicate triangular grids are superior to square grids (Gilbert 1987). The number of samples and the sample locations for the ISRM pond were determined using Visual Sample Plan (VSP)[1]. The boundary of the sample area (i.e., pond area footprint) was delineated in VSP and used as the basis for locating the random start systematic sampling grid, providing a uniform spread of sampling points over the sampling area. Additional details concerning the use of VSP to develop the statistical sampling design and derive the number of samples are discussed in Appendix A of this sampling and analysis instruction (SAI). Twelve soil samples will be collected as shown in Figure 3. A duplicate soil sample will be collected at one of the ISRM pond verification sample locations selected at the project analytical lead's discretion and analyzed for the COPCs identified in Table 1. A summary of the verification sample coordinates is provided in Table 2.

The soil samples will be analyzed for the COPCs identified in Table 1.

5.3.2 Verification Sampling of the Berm Soil

The ISRM pond berm soil will be removed and staged in a stockpile for evaluation of suitability for use as backfill for the remediated ISRM pond. The stockpile boundaries will be global position surveyed and used in VSP to identify verification sample locations consistent with the statistical sampling parameters used for the remediated ISRM pond as described above and in Appendix A of this SAI. Twelve soil samples will be collected over the surface of the stockpiled berm soil and analyzed for the COPCs identified in Table 1. Prior to initiating sample collection of the berm soil, a map of the sample locations and coordinates will be provided to DOE-RL and Ecology for their concurrence. A duplicate soil sample will be collected at one of the stockpile sample locations at the project analytical lead's discretion and analyzed for the COPCs identified in Table 1.

5.4 SAMPLING METHOD REQUIREMENTS

Soil sampling will be performed in accordance with ENV-1, ENV-1-2.16, "Soil and Sediment Sampling." A grab sample of soil will be collected at each of the sample locations specified in Section 5.3 and submitted for laboratory analysis as specified in Section 5.1.

5.5 SAMPLE HANDLING, SHIPPING, AND CUSTODY REQUIREMENTS

All sample handling, shipping, and custody should be performed in accordance with ENV-1, ENV-1-2.14, "Sample Packaging and Shipping"; ENV-1-2.13, "Chain of Custody"; and ENV-1-2.17, "Sample Storage and Shipping Facility."

[1] Visual Sample Plan is a site map-based user-interface program that may be downloaded at http://dqo.pnl.gov.

Figure 3. Verification Sample Location Map.

