0075869

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

08-AMRC-0101

JAN 31 2008

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Mr. Nicholas Ceto, Program Manager
Office of Environmental Cleanup
Hanford Project Office
U.S. Environmental Protection Agency
309 Bradley Blvd, Suite 115
Richland, Washington 99352

Dear Mr. Ceto:

TRANSMITTAL OF APPROVED CLEANUP VERIFICATION PACKAGE FOR THE 118-B-1, 105-B SOLID WASTE BURIAL GROUND, CVP-2007-00006, REVISION 0

This letter transmits the approved Cleanup Verification Package for 118-B-1, 105-B Solid Waste Burial Ground, Revision 0, for your use. Ms. L. C. Buelow of your staff has reviewed this document. If you have any questions, you may contact me or your staff may contact Chris Smith, of my staff, at (509) 372-1544.

Sincerely,

Joe R. Franco, Assistant Manager
for the River Corridor

AMRC:DCS

Enclosure

cc w/encl:
Administrative Record, A3-01 100-BC-2
L. C. Buelow, EPA

cc w/o encl:
R. A. Carlson, WCH
L. M. Dittmer, WCH

0075869

CVP-2007-00006
Rev. 0

Cleanup Verification Package for the 118-B-1, 105-B Solid Waste Burial Ground

Prepared for the U.S. Department of Energy
by Washington Closure Hanford

December 2007

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EXECUTIVE SUMMARY

This cleanup verification package documents completion of remedial action, sampling activities, and compliance with cleanup criteria for the 118-B-1, 105-B Solid Waste Burial Ground. The 118-B-1 Burial Ground, part of the 100-BC-2 Operable Unit, is located in the 100-B/C Area of the Hanford Site in southeastern Washington State. This waste site was the primary burial ground for general wastes from the operation of the 105-B Reactor and P-10 Tritium Separation Project and also received waste from the 105-N Reactor. The burial ground was in operation between 1944 and 1973 and received reactor hardware, process piping and tubing, fuel spacers, glassware, electrical components, tritium process wastes, soft wastes and other miscellaneous debris.

Remediation of the 118-B-1 Burial Ground began on February 2, 2004, and was completed on June 7, 2007. Remedial action activities involved removing and stockpiling the uncontaminated overburden, and removing the buried waste material and the underlying contaminated soil for disposal. All contaminated solid waste materials were disposed at the Environmental Restoration Disposal Facility, with the exception of spent nuclear fuel, which will be transferred to the 100-K Basins for interim storage prior to final packaging and disposal.

Results of cleanup verification sampling, laboratory analyses, and data evaluations for the 118-B-1 site (which includes the remediation footprint, the overburden and below cleanup level soil stockpiles, and the waste staging pile area) indicate that residual tritium concentrations in vadose zone soils below the remediation footprint exceed remedial action objectives for the protection of groundwater. An explanation of significant difference to the *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (Burial Grounds ROD) assessed balancing factors, and concluded that tritium-contaminated soil may remain in-place, with institutional controls that prohibit future irrigation to minimize further mobilization of

residual tritium contamination to groundwater and the Columbia River. All remedial action objectives and goals for direct exposure, protection of groundwater, and protection of the Columbia River for contaminants other than tritium have been met (see Table ES-1).

Soil cleanup levels were established in the Burial Ground ROD based on a limited ecological risk assessment. Although not required by the Burial Ground ROD, a comparison against ecological risk screening levels has been made for the 118-B-1 waste site contaminants of concern and contaminants of potential concern. Screening levels were not exceeded for the site constituents, with the exception of barium, boron, cadmium, lead, mercury, molybdenum, selenium, and vanadium. Exceedance of screening values does not necessarily indicate the existence of risk to ecological receptors. Concentrations of cadmium, vanadium, and selenium are within the range of Hanford Site background levels, and molybdenum concentrations are consistent with those seen elsewhere at the Hanford Site (no established background value is available for molybdenum). Exceedances for barium, boron, lead, and mercury will be evaluated in the context of additional lines of evidence as part of the baseline risk assessment. A more complete quantitative ecological risk assessment will be presented in the baseline risk assessment for the river corridor portion of the Hanford Site and will be used to support the final closeout decision for the 118-B-1 waste site.

This evaluation supports a reclassification of the 118-B-1 waste site to Interim Closed Out, in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) and the *Tri-Party Agreement Handbook Management Procedures,* Waste Site Reclassification Guideline TPA-MP-14 (DOE-RL 2007). A copy of the waste site reclassification form is included as Attachment ES-1.

Table ES-1. Summary of Remedial Action Goals for the 118-B-1 Burial Ground. (2 Pages)

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?	Ref.
Direct Exposure – Radionuclides	Attain 15 mrem/yr dose rate above background over 1,000 years.	The maximum predicted dose rates for the 118-B-1 Burial Ground are less than 15 mrem/yr. Carbon-14 and strontium-90 activities were not included in the plant ingestion pathway for the remediation footprint, because residual activities are below the root penetration zone.	Yes	a, b
Direct Exposure – Nonradionuclides	Attain individual COC/COPC RAGs.	All individual COC/COPC concentrations are below the direct exposure criteria.	Yes	c
Nonradionuclide Risk Requirements	Attain hazard quotient of less than 1 for all individual noncarcinogens.	All hazard quotients for individual nonradionuclide COCs/COPCs are less than 1.	Yes	d
	Attain a cumulative hazard quotient of less than 1 for noncarcinogens.	The cumulative hazard quotient for all areas and focused samples (8.8×10^{-1}) is less than 1.		d
	Attain an excess cancer risk of less than 1×10^{-6} for individual carcinogens.	All excess cancer risk values for individual nonradionuclide COCs/COPCs are less than 1×10^{-6}.		d
	Attain a total excess cancer risk of less than 1×10^{-5} for carcinogens.	The total excess carcinogenic risk for all areas and focused samples (8.0×10^{-7}) is less than 1×10^{-5}.		d
Groundwater/River Protection – Radionuclides	Attain single COC/COPC groundwater and river protection RAGS.	Among the radionuclide COCs/COPCs, only cesium-137, cobalt-60, strontium-90, and tritium are predicted to reach groundwater, at concentrations significantly below the RAGs. Tritium was not included in the evaluation for the remediation footprint, as an assessment of balancing factors concluded that residual tritium contamination should be left in-place with institutional controls to minimize further mobilization of residual tritium to groundwater.[e]	Yes	a, b
	Attain national primary drinking water regulations:[f] 4-mrem/yr (beta/gamma) dose rate to target receptor/organs.	All organ specific doses are below the 4-mrem/yr dose standard.		g

Table ES-1. Summary of Remedial Action Goals for the 118-B-1 Burial Ground. (2 Pages)

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?	Ref.
	Meet drinking water standards for alpha emitters: the more stringent of 15 pCi/L MCL or 1/25th of the derived concentration guide for DOE Order 5400.5.[h]	No alpha-emitting radionuclide COC/COPCs are predicted to impact groundwater.	Yes	a, b
	Meet total uranium standard of 21.2 pCi/L.[i]	Isotopic uranium concentrations are below background.	Yes	c
Groundwater/River Protection – Nonradionuclides	Attain individual nonradionuclide groundwater and river cleanup requirements.	Residual concentrations of multiple metals and organic compounds exceeded soil RAGs for the protection of groundwater and/or the Columbia River. However, none of these are predicted to migrate to groundwater (and thus the Columbia River) at concentrations exceeding groundwater or river criteria within 1,000 years, with the exception of beta-BHC.[j] However, modeling of the hydraulic conductivity and gradient data for the 100-B/C Area shows that there is a soil-to-groundwater dilution factor of approximately 6, indicating that beta-BHC will not leach to groundwater or the Columbia River at concentrations exceeding cleanup criteria. Therefore, residual contaminant concentrations achieve the remedial action objectives for groundwater and river protection.	Yes	c
Other Supporting Information	Sample design calculation brief.			k

[a] *118-B-1 Combined Areas Cleanup Verification RESRAD Calculation Brief*, 0100B-CA-V0308, Rev. 0 (Appendix C).
[b] *118-B-1 Burial Ground Cleanup Verification RESRAD Calculation Brief for Overburden, Below Cleanup Level (BCL), and Staging Pile Area Soil*, 0100B-CA-V0301, Rev. 0 (Appendix C).
[c] *118-B-1 Burial Ground Cleanup Verification 95% UCL Calculations*, 0100B-CA-V0299, Rev. 1 (Appendix C).
[d] *118-B-1 Burial Ground Hazard Quotient and Carcinogenic Risk Calculations*, 0100B-CA-V0300, Rev. 1 (Appendix C).
[e] *Explanation of Significant Difference for the Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units (100 Area Burial Grounds)* (EPA 2007).
[f] "National Primary Drinking Water Regulations" (40 *Code of Federal Regulations* 141).
[g] *118-B-1 Burial Ground Combined Areas Comparison to Drinking Water Standards (MCL) Calculation Brief*, 0100B-CA-V0309, Rev. 0 (Appendix C).
[h] *Radiation Protection of the Public and the Environment* (DOE Order 5400.5).
[i] Based on the isotopic distribution of uranium in the 100 Areas, the 30 µg/L MCL corresponds to 21.2 pCi/L. Concentration-to-activity calculations are documented in *Calculation of Total Uranium Activity Corresponding to a Maximum Contaminant Level for Total Uranium of 30 Micrograms per Liter in Groundwater* (BHI 2001).
[j] *100 Area Analogous Sites RESRAD Calculations*, 0100X-CA-V0050, Rev. 0, Bechtel Hanford, Inc., Richland, Washington (2005).
[k] *118-B-1 Shallow Zone, Overburden, BCL, and Staging Pile Sampling Plan*, 0100B-CA-V0284, Rev. 0 (Appendix C).

COC = contaminant of concern
COPC = contaminant of potential concern
MCL = maximum contaminant level (drinking water standard)
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose model)

Attachment ES-1. Waste Site Reclassification Form.

Date Submitted: 12/12/07 Originator: L. M. Dittmer Phone: 372-9227	**WASTE SITE RECLASSIFICATION FORM** Operable Unit(s): 100-BC-2 Waste Site Code: 118-B-1 Type of Reclassification Action: Closed Out ☐ Interim Closed Out ☒ No Action ☐ RCRA Postclosure ☐ Rejected ☐ Consolidated ☐	Control Number: 2007-032

This form documents agreement among parties listed authorizing classification of the subject unit as Closed Out, Interim Closed Out, No Action, RCRA Postclosure, Rejected, or Consolidated. This form also authorizes backfill of the waste management unit, if appropriate, for Closed Out and Interim Closed Out units. Final removal from the NPL of No Action and Closed Out waste management units will occur at a future date.

Description of current waste site condition:

The 118-B-1 Burial Ground was the primary burial ground for general wastes from the operation of the 105-B Reactor and P-10 Tritium Separation Project. Remediation, verification sampling, and RESidual RADioactivity (RESRAD) modeling have been performed in accordance with remedial action objectives and goals established by the *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (Burial Ground ROD), U.S. Environmental Protection Agency, Region 10, Seattle, Washington and the October 2007 *Explanation of Significant Difference for the Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units (100 Area Burial Grounds)* (118-B-1 ESD), U.S. Environmental Protection Agency, Region 10, Seattle, Washington. The selected remedy involved (1) excavating the site to the extent required to meet specified soil cleanup levels, (2) disposing of contaminated excavation materials at the Environmental Restoration Disposal Facility at the 200 Area of the Hanford Site or appropriate treatment, storage, and disposal facilities, (3) demonstrating through verification sampling and RESRAD modeling that cleanup goals have been achieved, and (4) proposing the site for reclassification as Interim Closed Out.

Basis for reclassification:

In accordance with this evaluation, the verification sampling and modeling results support a reclassification of this site to Interim Closed Out. The current site conditions achieve the remedial action objectives established in the Burial Ground ROD, as amended by the 118-B-1 ESD. The results show that residual tritium concentrations in the vadose zone beneath the burial ground exceed remedial action objectives for the protection of groundwater. The 118-B-1 ESD assessed balancing factors and concluded that residual tritium contamination should be left in-place with institutional controls to prohibit irrigation, minimizing further mobilization of residual tritium. The results of verification sampling and RESRAD modeling for contaminant concentrations other than tritium do not preclude any future uses (as bounded by the rural-residential scenario). With institutional controls to prevent irrigation, the results also demonstrate that residual contaminant concentrations are protective of groundwater and the Columbia River. The acceptability of direct exposure to residual tritium contamination in the deep vadose zone has not been demonstrated; therefore, institutional controls to prevent uncontrolled drilling or excavation into the deep zone are also required. The basis for reclassification is described in detail in the *Cleanup Verification Package for the 118-B-1, 105-B Solid Waste Burial Ground* (CVP-2007-00006), Washington Closure Hanford, Richland, Washington.

Waste Site Controls:

Engineered Controls: Yes ☐ No ☒ Institutional Controls: Yes ☒ No ☐ O&M requirements: Yes ☐ No ☒
Deed restrictions to prohibit irrigation and prevent uncontrolled drilling or excavation into the deep zone (greater than 4.6 m [15 ft] below ground surface).

S. L. Charboneau DOE Federal Project Director (printed)	Stacy Charboneau Signature	12/20/07 Date
NA Ecology Project Manager (printed)	Signature	Date
L. Buelow EPA Project Manager (printed)	Signature	1/9/08 Date

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ACRONYMS AND ABBREVIATIONS

BCL	below cleanup level
BCM	bank cubic meters
BCY	bank cubic yards
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
DOE-RL	U.S. Department of Energy Richland Operations Office
DQA	data quality assessment
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ESD	Explanation of Significant Difference
ICP	inductively coupled plasma
MCL	maximum contaminant level (drinking water standard)
PCB	polychlorinated biphenyl
RAG	remedial action goal
RDR/RAWP	remedial design report/remedial action work plan
RESRAD	RESidual RADioactivity dose assessment model
ROD	Record of Decision
SAP	sampling and analysis plan
SPA	staging pile area
SSI	site-specific instruction
SNF	spent nuclear fuel
TPH	total petroleum hydrocarbons
TSD	treatment, storage, and disposal
UCL	upper confidence limit
WAC	*Washington Administrative Code*

1.0 STATEMENT OF PROTECTIVENESS

This report demonstrates that the 118-B-1 Burial Ground was remediated in accordance with the *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (Burial Grounds ROD) (EPA 2000) and the *Explanation of Significant Difference for the Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units (100 Area Burial Grounds)* (118-B-1 ESD) (EPA 2007), and meets the objectives and goals for interim closure as established in the Burial Ground ROD and the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 2005).

The preferred remedy specified in the ROD (EPA 2000) and conducted for the 118-B-1 site included (1) excavating the site to the extent required to meet specified soil cleanup levels, (2) disposing of contaminated excavation materials at the Environmental Restoration Disposal Facility (ERDF) at the 200 Area of the Hanford Site or appropriate treatment, storage, and disposal (TSD) facilities, (3) backfilling the site with overburden and clean soil to average adjacent grade elevation, and (4) planting native vegetation species across the site. Excavation was driven by remedial action objectives for direct exposure, protection of groundwater, and protection of the Columbia River.

The results of verification sampling indicated that vadose zone soils beneath the burial ground contained residual tritium contamination in excess of remedial action objectives for the protection of groundwater. The 118-B-1 ESD (EPA 2007) was approved by the Tri-Parties to leave residual tritium-contaminated soil in-place based on consideration of balancing factors, and includes institutional controls to prohibit future irrigation at the 118-B-1 waste site. The results of verification sampling show that residual concentrations of contaminants other than tritium do not preclude any other future uses (as bounded by the rural-residential scenario) of shallow zone soils (i.e., surface to 4.6 m [15 ft] deep). Tritium activities in groundwater exceed the maximum contaminant level (MCL) of 20,000 pCi/L. With institutional controls to prevent irrigation, further mobilization of residual vadose zone tritium-contamination is predicted to be prevented to the extent that the MCL will not be exceeded for Columbia River water (EPA 2007). Further, removing this driving force will allow for natural decay of a larger portion of the residual vadose zone tritium inventory before reaching groundwater. Residual concentrations of non-tritium contaminants are protective of groundwater and the Columbia River. The acceptability of direct exposure to residual tritium contamination in the deep vadose zone has not been demonstrated; therefore, institutional controls to prevent uncontrolled drilling or excavation into the deep zone are also required.

Soil cleanup levels were established in the Burial Ground ROD (EPA 2000) based on a limited ecological risk assessment. Although not required by the Burial Ground ROD, a comparison against ecological risk screening levels has been made for the 118-B-1 waste site contaminants of concern (COCs)/contaminants of potential concern (COPCs). Screening levels were not exceeded for the site constituents, with the exception of barium, boron, cadmium, lead, mercury, molybdenum, selenium, and

vanadium. Exceedance of screening values does not necessarily indicate the existence of risk to ecological receptors. Concentrations of cadmium, vanadium, and selenium are within the range of Hanford Site background levels, and molybdenum concentrations are consistent with those seen elsewhere at the Hanford Site (no established background value is available for molybdenum). Exceedances for barium, boron, lead, and mercury will be evaluated in the context of additional lines of evidence as part of the baseline risk assessment. A more complete quantitative ecological risk assessment will be presented in the baseline risk assessment for the river corridor portion of the Hanford Site and will be used to support the final closeout decision for this waste site.

2.0 BACKGROUND AND GENERAL SITE INFORMATION

The 118-B-1 Burial Ground is located in the 100-BC-2 Operable Unit of the Hanford Site approximately 900 m (3,000 ft) east of the 105-C Reactor Building (Figures 1 and 2). This waste site operated from 1944 to 1973, receiving general radioactive and non-radioactive wastes from the 105-B and 105-N Reactors, construction wastes from modification of the 105-B Reactor Building, and process wastes from the P-10 Tritium Separation Project (Carpenter 1994).

The original burial ground consisted of six to eight trenches oriented in an east-west direction, but was expanded over its operational lifetime to 21 east-west trenches and 2 north-south trenches on the west side of the burial ground, according to historical documentation (Carpenter 1994) (Figure 3). During remediation of the site, it was discovered that 2 of the 23 trenches had not been used for waste disposal. The burial ground also consisted of several spline silos constructed from 3- to 3.7-m (10- to 12-ft) diameter metal culvert piping and 3 spacer pits shored with railroad ties. The overall lateral footprint of the burial ground prior to remediation was approximately 225 m by 90 m (740 ft by 300 ft).

A geophysical survey was performed over the 118-B-1 Burial Ground in 1993 (WHC 1993) to locate and map subsurface anomalies, and was validated by limited exploratory excavation in March 2002 (Ludowise 2002). Multiple subsurface anomalous zones were observed, generally consistent with the historical trench layout (Figure 3).

3.0 REMEDIAL ACTION SUMMARY

This section contains specific information about the excavation and disposal activities for the 118-B-1 Burial Ground. It also contains information about the types of wastes encountered in the burial ground and the field screening conducted.

Figure 1. Location of the 118-B-1 Burial Ground.

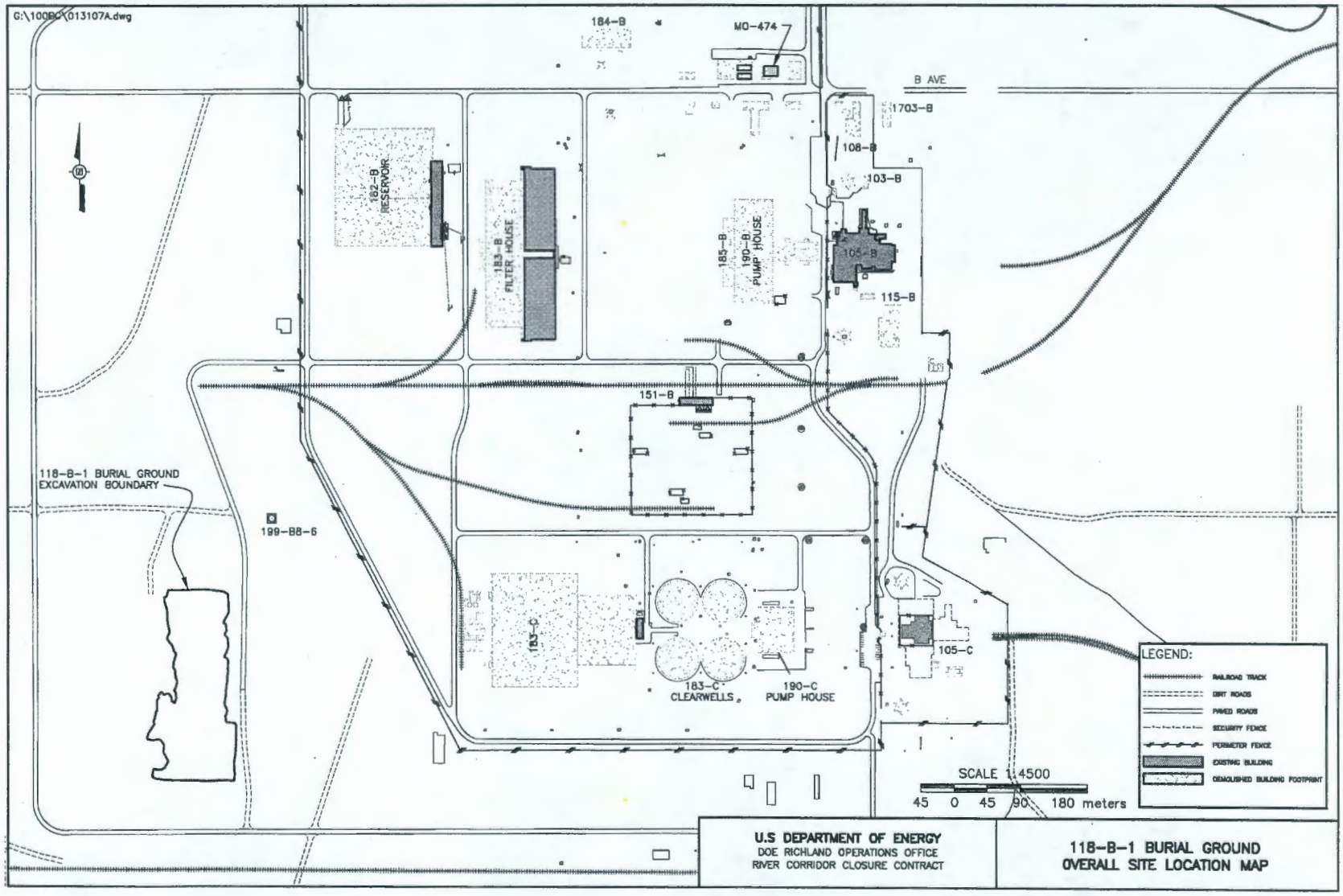
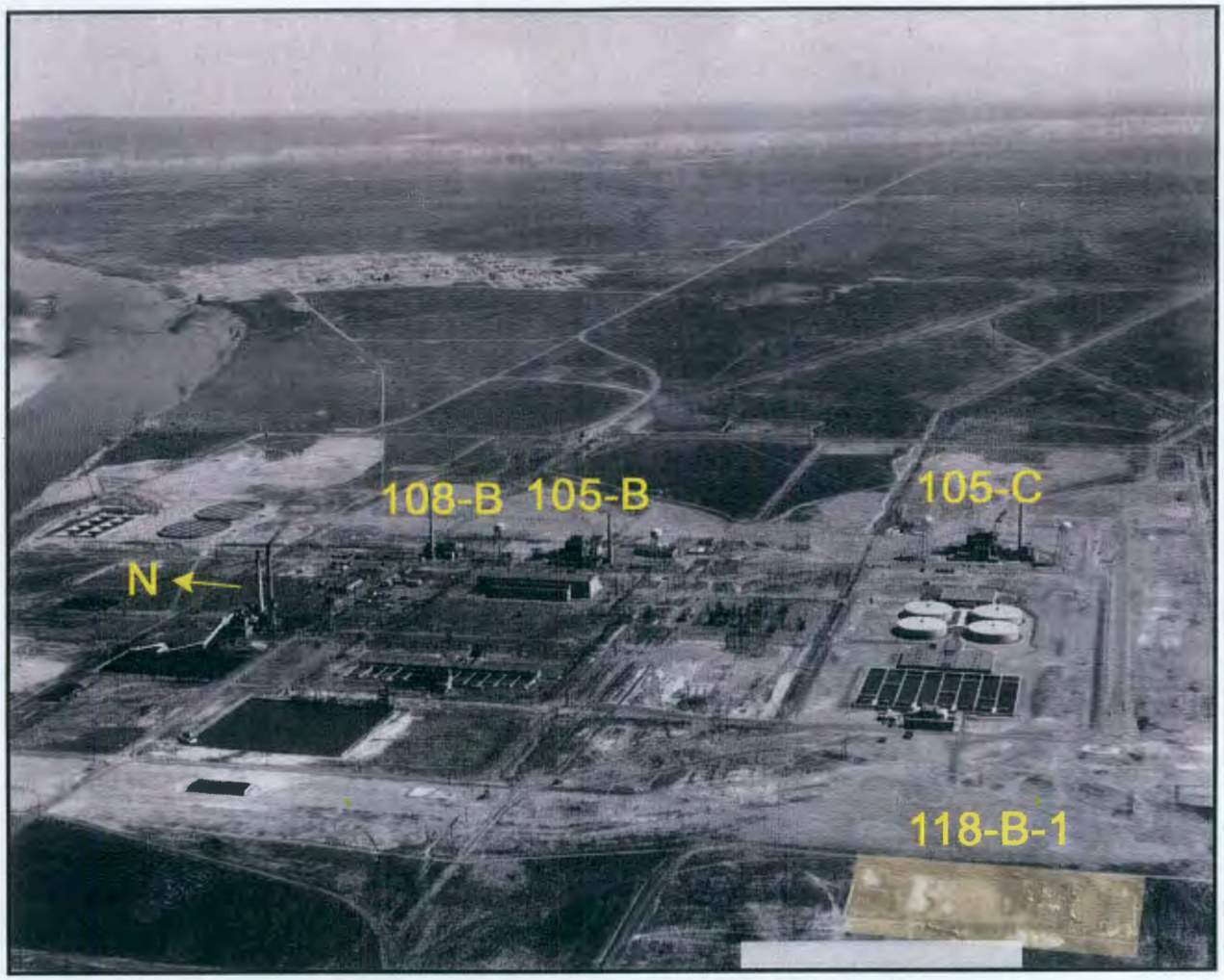


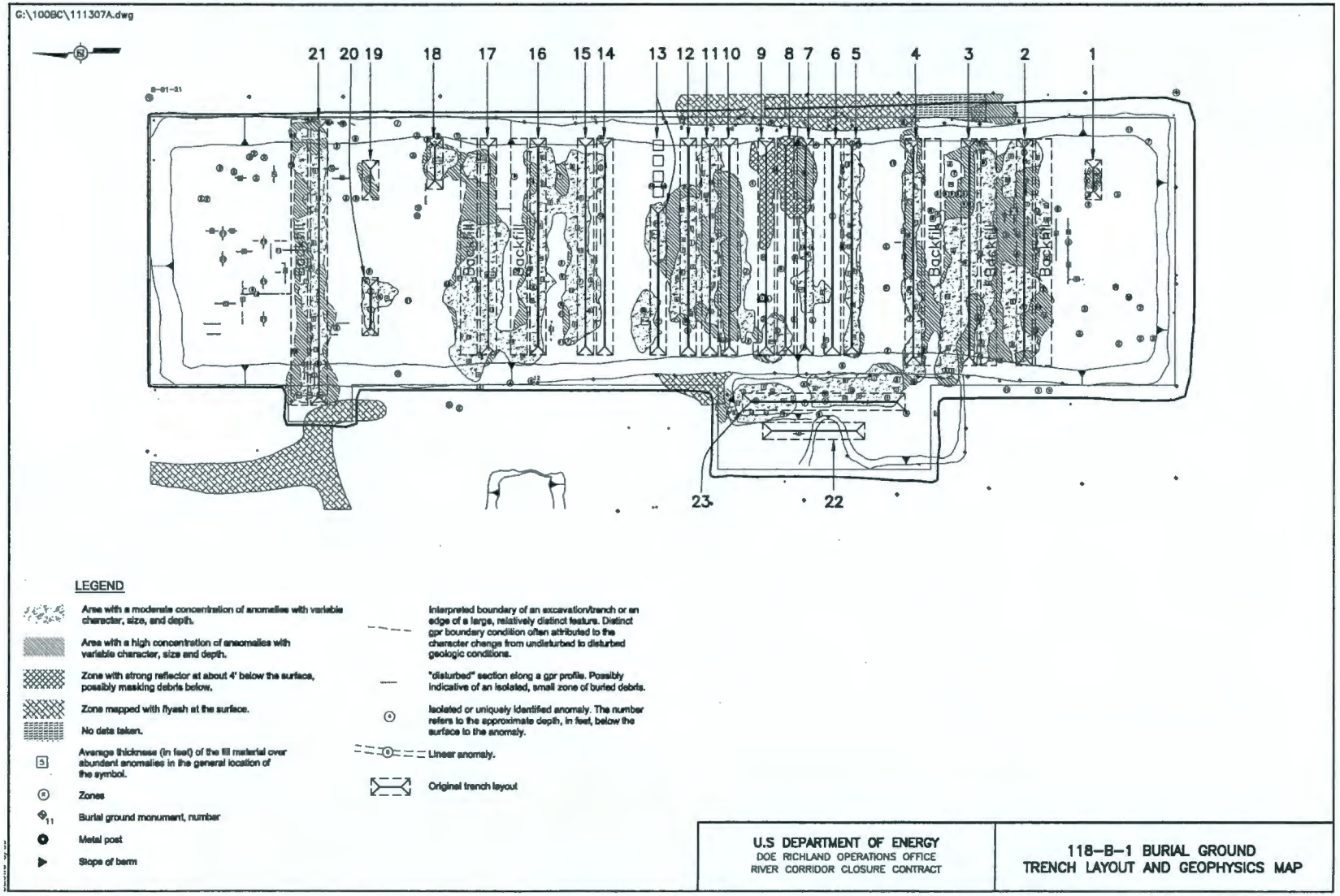
Figure 2. Historical Aerial Photograph of the 100-B/C Area, Including the 118-B-1 Burial Ground.