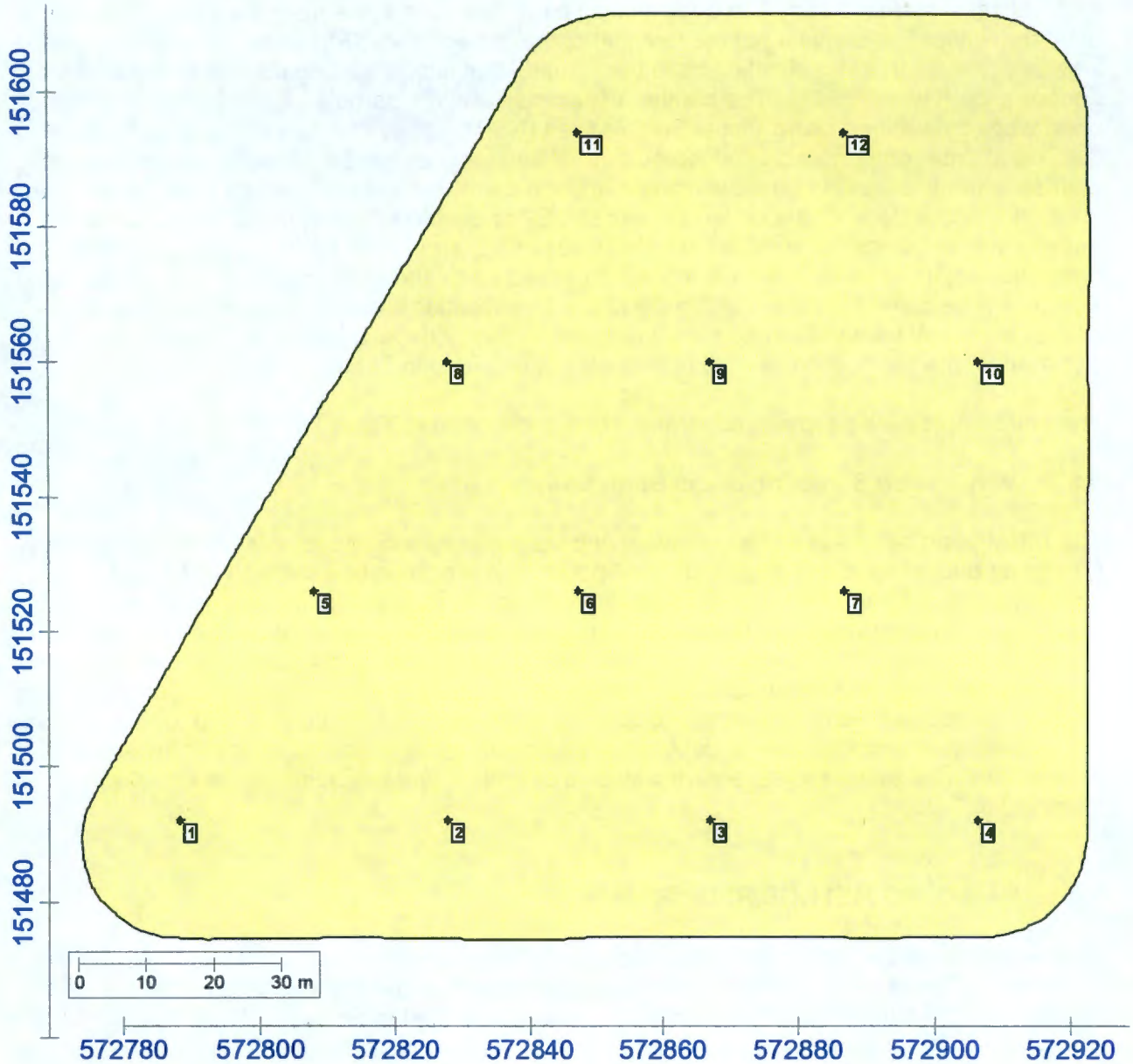


Table 2. ISRM Pond Verification Sample Summary.

Sample Location	HEIS Sample Number	Washington State Plane Coordinates		Sample Analysis
		Easting	Northing	
1	TBD	572788.3	151492.1	Chromium (total) [a], hexavalent chromium, chloride, nitrate, sulfide, sulfate, nitrate/nitrite, and pH
2	TBD	572827.6	151492.1	
3	TBD	572866.9	151492.1	
4	TBD	572906.2	151492.1	
5	TBD	572808.0	151526.1	
6	TBD	572847.2	151526.1	
7	TBD	572886.5	151526.1	
8	TBD	572827.6	151560.1	
9	TBD	572866.9	151560.1	
10	TBD	572906.2	151560.1	
11	TBD	572847.2	151594.2	
12	TBD	572886.5	151594.2	
Duplicate [b]	TBD	TBD	TBD	
Equipment blank	TBD	NA	NA	Chromium (total) [a], hexavalent chromium, chloride, nitrate, sulfide, sulfate, and nitrate/nitrite

[a] Analysis will be performed for the expanded list of ICP metals to include antimony, arsenic, barium, beryllium, boron, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, vanadium, and zinc.
[b] Duplicate soil sample will be collected at a location selected at the project analytical lead's discretion.

HEIS = Hanford Environmental Information System
ICP = inductively coupled plasma
NA = not applicable
pH = hydrogen ion concentration
TBD = to be determined

5.6 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIMES

The sample preservation, container, and holding time requirements for the analyses to be performed are summarized in Table 3.