3.1 EXCAVATION AND DISPOSAL INFORMATION

Remedial action of the 118-B-1 Burial Ground began on February 2, 2004, with overburden removal. Approximately 20,000 BCM (26,200 BCY) of overburden material was removed before beginning excavation and sorting of the burial ground on March 16, 2004. Suspect spent nuclear fuel (SNF) was discovered on September 15, 2004, and remedial activities suspended until the Authorization Basis could be assessed and revised to address SNF. Load-out operations resumed on April 11, 2005, for previously sorted and segregated material. All remedial activities (excavation, sorting, and load-out) resumed on August 24, 2005, and were completed on June 7, 2007, with the exception of characterization and dispositioning of SNF and approximately 100 remaining anomalous containers.

Figure 3. 118-B-1 Burial Ground Trench Layout and Geophysical Investigation Results.



Over 132,300 tons (120,000 metric tons) of debris and contaminated soil from the 118-B-1 Burial Ground was removed and disposed at ERDF. The post-excavation topographic survey for the burial ground is shown in Figure 4. At the conclusion of remediation activities, the excavated area was approximately 10 m (33 ft) at its deepest, with a lateral footprint of approximately 21,600 m^2 (5.3 acres). Approximately 136,000 m^2 (33.6 acres) in total at the site were disturbed, including stockpiles and waste sorting and staging areas. An aerial photograph taken near the completion of excavation activities is shown in Figure 5.

3.2 WASTE INFORMATION

Twenty-three burial trenches were anticipated in the 118-B-1 Burial Ground, based on historical information; geophysical investigations indicated debris in 22 of those trenches. Exploratory excavation was performed at Trench 22, where no indications of buried debris were observed by geophysical instrumentation, and no debris or other waste forms were identified. Excavation at Trench 1 revealed only a large piece of metal, and no further waste forms were encountered. Waste forms encountered in the other 21 trenches included several thousand perforated and non-perforated spacers, spline cases, piping and tubing, miscellaneous metal, tritium furnaces, wax, lead items, mineral oil, reactor parts and hardware, SNF, hydraulic hoses and parts, degraded personal protective equipment, glassware, compressed gas cylinders, friable and non-friable asbestos containing material, gaskets, metal lathe turnings, dried paints, tar, electrical components, suspect pipe joint compound, and other miscellaneous debris. Photographs of selected waste items are provided in Appendix A.

Additionally, approximately 1,500 anomalous items were discovered during excavation and sorting operations. Approximately 1,000 of these were tubes used for packaging and disposal of tritium gas, approximately 350 were barium desiccant tubes, 81 were tubes used for packaging and disposal of mercury, approximately 50 were glass/plastic bottles, and approximately 70 were unique anomalous containers or solids.

Suspect SNF discovered during remediation activities was staged in two bunkers within the 118-B-1 waste staging pile area. Six pieces of confirmed SNF and two fractional pieces were identified following characterization. This material was transferred to the 100-K fuel storage basins for interim storage prior to final packaging and disposal.

Figure 4. 118-B-1 Burial Ground Post-Excavation Topographic Survey.

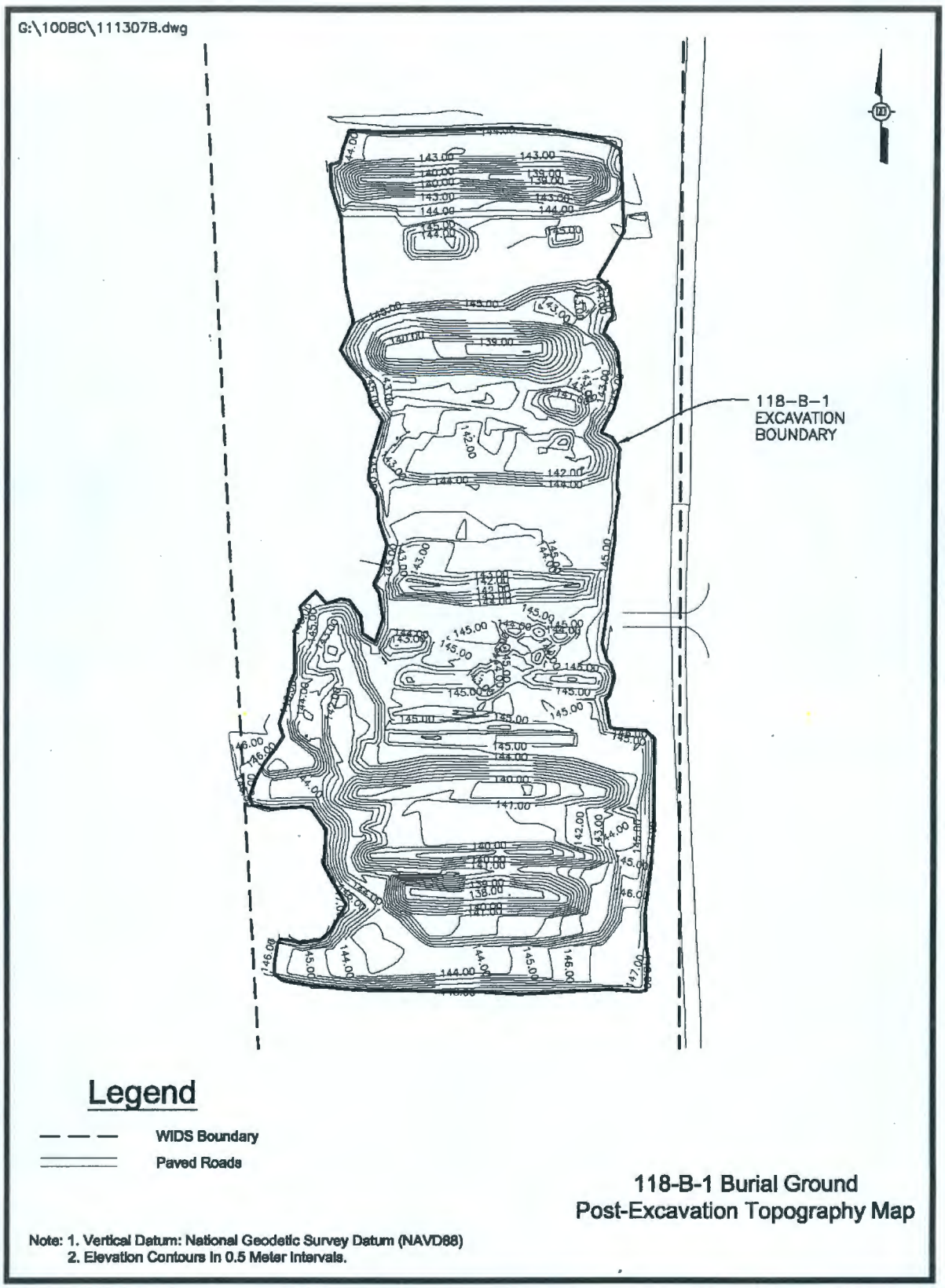


Figure 5. 118-B-1 Burial Ground After Major Excavation Activities (taken November 2006).

3.3 FIELD SCREENING

Radiological field screening was conducted during and after the site remedial actions as specified in the *100 Area Burial Grounds Remedial Action Sampling and Analysis Plan* (Burial Ground SAP) (DOE-RL 2001a). Field screening was used to guide the excavation to quickly assess the presence and level of contamination. Field screening at the site included using systematic global positioning radiological data mapping surveys in the excavation, on stockpiled material, and in interstitial areas with instrumentation specific to the detection of radiation associated with gamma and beta-emitting radionuclides.

The radiological surveys are provided in Appendix B. Multiple areas of elevated radiological activity requiring additional remediation were identified by the surveys. Additional material was selectively removed from these areas, and follow-up surveys performed using systematic global positioning surveys or hand-held instrumentation to confirm the adequacy of removal.

4.0 SAMPLING ACTIVITIES

Following remediation of the 118-B-1 Burial Ground, verification sampling was conducted in July 2006 and October through December 2006. Additional focused verification samples were collected from March to June 2007. Verification sampling is performed to collect data to determine if the remedial action goals (RAGs) have been met. RAGs are the specific numeric goals against which the verification data are evaluated to demonstrate attainment of the remedial action objectives as established in the Burial Ground ROD (EPA 2000) and the RDR/RAWP (DOE-RL 2005). The following subsections provide additional discussion of the information used to develop the COCs and COPCs for verification and focused sampling, as well as the sampling design selection and basis.

4.1 VERIFICATION SAMPLING DESIGN SELECTION AND BASIS

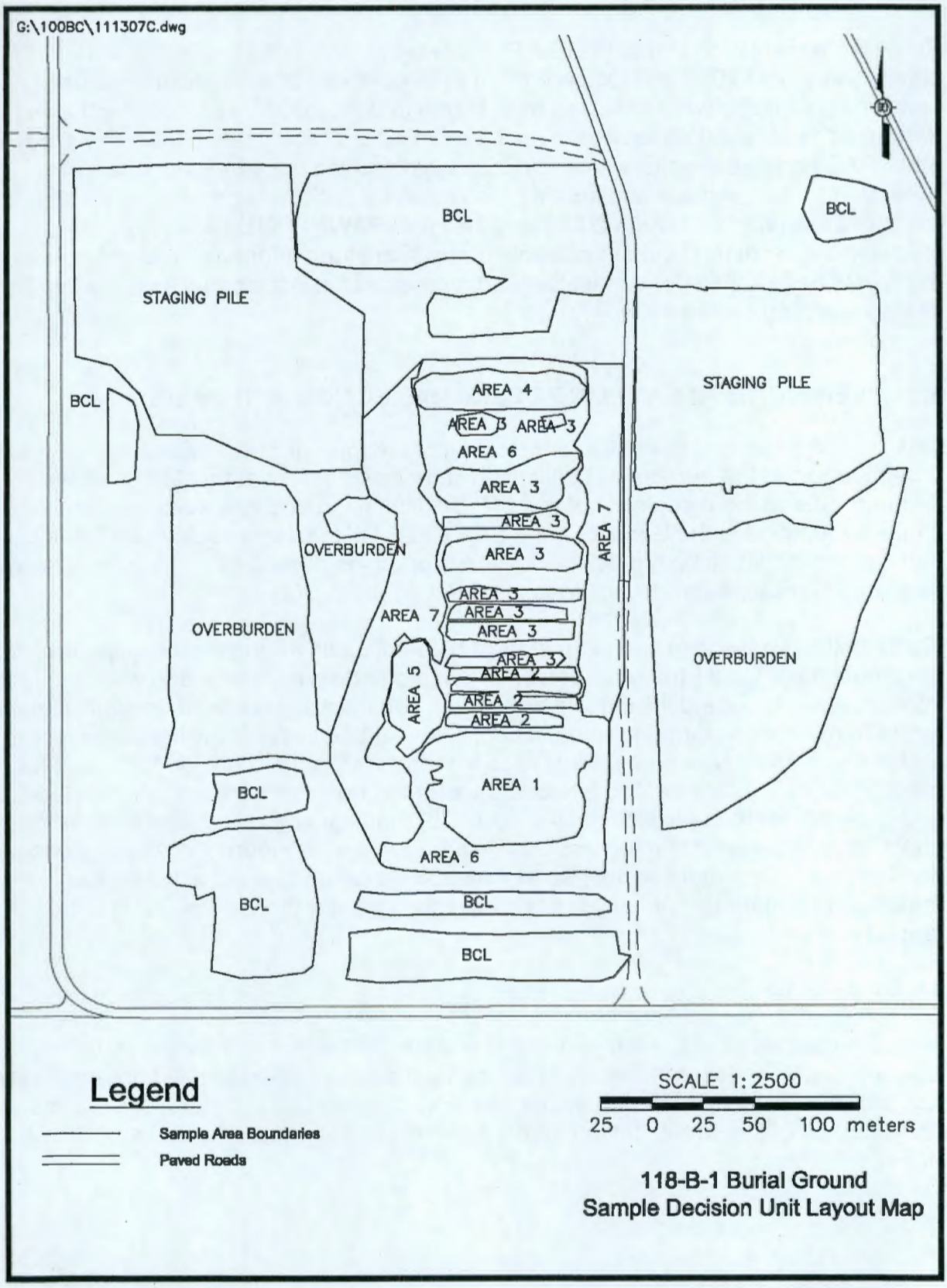
This section describes the basis for selection of an appropriate sampling design and the determination of the number of verification samples to collect at the 118-B-1 Burial Ground. Due to the complexity of the 118-B-1 Burial Ground, the standard sampling strategy identified in the Burial Ground SAP (DOE-RL 2001a) was deemed insufficient, and a more robust sampling design was developed, as described in the *Site Specific Instruction for Close-out Approach for 118-B-1* (WCH 2006).

For statistical verification sampling of the 118-B-1 Burial Ground remediation footprint, the footprints of the 21 trenches containing waste and surrounding land were grouped into one shallow zone decision unit with seven separate areas based on similarity of the waste forms observed during remediation, as described in the following subsections. In addition to these seven areas, the 118-B-1 waste site included one decision unit for the overburden stockpiles, divided into one area for the true overburden material stockpiles and one area for the below cleanup level (BCL) material stockpiles, and one decision unit/area for the waste staging and sorting area footprints (Figure 6). All ten areas were verified to meet the more restrictive shallow zone cleanup criteria, although the remediation footprint is partially in the deep zone (greater than 4.6 m [15 ft] below ground surface).

4.1.1 Area 1

Area 1 is composed of the footprints of Trenches 2 through 4. The waste stream observed within these trenches included general debris, perforated and non-perforated spacers, sandblasting material, gearboxes, compressed gas cylinders, small glass containers, mercury tubes, tritium tubes, asbestos, barium desiccant tubes, splines, and SNF.

Figure 6. 118-B-1 Area Boundaries for Verification Sampling.



4.1.2 Area 2

Area 2 is composed of the footprints of Trenches 5 through 8. The waste stream observed within these trenches included general debris, perforated and non-perforated spacers, tritium pots, and tritium furnaces.

4.1.3 Area 3

Area 3 is composed of the footprints of Trenches 9 through 20. The waste stream observed within these trenches included general debris, perforated and non-perforated spacers, tritium pots, tritium furnaces, small glass containers, mercury tubes, tritium tubes, wax, metal shavings, and a lead-lined cask.

4.1.4 Area 4

Area 4 is composed of the footprint of Trench 21. The waste stream observed within this trench included general debris, perforated and non-perforated spacers, ink, small glass containers, gearboxes, suspect herbicides, barium desiccant tubes, and silver slag.

4.1.5 Area 5

Area 5 is composed of the footprint of Trench 23. The waste stream observed within this trench included steel railing, a decayed drum containing oil, and elemental mercury.