5.7 QUALITY CONTROL REQUIREMENTS

The quality control (QC) procedures must be followed in the field and laboratory to ensure that reliable data are obtained. When performing this field sampling effort, care shall be taken to prevent the cross-contamination of sampling equipment, sample bottles, and other equipment that could compromise sample integrity.

Table 3. Sample Preservation, Containers, and Holding Times.

Analytical Method	Container	Quantity	Preservative	Holding Time
ICP metals – EPA Method 6010	Amber glass	250 g	None	6 months
Hexavalent chromium – EPA Method 7196	Glass/plastic	125 g	Cool 4°C (39.2°F)	30 days (soil)
Chloride, sulfate – EPA Method 300.0	Glass/plastic	125 g	Cool 4°C (39.2°F)	28 days
Sulfide – EPA Method 9030	Glass	125 g	Cool 4°C (39.2°F)	7 days
pH – EPA Method 9045	Glass/plastic	125 g	None	As soon as possible upon receipt at lab

EPA = U.S. Environmental Protection Agency
ICP = inductively couple plasma
pH = hydrogen ion concentration

5.7.1 Field Sampling

Field QC samples will consist of the following:

- Two field duplicate soil samples will be collected to verify the precision (reproducibility) of the laboratory analysis. One duplicate sample will be collected at one of the verification sample locations for the remediated ISRM pond and one from the berm stockpile. The duplicate sample locations will be selected at the discretion of the sampler and will be analyzed for the COPCs identified in Table 1 of this document.
- One equipment blank will be collected using clean silica sand and analyzed for the constituents identified in Table 2.
- One or more split samples may be collected by Ecology.
- Trip blanks are not required.

5.7.2 Laboratory Methods

Internal QA procedures for laboratory analysis will follow the requirements specified in the laboratory statement of work.

5.8 INSTRUMENT CALIBRATION AND MAINTENANCE

All field screening and analytical instruments shall be calibrated and maintained in accordance with ENV-1, ENV-1-2.36, "River Corridor Quality Assurance Program Plans." The results from all instrument calibration and maintenance activities shall be recorded in a bound logbook in accordance with procedures outlined in ENV-1, ENV-1-2.5, "Field Logbooks." Tags will be

attached to all field screening and onsite analytical instruments noting the date when the instrument was last calibrated as well as the calibration expiration date.

5.9 FIELD DOCUMENTATION

Field documentation shall be kept in accordance with ENV-1, including the following procedures: ENV-1-2.5, "Field Logbooks," and ENV-1-2.13, "Chain of Custody."

5.10 ASSESSMENTS AND RESPONSE ACTIONS

The WCH Field Remediation Quality Assurance Representative and/or personnel from the Quality Assurance and Services Group may conduct random surveillance and assessments in accordance with QA-1, *Quality Assurance*, Procedure QA-1-1.7, "WCH Surveillances – Internal, Subcontractor, and Other Hanford Contractors." Surveillance/assessment activities may be performed to verify compliance with the requirements outlined in this document, project work packages, the WCH Quality Assurance Program Description, WCH procedures, and regulatory requirements.

Deficiencies identified by surveillances/assessment activities shall be brought to management's attention and documented in accordance with QA-1-1.7 and QA-1.2, "Corrective Action Management." When appropriate, corrective actions will be taken by the project engineer in accordance with the *Hanford Analytical Services Quality Assurance Requirements Documents*, Vol. 1, Section 4.0 (DOE-RL 1997), to minimize recurrence.

5.11 DATA VERIFICATION AND VALIDATION REQUIREMENTS

Data verification and validation are performed on analytical data sets primarily to confirm that sampling and chain-of-custody documentation is complete, sample numbers can be tied to the specific sampling location, samples were analyzed within the required holding times, and analyses met the data quality requirements specified in this SAI. All data verification and validation shall be performed in accordance with ENV-1, ENV-1-2.12, "Data Package Validation Process" and *Data Validation Procedure for Chemical Analysis* (BHI 2000a).