4.1.6 Area 6

Area 6 is composed of the areas between trenches that were not included in Sampling Areas 1 through 5.

4.1.7 Area 7

Area 7 is composed of the haul roads between the burial ground and the waste staging and sorting areas.

4.1.8 Overburden Stockpiles

The overburden area consists of overburden removed from the 118-B-1 Burial Ground at the beginning of remedial operations as well as the historic spoils stockpiled onsite during excavation of the burial trenches.

4.1.9 BCL Stockpiles

The BCL stockpiles area consists of BCL material excavated in the layback between trenches.

4.1.10 Staging Pile Area Footprint

The staging pile area (SPA) decision unit consists of the footprints of two waste staging and sorting areas used during remedial activities.

4.1.11 Statistical Sampling Design

The number of sampling areas within each area was determined by the overall footprint size of the area, per the Burial Ground SAP (DOE-RL 2001a). The default number of verification samples for each decision subunit is four (4) composite samples. The required number of verification samples for each of the areas associated with the 118-B-1 waste site is listed in Table 1.

Each statistical verification sample was a composite formed by combining soil collected at four randomly selected nodes within each sampling area. The verification samples were submitted to offsite laboratories for analysis using approved Environmental Protection Agency (EPA) analytical methods, as required by the SAP (DOE-RL 2001a). The sample design methodology and sample location figures are presented in the calculation brief for verification sample design in Appendix C.

Table 1. Number of Statistical Verification Samples for the 118-B-1 Burial Ground.

Area	Footprint (ft^2)	Size Classification (ft^2)	Decision Subunits	Verification Samples
Area 1	40,600	Small (<100,000)	1	4 composites
Area 2	16,300	Small (<100,000)	1	4 composites
Area 3	50,000	Small (<100,000)	1	4 composites
Area 4	15,600	Small (<100,000)	1	4 composites
Area 5	11,700	Small (<100,000)	1	4 composites
Area 6	99,700	Small (<100,000)	1	4 composites
Area 7	99,000	Small (<100,000)	1	4 composites
Overburden Stockpiles	247,900	Medium (100,000 to 400,000)	4	16 composites
BCL Stockpiles	215,500	Medium (100,000 to 400,000)	4	16 composites
Staging Pile Area Footprint	300,100	Medium (100,000 to 400,000)	4	16 composites

BCL = below cleanup level

4.1.12 Focused Sampling

Focused samples were collected to provide confidence for the absence of contamination in residual soil beneath locations exhibiting visual soil stains, buried liquid

wastes or equipment, or large inventories of dangerous/hazardous wastes (e.g., lead debris and mercury-containing piping). Additionally, focused samples may be collected from locations where process knowledge indicates the potential for elevated concentrations of alpha- or beta-emitter contamination, or where waste characterization sampling results indicate potential elevated concentrations of chemical contaminants above RAGs.

Nineteen focused soil verification samples were collected, in addition to the statistical cleanup verification samples. Eleven of the focused samples were collected within the footprints of anomalous waste items or where high in-process sampling results occurred within the remediation footprint (Figure 7). Two of the focused samples were collected from soil underlying the SNF bunkers located in the SPA. The remaining six samples were collected at the locations of special waste staging areas. Additional description of the selection of focused samples is provided with the discussion of the development of COCs/COPCs, in Section 4.2.2.

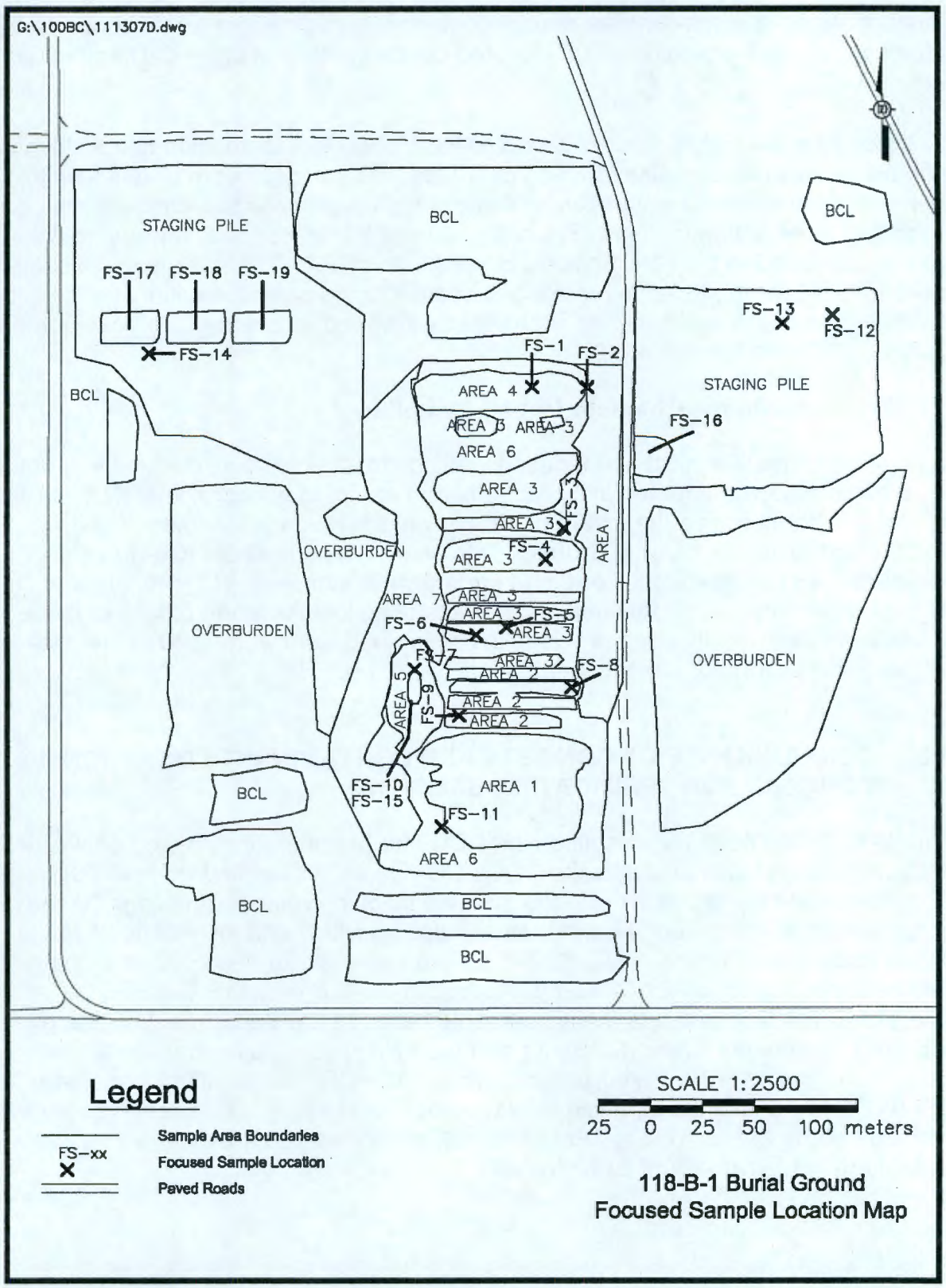
4.1.13 Tritium Plume Characterization Sampling

In addition to the statistical and focused verification samples collected, eleven potholes were excavated in the remediation footprint and sampled at approximately 1-m (3-ft) intervals to characterize the extent of tritium contamination in the vadose zone underlying the 118-B-1 Burial Ground. One characterization borehole was also completed, including vadose zone and groundwater sampling, at the location of the highest detections of residual tritium. The sampling locations and results of these characterization activities are provided in Appendix D, and were used in the assessment of balancing factors for the 118-B-1 ESD (EPA 2007).

4.2 CONTAMINANTS OF CONCERN AND CONTAMINANTS OF POTENTIAL CONCERN FOR VERIFICATION SAMPLING

The SAP (DOE-RL 2001a) identifies the COCs for burial grounds based on waste forms encountered. Additional waste site COCs/COPCs were identified for the 118-B-1 Burial Ground based on process knowledge and results of in-process sampling. Based on the observed waste forms found during remediation activities and the results of waste characterization sampling, COCs/COPCs were identified for each decision unit in the *Site Specific Instruction for Close-Out Approach for 118-B-1* (118-B-1 SSI) (WCH 2006). The 118-B-1 SSI documents the agreements between the Department of Energy Richland Operations Office (DOE-RL) and the EPA regarding interim waste site closeout for the 118-B-1 Burial Ground. The COCs/COPCs identified in the 118-B-1 SSI (WCH 2006) include americium-241, carbon-14, cesium-137, cobalt-60, europium-152, europium-154, europium-155, nickel-63, plutonium-238, plutonium-239/240, plutonium-241, silver-108m, strontium-90,

Figure 7. Location of Focused Verification Soil Samples at the 118-B-1 Burial Ground.



tritium, uranium-233/234, uranium-235, uranium-238, the expanded list of inductively coupled plasma (ICP) metals (arsenic, antimony, barium, beryllium, boron, cadmium, total chromium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, vanadium, and zinc), hexavalent chromium, mercury, polychlorinated biphenyls (PCBs), total petroleum hydrocarbons (TPH), semi-volatile organic compounds, volatile organic compounds, herbicides, pesticides, and asbestos. The COCs/COPCs detected at the 118-B-1 Burial Ground and their respective points of compliance, the remedial action goals (RAGs), are summarized in Section 5.0 of this cleanup verification package.

4.2.1 Statistical Sampling

The remediation footprint, stockpiles, and SPA footprint were divided into ten areas, based on use and the similarity of waste forms observed during remediation, as described in Section 4.1. The COCs/COPCs for the five areas associated with the remediation footprints for the burial trenches were identified based on the waste forms observed (WCH 2006). The COCs/COPCs for the remaining five areas (interstitial areas, haul roads, overburden stockpiles, BCL stockpiles, and the SPA footprint) are inclusive of all COCs/COPCs for the remediation footprint. The COCs/COPCs for each area are listed in Table 2.

Table 2. Summary of the 118-B-1 Waste Site COCs/COPCs for Statistical Verification Sampling. (2 Pages)

COCs/COPCs	Area 1	Area 2	Area 3	Area 4	Area 5	Areas 6 & 7, Overburden Stockpiles, BCL Stockpiles, and SPA
Radionuclides						
Americium-241	X	X[a]	X[a]			X
Carbon-14	X	X	X	X	X	X
Gamma-emitters[b]	X	X	X	X	X	X
Nickel-63	X	X	X	X	X	X
Plutonium-238	X	X[a]	X[a]			X
Plutonium-239/240	X	X[a]	X[a]			X
Plutonium-241	X	X[a]	X[a]			X
Strontium-90	X	X	X	X	X	X
Silver-108m	X	X	X	X	X	X
Tritium	X	X	X	X	X	X
Uranium-233/234	X					X
Uranium-235	X					X
Uranium-238	X					X

Table 2. Summary of the 118-B-1 Waste Site COCs/COPCs for Statistical Verification Sampling. (2 Pages)

COCs/COPCs	Area 1	Area 2	Area 3	Area 4	Area 5	Areas 6 & 7, Overburden Stockpiles, BCL Stockpiles, and SPA
Nonradionuclides						
Asbestos	X					X
ICP metals[c]	X	X	X	X	X	X
Hexavalent chromium	X	X	X	X	X	X
Mercury	X	X	X	X	X	X
Herbicides				X		X
Pesticides				X		X
PCBs	X		X	X	X	X
SVOA	X		X	X	X	X
TPH	X	X[a]	X	X	X	X
VOA	X		X	X	X	X

[a] Analyte was not identified as a COC/COPC (WCH 2006), but was inadvertently included in the requested analyses.
[b] Includes cesium-137, cobalt-60, europium-152, europium-154, and europium-155.
[c] The expanded list of ICP metals analysis was performed (arsenic, antimony, barium, beryllium, boron, cadmium, total chromium, lead, cobalt, copper, manganese, molybdenum, nickel, selenium, silver, vanadium, and zinc).

BCL = below cleanup level
COC = contaminant of concern
COPC = contaminant of potential concern
ICP = inductively coupled plasma
PCB = polychlorinated biphenyl
SPA = staging pile area
SVOA = semivolatile organic analysis
TPH = total petroleum hydrocarbons
VOA = volatile organic analysis

4.2.2 Focused Sampling

The COCs/COPCs for focused samples were identified based on waste forms encountered, in-process sampling, and process knowledge (WCH 2006), and are listed in Table 3.

Table 3. 118-B-1 Focused Verification Sample Summary. (3 Pages)

Sample Location	Sample Number	Associated Anomaly	Coordinate Locations[a]	COCs/COPCs
1	J12R24	Pesticide/herbicide odor in Trench 21	N 144048.4 E 564414.0	Herbicides, pesticides, PCBs, SVOA, TPH, and VOA
2	J12R25	Cache of barium desiccant tubes in Trench 21	N 144048.3 E 564441.1	ICP metals[b]
3	J12R26	Cache of tritium tubes in Trench 16	N 143978.3 E 564429.5	Tritium and ICP metals[b]
4	J12R27	Cache of tritium tubes in Trench 15	N 143962.9 E 564420.6	Tritium
5	J12R28	Cache of mercury tubes in Trench 12	N 143929.4 E 564401.6	ICP metals[b] and mercury

Table 3. 118-B-1 Focused Verification Sample Summary. (3 Pages)

Sample Location	Sample Number	Associated Anomaly	Coordinate Locations[a]	COCs/COPCs
6	J12R29	Cache of lead debris in Trench 10	N 143925.8 E 564387.2	ICP metals[b]
7	J13P85	Mercury-contaminated soil in Trench 23	N 143908.7 E564357.0	ICP metals[b] and mercury
8	J12R31	Cache of lead debris in Trench 7	N 143899.7 E 564433.3	ICP metals[b]
9	J12R32	Cache of lead debris in Trench 5	N 143885.7 E 564378.8	ICP metals[b]
10	J12R33	Deteriorated drum containing mineral oil in Trench 23	NA[c]	PCBs, SVOA, TPH, and VOA
11	J12R34	Cache of tritium and mercury tubes in Trench 2	N 143831.1 E 564370.1	Tritium, ICP metals[b], and mercury
12	J14Y75	SNF Bunker 1	N 144084.4 E 564559.6	Americium-241, gamma-emitting radionuclides, plutonium-238, plutonium-239/240, plutonium-241, uranium-233/234, uranium-235, and uranium-238
13	J14Y76	SNF Bunker 2	N 144080.2 E 564535.2	Americium-241, gamma-emitting radionuclides, plutonium-238, plutonium-239/240, plutonium-241, uranium-233/234, uranium-235, and uranium-238
14	J12XB3	Initial process cell dumping area	N 144065.2 E 564227.9	Gamma-emitting radionuclides, ICP metals[b], and mercury
15	J13NX4	Mercury-contaminated soil staging area in Trench 23	NA[d]	ICP metals[b] and mercury
16	J13P84	Mercury-contaminated soil staging area in waste staging pile area	NA[e]	ICP metals[b] and mercury
17	J14JJ3/ J152M1[f]	Mercury-contaminated soil staging area in west end of Process Cell 4	NA[g]	Gamma-emitting radionuclides, tritium, ICP metals[b], and mercury
18	J14L38	Mercury-contaminated soil staging area in middle of Process Cell 4	NA[g]	Gamma-emitting radionuclides, tritium, ICP metals[b], and mercury
19	J14L39	Mercury-contaminated soil staging area in east end of Process Cell 4	NA[g]	Gamma-emitting radionuclides, tritium, ICP metals[b], and mercury

Sources: Field logbooks EFL-1173-8, EFL-1173-10, EFL-1173-11, EFL-1173-12, and EFL-1173-13 (WCH 2007a, 2007b, 2007c, 2007d, 2007e)

[a] Washington State Plane, South Zone meters.

[b] Samples were analyzed for the expanded ICP metal list including antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, vanadium, silver, and zinc.

[c] Sample location adjusted from that listed in WCH (2006), due to significant topography change following loadout of mercury-contaminated soils. Sample was collected by combining multiple aliquots from the base of the trench excavation in the area into one sample.

[d] Sample was collected by combining multiple aliquots from the excavated staging area into one sample.

Table 3. 118-B-1 Focused Verification Sample Summary. (3 Pages)

[e] Sample was collected by combining multiple aliquots from areas with elevated field XRF mercury measurements into one sample.
[f] Results for Sample J14JJ3 indicated residual mercury contamination in excess of cleanup criteria. Additional material was removed and replacement Sample J152M1 was collected and analyzed for tritium, ICP metals, and mercury.
[g] Samples collected beneath staged mercury-contaminated soil in Process Cell 4 were collected by combining multiple aliquots from areas with elevated field XRF mercury measurements into one sample.

COC = contaminant of concern
COPC = contaminant of potential concern
ICP = inductively coupled plasma
NA = not applicable
PCB = polychlorinated biphenyl
SNF = spent nuclear fuel
SVOA = semivolatile organic analysis
TPH = total petroleum hydrocarbons
VOA = volatile organic analysis
XRF = x-ray fluorescence

5.0 SAMPLING RESULTS

All verification samples were submitted to offsite laboratories for analysis using approved U.S. Environmental Protection Agency (EPA) analytical methods, as required per the Burial Ground SAP (DOE-RL 2001a). The laboratory-reported data results from the verification sampling were used in the statistical calculations and are included with the 95% upper confidence limit (UCL) calculations in Appendix C. The laboratory-reported data for the focused samples are included with the supporting data attached to the 95% UCL calculations.

The primary statistical calculation to evaluate compliance with cleanup standards is the 95% UCL on the arithmetic mean of the data. The 95% UCL values for each COC/COPC are computed for each of the 118-B-1 Burial Ground areas as specified by the RDR/RAWP (DOE-RL 2005), with calculations provided in Appendix C. Prior to calculating the 95% UCL, the individual sample results are reviewed and, as appropriate, adjusted per the SAP (DOE-RL 2001a) and RDR/RAWP (DOE-RL 2005). When a nonradionuclide COC was detected in fewer than 50% of the verification samples collected, the maximum detected value was used for comparison against the RAGs. Statistical evaluations were not performed on data sets with no reported detections. Evaluation of the verification data from the focused samples was performed by direct comparison of the maximum sample result from all focused samples for each COC/COPC against cleanup criteria.

Comparisons of the statistical results for site COCs/COPCs with the RAGs (cleanup criteria) for each of the 118-B-1 Burial Ground areas are listed in Tables 4 through 13. Comparison of the maximum results for COCs/COPCs detected in focused verification samples with the RAGs are listed in Table 14. Calculated cleanup levels are not presented in the *Cleanup Levels and Risk Calculations (CLARC) Database* (Ecology 2005) under the *Washington Administrative Code* (WAC) 173-340-740(3) for aluminum, calcium, iron, magnesium, potassium, silicon, and sodium; therefore, these constituents are not considered site COCs/COPCs. Potassium-40, radium-226, radium-228,

thorium-228, and thorium-232 were detected in samples collected at the site, but are not considered within the statistical calculations. These isotopes are naturally occurring, not related to the operational history of the site, and/or were detected below background levels. All individual cleanup verification sample results are included with the 95% UCL calculation in Appendix C.

Initial data results from Area 5 and the SPA footprint indicated the presence of cesium-137 and tritium, respectively, at concentrations exceeding the cleanup criteria in one sampling area of each decision unit. Consequently, additional soil was removed from these areas and the areas re-sampled and analyzed for gamma-emitting radionuclides and tritium, respectively. The second analyses for cesium-137 and tritium were used to perform the 95% UCL calculations for Area 5 and the SPA, respectively, the results of which are presented in Tables 8 and 13.

Initial focused sample data results from the western end of the mercury-contaminated soil staging area in Process Cell 4 (Focused Sample 17) indicated the presence of residual mercury at a concentration exceeding the cleanup criteria. Consequently, additional soil was removed from this area and the area re-sampled and analyzed for tritium, ICP metals, and mercury. The second analysis for mercury was used in evaluation of the focused sample results, and the maximum results for tritium and ICP metals from each sampling event were used in the evaluation, the results of which are presented in Table 14.

A portion of the verification data for the herbicide 2,4-DB in the SPA footprint were rejected due to data quality deficiencies. The maximum detected accepted value was used for evaluation purposes in the SPA footprint, with additional discussion provided in the data quality assessment (DQA) (Appendix E).

Table 4. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 1 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Carbon-14	1.93	5.16	--[c]	--[c]	No	Yes[e]
Cesium-137	0.201	6.2	1,465[d]	1,465[d]	No	
Cobalt-60	0.039	1.4	13,900[d]	13,900[d]	No	
Europium-152	0.695	3.3	--[c]	--[c]	No	
Strontium-90	0.125	4.5	27.6[d]	27.6[d]	No	
Tritium	158	459[d]	12.6[d]	12.6[d]	Yes	--[f]
Uranium-233/234	0.566 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
Uranium-235	0.051 (<BG)	0.61[c]	0.5[h]	0.5[h]	No	--
Uranium-238	0.518 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--

Table 4. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 1 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Arsenic	3.2 (<BG)	20	20	20	No	--
Barium	60.4 (<BG)	5,600[i]	132[i,j]	224[i]	No	--
Beryllium	0.60 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--
Boron[l]	1.4	16,000	320	--[m]	No	--
Chromium (total)	7.1 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--
Cobalt	10.2 (<BG)	1,600	32	--[m]	No	--
Copper	17.7 (<BG)	2,960	59.2	22.0[j]	No	--
Lead	4.8 (<BG)	353	10.2[j]	10.2[j]	No	--
Manganese	381 (<BG)	11,200	512[j]	512[j]	No	--
Mercury	1.3	24	0.33[j]	0.33[j]	Yes	Yes[n]
Nickel	11.2 (<BG)	1,600	19.1[j]	27.4	No	--
Vanadium	52.0 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	45.8 (<BG)	24,000	480	67.8[j]	No	--
bis(2-Ethylhexyl)phthalate	0.19	71.4	0.625	0.36	No	--
Di-n-butylphthalate	0.12	8,000	160	540	No	--
4-Methyl-2-pentanone	0.006	6,400	64	--[m]	No	--
Acetone	0.014	72,000	720	--[m]	No	--
Methylene chloride	0.019	133	0.5	0.94	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 5. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 2 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Cesium-137	0.163	6.2	1,465[d]	1,465[d]	No	Yes[e]
Strontium-90	0.172	4.5	27.6[d]	27.6[d]	No	
Tritium	39.4	459[d]	12.6[d]	12.6[d]	Yes	--[f]

Table 5. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 2 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Arsenic	2.9 (<BG)	20	20	20	No	--
Barium	58.1 (<BG)	5,600[i]	132[i,j]	224[i]	No	--
Beryllium	0.64 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--
Boron[l]	4.7	16,000	320	--[m]	No	--
Chromium (total)	6.7 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--
Chromium (hexavalent)	0.29	2.1	4.8[o]	2	No	--
Cobalt	8.5 (<BG)	1,600	32	--[m]	No	--
Copper	16.6 (<BG)	2,960	59.2	22.0[j]	No	--
Lead	4.8 (<BG)	353	10.2[j]	10.2[j]	No	--
Manganese	321 (<BG)	11,200	512[j]	512[j]	No	--
Nickel	10.5 (<BG)	1,600	19.1[j]	27.4	No	--
Vanadium	54.5 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	43.2 (<BG)	24,000	480	67.8[j]	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 6. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 3 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Cesium-137	0.776	6.2	1,465[d]	1,465[d]	No	Yes[e]
Strontium-90	2.56	4.5	27.6[d]	27.6[d]	No	
Tritium	12.8	459[d]	12.6[d]	12.6[d]	Yes	--[f]

Table 6. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 3 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Arsenic	3.7 (<BG)	20	20	20	No	--
Barium	62.6 (<BG)	5,600[i]	132[i,j]	224[i]	No	--
Beryllium	0.63 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--
Boron[l]	6.5	16,000	320	--[m]	No	--
Chromium (total)	7.7 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--
Chromium (hexavalent)	0.21	2.1	4.8[o]	2	No	--
Cobalt	9.1 (<BG)	1,600	32	--[m]	No	--
Copper	17.1 (<BG)	2,960	59.2	22.0[j]	No	--
Lead	5.7 (<BG)	353	10.2[j]	10.2[j]	No	--
Manganese	367 (<BG)	11,200	512[j]	512[j]	No	--
Mercury	0.21 (<BG)	24	0.33[j]	0.33[j]	No	--
Nickel	15.9 (<BG)	1,600	19.1[j]	27.4	No	--
Vanadium	47.5 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	43.7 (<BG)	24,000	480	67.8[j]	No	--
bis(2-Ethylhexyl)phthalate	0.14	71.4	0.625	0.36	No	--
Di-n-butylphthalate	0.16	8,000	160	540	No	--
4-Methyl-2-pentanone	0.006	6,400	64	--[m]	No	--
Acetone	0.015	72,000	720	--[m]	No	--
Carbon tetrachloride	0.009	7.7	0.034	0.05	No	--
Methylene chloride	0.019	133	0.5	0.94	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 7. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 4 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Cesium-137	0.345	6.2	1,465[d]	1,465[d]	No	Yes[e]
COC/COPC	**Statistical Result (mg/kg)**	**Remedial Action Goals[a] (mg/kg)**			**Does the Statistical Data Set Exceed RAGs?**	**Does the Statistical Result Pass RESRAD Modeling?**
		Direct Exposure	**Soil Cleanup Level for Groundwater Protection**	**Soil Cleanup Level for River Protection**		
Arsenic	3.5 (<BG)	20	20	20	No	--
Barium	48.6 (<BG)	5,600[i]	132[i,j]	224[i]	No	--
Beryllium	0.40 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--
Boron[l]	3.9	16,000	320	--[m]	No	--
Chromium (total)	6.6 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--
Chromium (hexavalent)	0.22	2.1	4.8[o]	2	No	--
Cobalt	8.6 (<BG)	1,600	32	--[m]	No	--
Copper	16.2 (<BG)	2,960	59.2	22.0[j]	No	--
Lead	4.9 (<BG)	353	10.2[j]	10.2[j]	No	--
Manganese	334 (<BG)	11,200	512[j]	512[j]	No	--
Nickel	10.6 (<BG)	1,600	19.1[j]	27.4	No	--
Vanadium	49.9 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	42.1 (<BG)	24,000	480	67.8[j]	No	--
Aroclor-1254	0.080	0.5	0.017[p]	0.017[p]	Yes	Yes[n]
bis(2-Ethylhexyl)phthalate	0.41	71.4	0.625	0.36	Yes	Yes[n]
Di-n-butylphthalate	0.063	8,000	160	540	No	--
Diethylphthalate	0.017	64,000	1,280	4,600	No	--
Phenol	0.17	24,000	480	4,200	No	--
Acetone	0.012	72,000	720	--[m]	No	--
Carbon tetrachloride	0.016	7.7	0.034	0.05	No	--
Methylene chloride	0.010	133	0.5	0.94	No	--
beta-BHC	0.0078	0.556	0.00486	0.00554	Yes	Yes[q]
4,4'-DDE	0.016	2.94	0.0257	0.005[p]	Yes	Yes[n]
Dieldrin	0.0038	0.0625	0.003[p]	0.003[p]	Yes	Yes[n]
Endosulfan sulfate	0.0022	480	9.6	0.0112	No	--
Endrin	0.0015	24	0.2	0.039	No	--
Endrin aldehyde	0.0055	24	0.2	0.039	No	--
gamma-Chlordane	0.0025	0.769[r]	0.0165[p,r]	0.0165[p]	No	--

Table 7. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 4 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
2,4-D	0.013	800	7	--[m]	No	--
2,4-DB	0.016	640	12.8	--[m]	No	--
Dalapon	0.037	2,400	20	--[m]	No	--
Dichloroprop[s]	0.14	800	7	--[m]	No	--
Pentachlorophenol	0.014	8.33	0.073	0.056	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 8. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 5 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Cesium-137	2.40	6.2	1,465[d]	1,465[d]	No	Yes[e]
Strontium-90	1.89	4.5	27.6[d]	27.6[d]	No	
COC/COPC	**Statistical Result (mg/kg)**	**Remedial Action Goals[a] (mg/kg)**			**Does the Statistical Data Set Exceed RAGs?**	**Does the Statistical Result Pass RESRAD Modeling?**
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Arsenic	2.8 (<BG)	20	20	20	No	--
Barium	46.7 (<BG)	5,600[i]	132[i,j]	224[i]	No	--
Beryllium	0.1 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--
Boron[l]	1.1	16,000	320	--[m]	No	--
Cadmium[t]	0.20 (<BG)	13.9	0.81[j]	0.81[j]	No	--
Chromium (total)	5.0 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--
Chromium (hexavalent)	0.26	2.1	4.8[o]	2	No	--
Cobalt	7.2 (<BG)	1,600	32	--[m]	No	--
Copper	14.8 (<BG)	2,960	59.2	22.0[j]	No	--

Table 8. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 5 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Lead	3.8 (<BG)	353	10.2[j]	10.2[j]	No	--
Manganese	290 (<BG)	11,200	512[j]	512[j]	No	--
Mercury	0.03 (<BG)	24	0.33[j]	0.33[j]	No	--
Nickel	7.4 (<BG)	1,600	19.1[j]	27.4	No	--
Vanadium	37.4 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	36.8 (<BG)	24,000	480	67.8[j]	No	--
bis(2-Ethylhexyl)phthalate	0.17	71.4	0.625	0.36	No	--
Acetone	0.017	72,000	720	--[m]	No	--
Methylene chloride	0.013	133	0.5	0.94	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 9. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 6 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Cesium-137	0.150	6.2	1,465[d]	1,465[d]	No	Yes[e]
Tritium	3.19	459[d]	12.6[d]	12.6[d]	No	--[f]
Uranium-233/234	0.550 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
Uranium-238	0.690 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
COC/COPC	**Statistical Result (mg/kg)**	**Remedial Action Goals[a] (mg/kg)**			**Does the Statistical Data Set Exceed RAGs?**	**Does the Statistical Result Pass RESRAD Modeling?**
		Direct Exposure	**Soil Cleanup Level for Groundwater Protection**	**Soil Cleanup Level for River Protection**		
Arsenic	4.1 (<BG)	20	20	20	No	--
Barium	80.1 (<BG)	5,600[i]	132[i,j]	224[i]	No	--
Beryllium	0.36 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--