5.12 DATA EVALUATION AND ASSESSMENT

The verification soil samples will be requested for full protocol laboratory analysis. Post-data collection activities generally will follow those outlined in *Statistical Guidance for Ecology Site Managers* (Ecology 1992) and the U.S. Environmental Protection Agency's *Data Quality Assessment: A Reviewer's Guide* (EPA 2006). The data analyst will be familiar with the context of the site remedial action and goals for data collection and assessment for the 100-HR-3 operable units.

The data will be verified and validated before undergoing statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of the statistical analyses that were performed as well as to achieve a general understanding of the verification sampling data. The data will be used to assess if the sample results are adequate in

both quality and quantity to support the primary objective of demonstrating that the ISRM pond has been adequately removed and that the berm stockpile soil may be used for backfill material.

6.0 DECOMMISSIONING CLOSEOUT REPORT

A decommissioning closeout report will be prepared discussing the ISRM pond removal activities, waste disposal, and the results of verification sampling.

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APPENDIX A

STATISTICAL SAMPLE DESIGN

APPENDIX A

STATISTICAL SAMPLE DESIGN

A.1 SUMMARY

This appendix summarizes the sampling design used, associated statistical assumptions, and general guidelines to be used for conducting post-sampling data analysis. The sampling plan components presented include how many sampling locations to choose and where within the sampling area to collect those samples. Sampling and analysis requirements are provided in Section 5.0 of this verification sampling and analysis plan. As previously discussed, two decision units have been identified: one for the remediated ISRM pond and the other for the berm soil stockpile. The statistical sample design described in this appendix was applied to the footprint of the ISRM pond and will also be used for the berm soil stockpile.

A.2 PRIMARY SAMPLING OBJECTIVE

The primary purpose of sampling at this site is to compare a site mean value with a fixed threshold. The decision rule for demonstrating compliance with the cleanup criteria requires comparison of the true population mean, as estimated by the 95% upper confidence limit on the sample mean, with the cleanup level. The working hypothesis (or "null" hypothesis) is that the mean value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the mean value is less than the threshold. Visual Sample Plan[2] (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.

A.3 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 selected because the conceptual model and past cleanup verification sampling indicates that typical parametric assumptions may not be true.

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

The Washington State Department of Ecology publication *Guidance on Sampling and Data Analysis Methods* (Ecology 1995) recommends that systematic sampling with sample locations distributed over the entire study area be used. Therefore, a systematic grid sampling design with a random start was selected for use in VSP. Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of

[2] Visual Sample Plan is a site map-based user-interface program that may be downloaded at http://vsp.pnl.gov.

systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

A.4 NUMBER OF TOTAL SAMPLES: CALCULATION EQUATION AND INPUTS

The equation used to calculate the number of samples is based on a Sign test (Gilbert et al. 2001). For this site, the null hypothesis is rejected in favor of the alternative one if the 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 as follows:

$$n = 1.20\left[\frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{4(Sign P - 0.5)^2}\right]$$

where

$$Sign\ P = \Phi\left(\frac{\Delta}{s_{Total}}\right)$$

$\Phi(z)$ = the cumulative standard normal distribution on $(-\infty,z)$ (see Gilbert et al. 2001 for details)
n = the number of samples
S_{total} = the estimated standard deviation of the measured values including analytical error
Δ = the width of the gray region
α = the acceptable probability of incorrectly concluding the site mean is less than the threshold
β = the acceptable probability of incorrectly concluding the site mean exceeds the threshold
$Z_{1-\alpha}$ = the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$
$Z_{1-\beta}$ = the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

NOTE: The *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (EPA et al. 2000) 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 et al. 2000).

The values of these inputs that result in the calculated number of sampling locations are summarized in Table A-1.

Table A-1. VSP User Inputs.

Parameter	Value	Basis
S	0.4	Estimated standard deviation based on a unit action level.
Δ	0.5	Set at one-half the unit action level.
α	5%	False rejection rate.
β	20%	False acceptance rate.
$Z_{1-\alpha}$	1.64485	This value is automatically calculated by VSP based on the user-defined value of α.
$Z_{1-\beta}$	0.841621	This value is automatically calculated by VSP based on the user-defined value of β.
MARSSIM overage	20%	User-defined sample increase factor.

α = alpha (%), probability of mistakenly concluding that μ < action level
β = beta (%), probability of mistakenly concluding that μ > action level
DQO = data quality objective
MARSSIM = *Multi-Agency Radiation Survey and Site Investigation Manual* (EPA et al. 2000)
VSP = Visual Sample Plan

In order to use VSP to calculate the number of samples, *n*, it is necessary to have an estimate of the sample standard deviation (*S*). Because this is unknown without collection of samples, the standard deviation for each population was assumed to be less than 40% of the corresponding action level for that contaminant. Using this standard deviation value and an acceptable lower gray region boundary (50% of the action level) in VSP, the estimated number of verification samples to collect is 12.

Table A-2 summarizes the sampling design that was developed. Table A-3 lists sampling location coordinates.

Table A-2. Summary of Sampling Design. (2 Pages)

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 total number of samples	12
Number of samples on map [a]	12
Number of selected sample areas [b]	1

Table A-2. Summary of Sampling Design. (2 Pages)

Specified sampling area [c]	ISRM pond footprint – 16,038.5 m^2 (172,637 ft^2)
Size of grid/area of grid cell [d]	ISRM pond footprint – 39.3 m/1,336.5 m^2 (128.9 ft/14,386.5 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 shaded 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 shaded 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.
MARSSIM = *Multi-Agency Radiation Survey and Site Investigation Manual* (EPA et al. 2000)

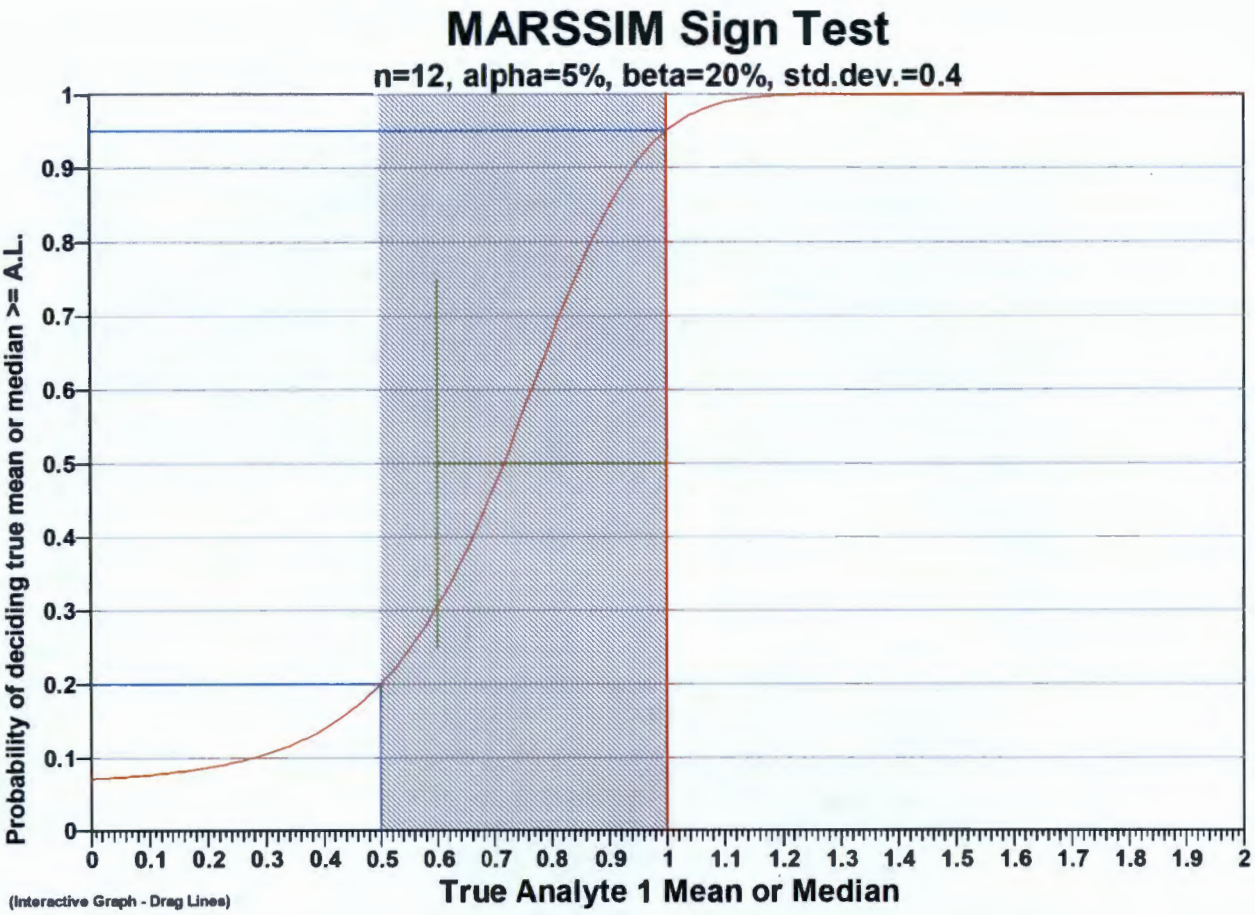
Table A-3. Verification Sample Location Coordinates.