Table 9. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 6 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Boron[l]	6.1	16,000	320	--[m]	No	--
Chromium (total)	7.4 (<BG)	80,000[j]	18.5[j]	18.5[j]	No	--
Chromium (hexavalent)	0.27	2.1	4.8[o]	2	No	--
Cobalt	8.5 (<BG)	1,600	32	--[m]	No	--
Copper	16.6 (<BG)	2,960	59.2	22.0[j]	No	--
Lead	5.0 (<BG)	353	10.2[j]	10.2[j]	No	--
Manganese	323 (<BG)	11,200	512[j]	512[j]	No	--
Mercury	0.02 (<BG)	24	0.33[j]	0.33[j]	No	--
Nickel	11.4 (<BG)	1,600	19.1[j]	27.4	No	--
Vanadium	49.0 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	41.4 (<BG)	24,000	480	67.8[j]	No	--
bis(2-Ethylhexyl)phthalate	0.32	71.4	0.625	0.36	Yes[u]	Yes[n]
Butylbenzylphthalate	0.024	16,000	320	250	No	--
Di-n-butylphthalate	0.079	8,000	160	540	No	--
Phenol	0.023	24,000	480	4,200	No	--
Acetone	0.008	72,000	720	--[m]	No	--
Carbon tetrachloride	0.007	7.7	0.034	0.05	No	--
Methylene chloride	0.008	133	0.5	0.94	No	--
Aldrin	0.00050	0.0588	0.00165[p]	0.00165[p]	No	--
2,4-D	0.062	800	7	--[m]	No	--
2,4-DB	0.043	640	12.8	--[m]	No	--
2,4,5-TP	0.012	640	5	--[m]	No	--
Dalapon	0.036	2,400	20	--[m]	No	--
Dichloroprop[s]	0.10	800	7	--[m]	No	--

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-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 10. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 7 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Cesium-137	0.517	6.2	1,465[d]	1,465[d]	No	Yes[e]
Europium-152	0.098	3.3	--[c]	--[c]	No	
Uranium-233/234	0.671 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
Uranium-238	0.725 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
COC/COPC	**Statistical Result (mg/kg)**	**Remedial Action Goals[a] (mg/kg)**			**Does the Statistical Data Set Exceed RAGs?**	**Does the Statistical Result Pass RESRAD Modeling?**
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Arsenic	3.5 (<BG)	20	20	20	No	--
Barium	132	5,600[i]	132[i,j]	224[i]	Yes	Yes[n]
Beryllium	0.31 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--
Boron[l]	13.7	16,000	320	--[m]	No	--
Chromium (total)	8.9 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--
Chromium (hexavalent)	0.28	2.1	4.8[o]	2	No	--
Cobalt	7.5 (<BG)	1,600	32	--[m]	No	--
Copper	22.2	2,960	59.2	22.0[j]	Yes	Yes[n]
Lead	11.0	353	10.2[j]	10.2[j]	Yes	Yes[n]
Manganese	329 (<BG)	11,200	512[j]	512[j]	No	--
Mercury	0.02 (<BG)	24	0.33[j]	0.33[j]	No	--
Molybdenum[l]	2.1	400	8	--[m]	No	--
Nickel	10.6 (<BG)	1,600	19.1[j]	27.4	No	--
Vanadium	39.8 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	47.5 (<BG)	24,000	480	67.8[j]	No	--
2-Methylnaphthalene	0.026	320	3.2	--[m]	No	--
Diethylphthalate	0.025	64,000	1,280	4,600	No	--
Naphthalene	0.019	1,600	16.0	988	No	--
Acetone	0.009	72,000	720	--[m]	No	--
Carbon tetrachloride	0.011	7.7	0.034	0.05	No	--
Methylene chloride	0.008	133	0.5	0.94	No	--
alpha-Chlordane	0.012	0.769[r]	0.0165[p,r]	0.0165[p]	No	--
4,4'-DDE	0.015	2.94	0.0257	0.005[p]	Yes	Yes[n]
Dieldrin	0.002	0.0625	0.003[p]	0.003[p]	No	--
Endrin ketone	0.0078	24	0.2	0.039	No	--

Table 10. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Area 7 Verification Sampling Event.* (2 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Methoxychlor	0.0091	400	4	1.67	No	--
2,4-D	0.023	800	7	--[m]	No	--
2,4-DB	0.027	640	12.8	--[m]	No	--
Dalapon	0.027	2,400	20	--[m]	No	--
Dicamba	0.013	2,400	48	--[m]	No	--
Dichloroprop[s]	0.050	800	7	--[m]	No	--
Picloram	0.014	5,600	50	--[m]	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 11. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Overburden Verification Sampling Event.* (3 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Cesium-137	0.225 (<BG)	6.2	1,465[d]	1,465[d]	No	--
Europium-152	0.07	3.3	--[c]	--[c]	No	Yes[v]
Strontium-90	0.175 (<BG)	4.5	27.6[d]	27.6[d]	No	--
Uranium-233/234	0.542 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
Uranium-235	0.033 (<BG)	0.61[c]	0.5[h]	0.5[h]	No	--
Uranium-238	0.556 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
COC/COPC	**Statistical Result (mg/kg)**	**Remedial Action Goals[a] (mg/kg)**			**Does the Statistical Data Set Exceed RAGs?**	**Does the Statistical Result Pass RESRAD Modeling?**
		Direct Exposure	**Soil Cleanup Level for Groundwater Protection**	**Soil Cleanup Level for River Protection**		
Arsenic	3.1 (<BG)	20	20	20	No	--
Barium	59.3 (<BG)	5,600[i]	132[i,j]	224[i]	No	--
Beryllium	0.48 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--

Table 11. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Overburden Verification Sampling Event.* (3 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Boron[l]	2.0	16,000	320	--[m]	No	--
Cadmium[t]	0.43 (<BG)	13.9	0.81[j]	0.81[j]	No	--
Chromium (total)	7.2 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--
Chromium (hexavalent)	0.23	2.1	4.8[o]	2	No	--
Cobalt	8.7 (<BG)	1,600	32	--[m]	No	--
Copper	16.0 (<BG)	2,960	59.2	22.0[j]	No	--
Lead	5.1 (<BG)	353	10.2[j]	10.2[j]	No	--
Manganese	346 (<BG)	11,200	512[j]	512[j]	No	--
Mercury	0.05 (<BG)	24	0.33[j]	0.33[j]	No	--
Molybdenum[l]	0.83	400	8	--[m]	No	--
Nickel	10.1 (<BG)	1,600	19.1[j]	27.4	No	--
Selenium[t]	0.67 (<BG)	400	5	1	No	--
Vanadium	46.6 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	40.0 (<BG)	24,000	480	67.8[j]	No	--
Aroclor-1254	0.038	0.5	0.017[p]	0.017[p]	Yes	Yes[n]
bis(2-Ethylhexyl)phthalate	0.06	71.4	0.625	0.36	No	--
Di-n-butylphthalate	0.12	8,000	160	540	No	--
Phenol	0.022	24,000	480	4,200	No	--
4-Methyl-2-pentanone	0.011	6,400	64	--[m]	No	--
Acetone	0.039	72,000	720	--[m]	No	--
Carbon tetrachloride	0.011	7.7	0.034	0.05	No	--
Methylene chloride	0.016	133	0.5	0.94	No	--
Toluene	0.002	6,400	64	1,360	No	--
Xylenes (total)	0.001	16,000	160	--[m]	No	--
beta-BHC	0.00064	0.556	0.00486	0.00554	No	--
4,4'-DDD	0.0019	4.17	0.0365	0.005[p]	No	--
4,4'-DDE	0.0013	2.94	0.0257	0.005[p]	No	--
4,4'-DDT	0.0011	2.94	0.0257	0.005[p]	No	--
Endosulfan I	0.0028	480	9.6	0.0112	No	--
Endosulfan II	0.00060	480	9.6	0.0112	No	--
Endosulfan sulfate	0.00087	480	9.6	0.0112	No	--
Endrin aldehyde	0.0019	24	0.2	0.039	No	--
gamma-Chlordane	0.0025	0.769[r]	0.0165[p,r]	0.0165[p]	No	--

Table 11. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Overburden Verification Sampling Event.* (3 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Methoxychlor	0.0067	400	4	1.67	No	--
2,4-D	0.026	800	7	--[m]	No	--
2,4-DB	0.087	640	12.8	--[m]	No	--
2,4,5-T	0.0039	800	16	--[m]	No	--
2,4,5-TP	0.0096	640	5	--[m]	No	--
Dalapon	0.023	2,400	20	--[m]	No	--
Dicamba	0.016	2,400	48	--[m]	No	--
Dichloroprop[s]	0.11	800	7	--[m]	No	--
Pentachlorophenol	0.016	8.33	0.073	0.056	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 12. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 BCL Material Stockpiles Verification Sampling Event.* (3 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Cesium-137	0.159	6.2	1,465[d]	1,465[d]	No	Yes[v]
Cobalt-60	0.05	1.4	13,900[d]	13,900[d]	No	
Europium-152	0.068	3.3	--[c]	--[c]	No	
Strontium-90	0.120	4.5	27.6[d]	27.6[d]	No	
Uranium-233/234	0.564 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
Uranium-235	0.039 (<BG)	0.61[c]	0.5[h]	0.5[h]	No	--
Uranium-238	0.587 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--

Table 12. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 BCL Material Stockpiles Verification Sampling Event.* (3 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Arsenic	3.7 (<BG)	20	20	20	No	--
Barium	60.8 (<BG)	5,600[i]	132[i,j]	224[i]	No	--
Beryllium	0.56 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--
Boron[l]	1.8	16,000	320	--[m]	No	--
Chromium (total)	8.1 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--
Chromium (hexavalent)	0.24	2.1	4.8[o]	2	No	--
Cobalt	9.2 (<BG)	1,600	32	--[m]	No	--
Copper	15.9 (<BG)	2,960	59.2	22.0[j]	No	--
Lead	5.1 (<BG)	353	10.2[j]	10.2[j]	No	--
Manganese	366 (<BG)	11,200	512[j]	512[j]	No	--
Mercury	0.03 (<BG)	24	0.33[j]	0.33[j]	No	--
Molybdenum[l]	0.43	400	8	--[m]	No	--
Nickel	11.1 (<BG)	1,600	19.1[j]	27.4	No	--
Selenium[t]	1.0	400	5	1	No	--
Vanadium	48.8 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	41.4 (<BG)	24,000	480	67.8[j]	No	--
bis(2-Ethylhexyl)phthalate	0.08	71.4	0.625	0.36	No	--
Di-n-butylphthalate	0.13	8,000	160	540	No	--
Diethylphthalate	0.019	64,000	1,280	4,600	No	--
Phenol	0.034	24,000	480	4,200	No	--
4-Methyl-2-pentanone	0.007	6,400	64	--[m]	No	--
Acetone	0.020	72,000	720	--[m]	No	--
Carbon tetrachloride	0.011	7.7	0.034	0.05	No	--
Methylene chloride	0.014	133	0.5	0.94	No	--
Toluene	0.001	6,400	64	1,360	No	--
Xylenes (total)	0.001	16,000	160	--[m]	No	--
beta-BHC	0.0022	0.556	0.00486	0.00554	No	--
4,4'-DDT	0.0016	2.94	0.0257	0.005[p]	No	--
Endosulfan I	0.0049	480	9.6	0.0112	No	--
Endosulfan sulfate	0.00084	480	9.6	0.0112	No	--
Endrin aldehyde	0.0015	24	0.2	0.039	No	--
Endrin ketone	0.0014	24	0.2	0.039	No	--
Heptachlor	0.00043	0.222	0.002	0.002[p]	No	--

Table 12. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 BCL Material Stockpiles Verification Sampling Event.* (3 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Methoxychlor	0.0053	400	4	1.67	No	--
2,4-DB	0.0098	640	12.8	--[m]	No	--
Dalapon	0.048	2,400	20	--[m]	No	--
Dicamba	0.013	2,400	48	--[m]	No	--
Dichloroprop[s]	0.21	800	7	--[m]	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BCL = below cleanup level
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 13. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Staging Pile Area Footprint Verification Sampling Event.* (3 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Americium-241	0.061	31.1	--[c]	--[c]	No	Yes[v]
Carbon-14	1.6	5.16	--[c]	--[c]	No	
Cesium-137	0.57	6.2	1,465[d]	1,465[d]	No	
Cobalt-60	0.028	1.4	13,900[d]	13,900[d]	No	
Europium-152	0.20	3.3	--[c]	--[c]	No	
Nickel-63	5.05	4,013[d]	83[d]	83[d]	No	
Plutonium-239/240	0.125	33.9	--[c]	--[c]	No	
Strontium-90	0.236	4.5	27.6[d]	27.6[d]	No	
Tritium	14.6	459[d]	12.6[d]	12.6[d]	Yes	
Uranium-233/234	0.625 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
Uranium-235	0.042 (<BG)	0.61[c]	0.5[h]	0.5[h]	No	--
Uranium-238	0.562 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--

Table 13. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Staging Pile Area Footprint Verification Sampling Event.* (3 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Arsenic	2.3 (<BG)	20	20	20	No	--
Barium	72.5 (<BG)	5,600[i]	132[i,j]	224[i]	No	--
Beryllium	0.36 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--
Boron[l]	1.9	16,000	320	--[m]	No	--
Cadmium[t]	0.53 (<BG)	13.9	0.81[j]	0.81[j]	No	--
Chromium (total)	8.3 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--
Chromium (hexavalent)	0.27	2.1	4.8[o]	2	No	--
Cobalt	7.7 (<BG)	1,600	32	--[m]	No	--
Copper	14.8 (<BG)	2,960	59.2	22.0[j]	No	--
Lead	4.7 (<BG)	353	10.2[j]	10.2[j]	No	--
Manganese	330 (<BG)	11,200	512[j]	512[j]	No	--
Mercury	0.13 (<BG)	24	0.33[j]	0.33[j]	No	--
Molybdenum[n]	0.45	400	8	--[m]	No	--
Nickel	10.8 (<BG)	1,600	19.1[j]	27.4	No	--
Vanadium	46.4 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	38.8 (<BG)	24,000	480	67.8[j]	No	--
Aroclor-1242	0.047	0.5	0.017[p]	0.017[p]	Yes	Yes[n]
Aroclor-1254	0.17	0.5	0.017[p]	0.017[p]	Yes	Yes[n]
Aroclor-1260	0.056	0.5	0.017[p]	0.017[p]	Yes	Yes[n]
bis(2-Ethylhexyl)phthalate	0.09	71.4	0.625	0.36	No	--
Di-n-butylphthalate	0.11	8,000	160	540	No	--
Methylene chloride	0.014	133	0.5	0.94	No	--
Trichloroethene	0.002	2.5	0.01	0.31	No	--
Aldrin	0.0010	0.0588	0.00165[p]	0.00165[p]	No	--
alpha-Chlordane	0.00080	0.769[r]	0.0165[p,r]	0.0165[p]	No	--
beta-BHC	0.00082	0.556	0.00486	0.00554	No	--
4,4'-DDE	0.0065	2.94	0.0257	0.005[r]	Yes	Yes[n]
Endosulfan sulfate	0.0019	480	9.6	0.0112	No	--
gamma-Chlordane	0.0065	0.769[r]	0.0165[p,r]	0.0165[p]	No	--
Methoxychlor	0.0017	400	4	1.67	No	--
2,4-D	0.048	800	7	--[m]	No	--
2,4-DB	0.028[w]	640	12.8	--[m]	No	--
2,4,5-T	0.013	800	16	--[m]	No	--

Table 13. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-B-1 Staging Pile Area Footprint Verification Sampling Event.* (3 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Statistical Data Set Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
2,4,5-TP	0.043	640	5	--[m]	No	--
Dalapon	0.043	2,400	20	--[m]	No	--
Dicamba	0.023	2,400	48	--[m]	No	--
Dichloroprop[s]	0.049	800	7	--[m]	No	--
Pentachlorophenol	0.0040	8.33	0.073	0.056	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Table 14. Comparison of Maximum Contaminant Concentrations to Action Levels for the 118-B-1 Focused Verification Samples.* (2 Pages)

COC/COPC	Maximum Result (pCi/g)	Generic Site Lookup Values[a] (pCi/g)			Does the Maximum Result Exceed Lookup Values?	Does the Maximum Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Cesium-137	0.353	6.2	1,465[d]	1,465[d]	No	Yes[e]
Cobalt-60	0.155	1.4	13,900[d]	13,900[d]	No	
Tritium	137	459[d]	12.6[d]	12.6[d]	Yes	--[f]
Uranium-233/234	0.587 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
Uranium-238	0.564 (<BG)	1.1[g]	1.1[g]	1.1[g]	No	--
COC/COPC	**Maximum Result (mg/kg)**	**Remedial Action Goals[a] (mg/kg)**			**Does the Maximum Result Exceed Lookup Values?**	**Does the Maximum Result Pass RESRAD Modeling?**
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Arsenic	7.0	20	20	20	No	--
Barium	261	5,600[i]	132[i,j]	224[i]	Yes	Yes[n]
Beryllium	0.58 (<BG)	10.4[k]	1.51[j]	1.51[j]	No	--
Boron[l]	24.5	16,000	320	--[m]	No	--
Cadmium[t]	0.28 (<BG)	13.9	0.81[j]	0.81[j]	No	--
Chromium (total)	16.4 (<BG)	80,000[i]	18.5[j]	18.5[j]	No	--

Table 14. Comparison of Maximum Contaminant Concentrations to Action Levels for the 118-B-1 Focused Verification Samples.* (2 Pages)

COC/COPC	Maximum Result (mg/kg)	Remedial Action Goals[a] (mg/kg)			Does the Maximum Result Exceed Lookup Values?	Does the Maximum Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Cobalt	11.3 (<BG)	1,600	32	--[m]	No	--
Copper	28.0	2,960	59.2	22.0[j]	Yes	Yes[n]
Lead	34.3	353	10.2[j]	10.2[j]	Yes	Yes[n]
Manganese	421 (<BG)	11,200	512[j]	512[j]	No	--
Mercury	14.5	24	0.33[j]	0.33[j]	Yes	Yes[n]
Molybdenum[l]	0.81	400	8	--[m]	No	--
Nickel	15.2 (<BG)	1,600	19.1[j]	27.4	No	--
Vanadium	62.8 (<BG)	560	85.1[j]	--[m]	No	--
Zinc	65.1 (<BG)	24,000	480	67.8[j]	No	--
bis(2-Ethylhexyl)phthalate	0.038	71.4	0.625	0.36	No	--
Acetone	0.099	72,000	720	--[m]	No	--
Methylene chloride	0.016	133	0.5	0.94	No	--
Methoxychlor	0.0047	400	4	1.67	No	--
Dicamba	0.0091	2,400	48	--[m]	No	--

*All footnotes are provided following Table 14.

-- = not applicable
BG = background (obtained from DOE-RL 1996 and DOE-RL 2001b, unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
NA = not applicable
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

Verification Sample Summary Table Footnotes

[a] Lookup values and RAGs obtained from the RDR/RAWP (DOE-RL 2005) or calculated per WAC 173-340-720, 730, and 740, Method B, 1996, unless otherwise noted.
[b] Activity corresponding to a single-radionuclide 15 mrem/yr exposure as calculated using a generic RESidual RADioactivity (RESRAD) model (DOE-RL 2005).
[c] No value—RESRAD modeling predicts the contaminant will not reach groundwater within 1,000 years.
[d] Lookup value calculated per *100 Area Radionuclide and Nonradionuclide Lookup Values for the 1995 Interim Remedial Action Record of Decision* (BHI 2004).
[e] *118-B-1 Combined Areas Cleanup Verification RESRAD Calculation Brief*, Appendix C.
[f] The 118-B-1 ESD provides for controls to minimize further mobilization of residual tritium contamination in the deep vadose zone and allow interim site closure without further excavation based on evaluation of balancing factors.
[g] The calculated lookup value is below the Hanford-specific statistical soil background activity. The value presented is the Hanford-specific statistical soil background activity.
[h] The lookup value is below the required minimum detectable activity (MDA). The value presented is the required MDA.

[i] Noncarcinogenic cleanup levels calculated from WAC 173-340, 1996 (Method B), as presented in the RDR/RAWP (DOE-RL 2005).
[j] Where cleanup levels are less than background, cleanup levels default to background (WAC 173-340-700[4][d]) (1996).
[k] Carcinogenic cleanup level calculated based on the inhalation exposure pathway per WAC 173-340-750[3], 1996 (Method B for air quality) and an airborne particulate mass loading rate of 0.0001 g/m^3 (WDOH 1997).
[l] No Hanford Site-specific or Washington State background value available.
[m] No parameters (bioconcentration factors or ambient water quality criteria values) are available from the Ecology Cleanup Levels and Risk Calculations database (Ecology 2005) or other databases to calculate cleanup levels (WAC 173-340-730(3)(a)(iii), 1996 [Method B for surface waters]).
[n] Based on the *100 Area Analogous Sites RESRAD Calculations* (BHI 2005) and contaminant-specific soil portioning coefficient (K_d) value, contaminant will not migrate vertically more than 3 m (10 ft) in 1,000 years. Because the vadose zone underlying the site is greater than 13.4 m (44 ft) thick, the contaminant will not reach groundwater (and thus the Columbia River) in 1,000 years.
[o] Calculated cleanup level (per WAC 173-340-720(3), 1996 [Method B for groundwater] and WAC 173-340-740(3)(a)(ii)(A), 1996 ["100 times rule"]) presented is lower than that presented in the RDR/RAWP (DOE-RL 2005), based on updated oral reference dose value (as provided in the EPA's Integrated Risk Information System available on the internet at http://www.epa.gov/iris).
[p] Where cleanup levels are less than the required detection limit (RDL), cleanup levels default to the RDL (WAC 173-340-707[2], 1996 and DOE-RL 2005).
[q] The soil-to-groundwater dilution factor modeled for the 100-B/C Area indicates that the small residual mass of beta-BHC will not be sufficient to migrate to groundwater or the river and result in a concentration exceeding the WAC 173-340-720(3), 1996 (Method B for groundwater) carcinogenic groundwater cleanup level (0.0486 µg/L) or the WAC 173-340-730(3), 1996 (Method B for surface waters) carcinogenic surface water cleanup level (0.0277 µg/L).
[r] Carcinogenic cleanup level calculated from WAC 173-340, 1996 (Method B), as presented in the RDR/RAWP (DOE-RL 2005).
[s] Toxicity data for this chemical are not available. RAGs for dichloroprop are based on the surrogate chemical 2,4-D.
[t] Hanford Site-specific background value is not available; not evaluated during background study. Value used is from *Natural Background Soil Metals Concentrations in Washington State* (Ecology 1994).
[u] The statistical verification data set fails the third component of the WAC 173-340-740(7)(e) 3-part test in comparison against soil RAG for river protection (i.e., more than 10% of the data set exceeds the soil RAG value).
[v] *118-B-1 Burial Ground Cleanup Verification RESRAD Calculation Brief for Overburden, Below Cleanup Level (BCL), and Staging Pile Area Soil*, Appendix C.
[w] A portion of the 2,4-DB data for the staging pile area was rejected based on data quality deficiencies; the value presented is the maximum detected accepted value.

6.0 DATA EVALUATION

This section demonstrates that remedial actions at the 118-B-1 Burial Ground have achieved the applicable RAGs and comply with applicable nonradionuclide risk requirements and WAC 173-340-740(7)(e) three-part test criteria. This section also describes the RESidual RADioactivity (RESRAD) modeling performed that predicts the dose rate, the excess lifetime cancer risk, and the impact on groundwater and the river from residual radionuclide COC/COPC concentrations. This section also presents a comparison against ecological soil screening levels.

6.1 COMPARISON OF SAMPLE DATA TO RAGS

Tables 4 through 14 compare the cleanup verification statistical and focused sample values to the soil RAGs and lookup values for direct exposure, protection of groundwater, and protection of the Columbia River. Barium, copper, lead, mercury, aroclor-1242, aroclor-1254, aroclor-1260, bis(2-ethylhexyl)phthalate, 4,4'-DDE, and dieldrin were quantified at concentrations exceeding soil protection RAGs for groundwater and/or river protection in one or more areas. Data were not collected on the vertical extent of these contaminants, but given the lowest soil-partitioning coefficient for these constituents (22 mL/g for copper), none would be expected to migrate more than 3 m (10 ft) vertically in 1,000 years (BHI 2005). The vadose zone underlying the 118-B-1 Burial Ground excavation is greater than 13.4 m (44 ft) thick; therefore, residual concentrations of these contaminants are predicted to be protective of groundwater. The only pathway for contaminant migration to the Columbia River is via groundwater; therefore, residual concentrations of these contaminants are also predicted to be protective of the Columbia River.

The pesticide beta-BHC was also quantified slightly above the soil RAGs for groundwater and river protection in one sample from Area 4. The low soil-partitioning coefficient associated with this contaminant (2.14 mL/g) prevents the use of conservative migration modeling to demonstrate protectiveness. However, modeling of the hydraulic conductivity and gradient data for the 100-B/C Area shows that there is a soil-to-groundwater dilution factor of approximately 6 in the soils underlying the 118-B-1 site, which indicates that beta-BHC will not leach to groundwater at concentrations exceeding the most restrictive WAC 173-340-720 cleanup level for groundwater (0.049 µg/L). Further, the fact that the only detection of beta-BHC in this area was a trace residual concentration detected in one soil sample suggests that there is insufficient residual mass of beta-BHC present to migrate through 13.4 m (44 ft) of underlying vadose zone soil to reach groundwater (and thus the Columbia River) and result in concentrations exceeding groundwater or surface water RAGs. Therefore, the remedial action objectives for protection of groundwater and the Columbia River are considered to have been achieved.

Tritium was also quantified above lookup values for the protection of groundwater and the Columbia River in Areas 1, 2, and 3, as well as the SPA footprint, and in focused samples associated with those areas. These exceedances were addressed by site-specific assessment and RESRAD modeling, described in Section 6.5 of this document.

6.2 COMPARISON OF SAMPLE DATA TO ECOLOGICAL RISK SCREENING LEVELS

Soil cleanup levels were established in the Burial Ground ROD (EPA 2000) based on a limited ecological risk assessment. Although not required by the Burial Ground ROD, a comparison against ecological risk screening levels has been made for the 118-B-1 waste site COCs/COPCs. Screening levels were not exceeded for the site constituents, with the exception of barium, boron, cadmium, lead, mercury, molybdenum, selenium, and vanadium. Exceedance of screening values does not necessarily indicate the

existence of risk to ecological receptors. Concentrations of cadmium, vanadium, and selenium are within the range of Hanford Site background levels, and molybdenum concentrations are consistent with those seen elsewhere at the Hanford Site (no established background value is available for molybdenum). Exceedances for barium, boron, lead, and mercury will be evaluated in the context of additional lines of evidence as part of the baseline risk assessment. A more complete quantitative ecological risk assessment will be presented in the baseline risk assessment for the river corridor portion of the Hanford Site and will be used to support the final closeout decision for this waste site.

6.3 HUMAN HEALTH RISK EVALUATION FOR NONRADIONUCLIDES

The human health risk evaluations are calculated for nonradionuclide COCs/COPCs, per WAC 173-340-740(3)(a)(iii)(A) and (B). The requirements include a hazard quotient of less than 1.0 for all individual noncarcinogens, a cumulative hazard quotient of less than 1.0, an individual contaminant carcinogenic risk of less than 1×10^{-6}, and a cumulative excess carcinogenic risk of less than 1×10^{-5}. The details of the hazard quotient calculations are provided in Appendix C.

Hazard quotient and excess carcinogenic risk calculations were conservatively performed for the 118-B-1 Burial Ground using the highest of the focused and statistical values from all areas. Risk values were not calculated for constituents that were not detected or were detected at concentrations below Hanford Site or Washington State background values. All individual hazard quotients are below 1.0, and all individual excess carcinogenic risk values are below 1×10^{-6}. The cumulative hazard quotient for the 118-B-1 waste site is 8.8×10^{-1} and the cumulative excess carcinogenic risk value is 8.0×10^{-7}, satisfying the criteria of less than 1.0 and less than 1×10^{-5}, respectively. Therefore, nonradionuclide risk requirements are met.

6.4 WAC THREE-PART TEST FOR NONRADIONUCLIDES

When using a statistical sampling approach, a RAG requirement for nonradionuclides is the WAC 173-340-740(7)(e) three-part test. The WAC 173-340 three-part test consists of the following criteria: (1) the cleanup verification 95% UCL value must be less than the cleanup level, (2) no single detection can exceed two times the cleanup criteria, and (3) the percentage of samples exceeding the cleanup criteria must be less than 10% of the data set.

The application of the three-part test for the 118-B-1 Burial Ground is included in the 95% UCL calculation (Appendix C). The results of this evaluation indicate that all residual COC/COPC concentrations pass the three-part test in comparison against applicable RAGs, except for barium, copper, lead, mercury, bis(2-ethylhexyl)phthalate, and 4,4'-DDE in comparison against soil RAGs for protection of groundwater and/or the Columbia River in one or more sampling areas. However, based on RESRAD modeling (BHI 2005), as described in Section 6.1, none of these contaminants are predicted to

migrate to groundwater or the Columbia River in 1,000 years. Therefore, the requirements of the three-part test are met.