Sample Location	X Coordinate	Y Coordinate	Type
1	572788.3	151492.1	Systematic
2	572827.6	151492.1	Systematic
3	572866.9	151492.1	Systematic
4	572906.2	151492.1	Systematic
5	572808.0	151526.1	Systematic
6	572847.2	151526.1	Systematic
7	572886.5	151526.1	Systematic
8	572827.6	151560.1	Systematic
9	572866.9	151560.1	Systematic
10	572906.2	151560.1	Systematic
11	572847.2	151594.2	Systematic
12	572886.5	151594.2	Systematic

Figure A-1 is a performance goal diagram, described in the U.S. Environmental Protection Agency's *Guidance on Systematic Planning Using the Data Quality Objectives* (EPA 2006b). It shows the probability of concluding that 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 solid vertical line to the right of the gray region 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 line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed line is positioned at β on the vertical axis. The short vertical line in the gray region to the left of the action level is positioned at one standard deviation below the threshold. The shape of the 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 will change.

Figure A-1. Performance Goal Diagram.



A.5 STATISTICAL ASSUMPTIONS

The assumptions associated with the formulas for computing the number of samples are as follows.

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

The first three assumptions are reasonable and conservative based on consideration of past cleanup verification sampling. The last assumption is valid because the gridded sample locations were selected based on a random start.

A.6 SENSITIVITY ANALYSIS

The sensitivity of the calculation of the number of samples was explored by varying *S*, lower bound of the gray region, β, α, and examining the resulting changes in the number of samples. Table A-4 shows the results of this analysis.

Table A-4. Results of the Sensitivity Analysis.

Number of Samples							
AL=1		α=5		α=10		α=15	
		s=0.8	s=0.4	s=0.8	s=0.4	s=0.8	s=0.4
LBGR=60	β=15	60	20	45	15	36	12
	β=20	52	17	38	12	30	10
	β=25	45	15	33	11	24	9
LBGR=50	β=15	40	15	30	11	24	9
	β=20	35	12	26	10	21	8
	β=25	30	11	22	9	17	6
LBGR=40	β=15	30	12	22	10	18	8
	β=20	26	11	20	9	15	6
	β=25	22	10	16	8	12	5

α = alpha (%), probability of mistakenly concluding that μ < action level
AL = action level (threshold)
β = beta (%), probability of mistakenly concluding that μ > action level
LBGR = lower bound of the gray region (% of action level)
s = standard deviation

A.7 RECOMMENDED DATA ANALYSIS ACTIVITIES

Post-data collection activities generally follow those outlined in the U.S. Environmental Protection Agency's *Guidance for Data Quality Assessment: A Reviewer's Guide* (EPA 2006a). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify, to the extent possible, the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling at this site is to compare the site mean value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

A.8 REFERENCES

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