6.5 RESRAD MODELING FOR RADIONUCLIDES

For radionuclide contaminants, site-specific RESRAD (ANL 2005) modeling was used to determine contaminant migration and to predict the dose rate, the excess lifetime cancer risk, and the impact on groundwater and the Columbia River from residual radionuclide COC/COPC concentrations (DOE-RL 2005). For the 118-B-1 Burial Ground, separate evaluations were performed for the overburden stockpiles, BCL material stockpiles, and staging pile footprint. The maximum value for each radionuclide analyte for all remediation footprint areas (Areas 1 through 7) and focused samples were conservatively included in one combined evaluation. Residual tritium concentrations within the remediation footprint were not included in the RESRAD evaluations for groundwater and river protection, because institutional controls implemented per the 118-B-1 ESD (EPA 2007) will allow attenuation of residual vadose zone tritium contamination. Residual concentrations of carbon-14 and strontium-90 were not included in the plant ingestion pathway for the remediation footprint, as this would lead to a predicted exceedance of direct exposure criteria, and residual concentrations of these contaminants are below the root penetration zone.

The individual radionuclide cleanup statistical values from Tables 4 through 14 were entered into the RESRAD computer code with the results included in the RESRAD calculations in Appendix C. The RESRAD-derived groundwater radionuclide concentrations as compared to groundwater RAGs are provided in the RESRAD calculations and the Comparison to Drinking Water Standards Calculation in Appendix C. Specific results from the calculations are summarized in the following subsections.

6.5.1 Attainment of Radionuclide Direct Exposure RAG

The direct exposure RAG for radionuclide COCs is expressed in terms of an allowable radiation dose rate above background, which is 15 mrem/yr over 1,000 years. The results of the RESRAD dose rate predictions for the 118-B-1 Burial Ground are summarized in Figures 8 through 11. The maximum dose rates for all areas occurs in the present year (2007), with predicted values of 13.0 mrem/yr, 0.309 mrem/yr, 1.70 mrem/yr, and 6.96 mrem/yr for the combined remediation footprint, overburden stockpiles, BCL material stockpiles, and SPA footprint, respectively. All dose rate predictions are less than the 15 mrem/yr RAG over 1,000 years.

6.5.2 Attainment of Radionuclide Excess Lifetime Cancer Risk Goal

The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 *Code of Federal Regulations* [CFR] 300) presents a target range for residual radionuclide risk of 10^{-4} to 10^{-6}. The RESRAD model calculates the excess lifetime cancer risk associated

Figure 8. RESRAD Analysis for the Combined Areas in the Remediation Footprint– All Radionuclides, All-Pathways Dose Rate Estimate.

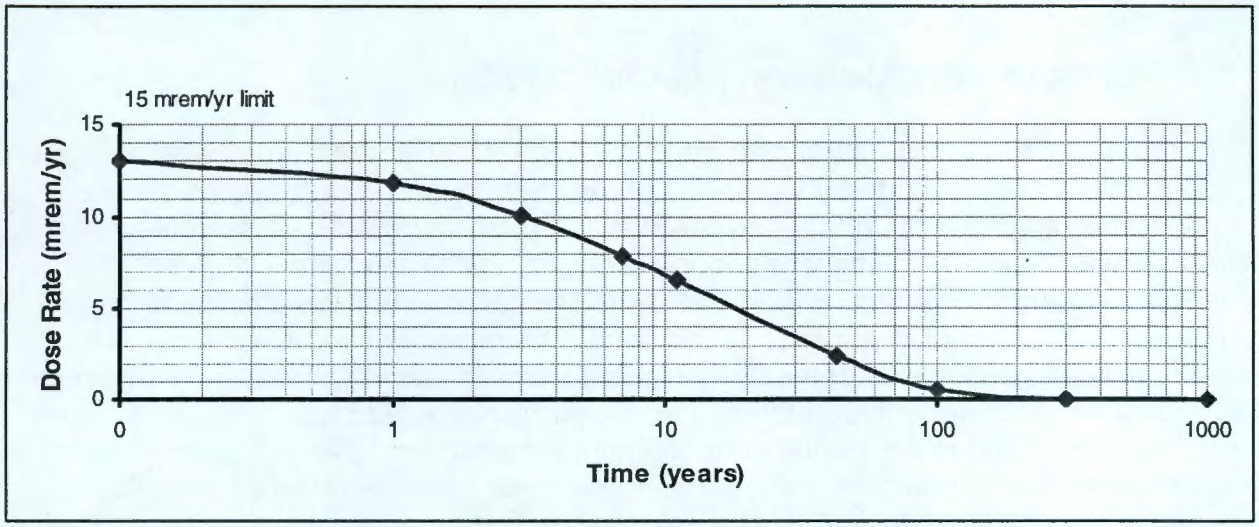
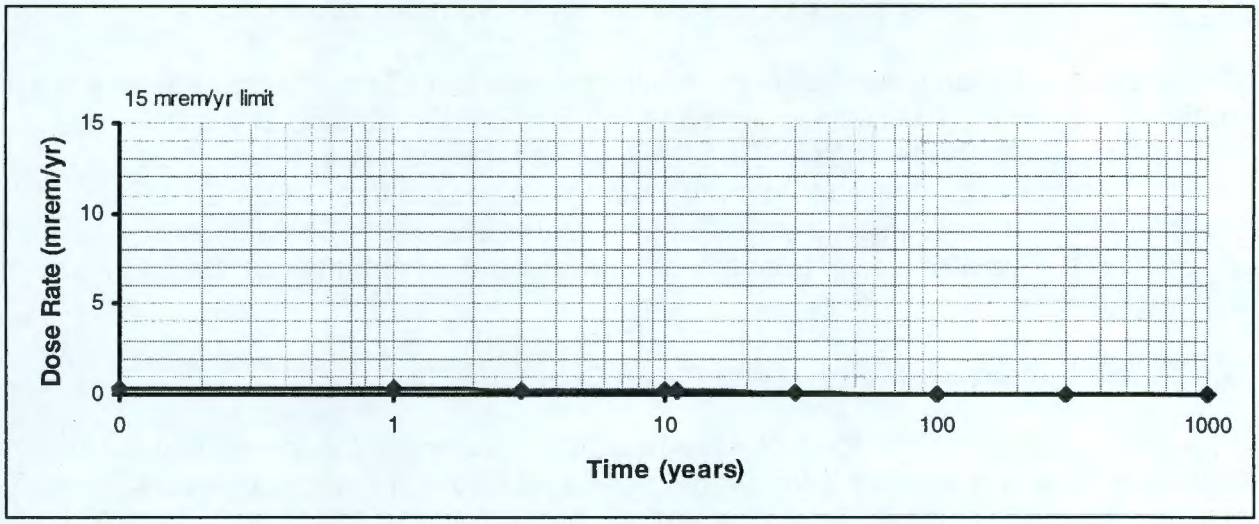


Figure 9. RESRAD Analysis for the Overburden Stockpiles– All Radionuclides, All-Pathways Dose Rate Estimate.



with the estimated radiation dose rates, with results summarized in Figures 12 through 15. For the 118-B-1 Burial Ground, the maximum excess lifetime cancer risk occurs at the present year (2007) for all areas, with predicted values of 1.38×10^{-4}, 3.65×10^{-6}, 1.98×10^{-5}, and 5.82×10^{-5} for the combined remediation footprint, overburden stockpiles, BCL material stockpiles, and SPA footprint, respectively.

6.5.3 Attainment of Radionuclide Groundwater and River Protection RAGS

The attainment of groundwater and river protection RAGs for radionuclides is determined by four criteria: (1) attain single COC/COPC groundwater and river RAGs, (2) attain the National Primary Drinking Water Regulations (40 CFR 141) 4 mrem/yr

Figure 10. RESRAD Analysis for the BCL Stockpiles– All Radionuclides, All-Pathways Dose Rate Estimate.

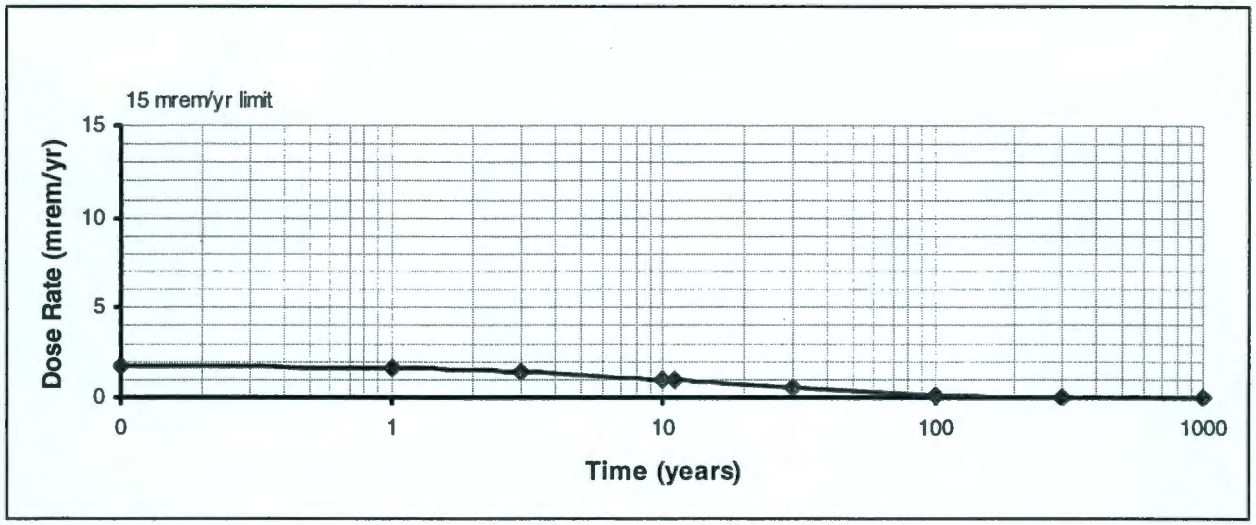
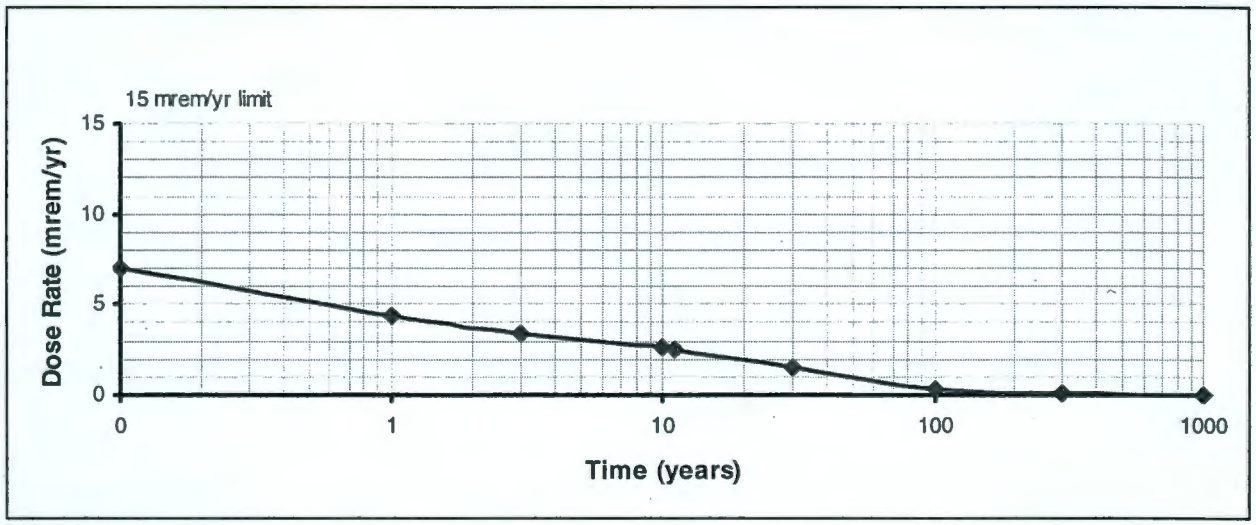


Figure 11. RESRAD Analysis for the SPA Footprint– All Radionuclides, All-Pathways Dose Rate Estimate.



(beta/gamma) dose standard to target receptor/organ, and (3) meet drinking water standards for non-uranium alpha-emitters (the more stringent of 15 pCi/L MCL or 1/25th of the derived concentration guide [DOE Order 5400.5]); and 4) meet total uranium standard of 21.2 pCi/L.

The first criterion is determined by comparing peak concentrations of radionuclide COCs/COPCs to the RAGs. The peak concentration is the maximum predicted value from all areas evaluated, as shown in the RESRAD calculation briefs in Appendix C. Of the radionuclide COCs/COPCs for the 118-B-1 Burial Ground, only cesium-137, cobalt-60, strontium-90, and tritium are predicted to reach groundwater in 1,000 years.

Figure 12. RESRAD Analysis – Radionuclide Risk, All Pathways – Combined Areas in the Remediation Footprint.

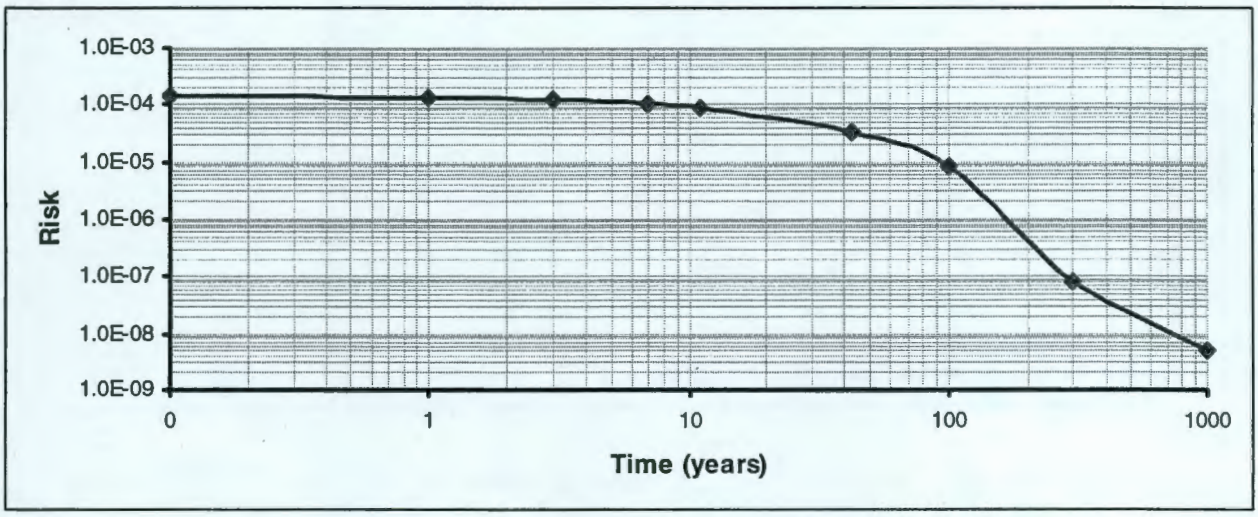
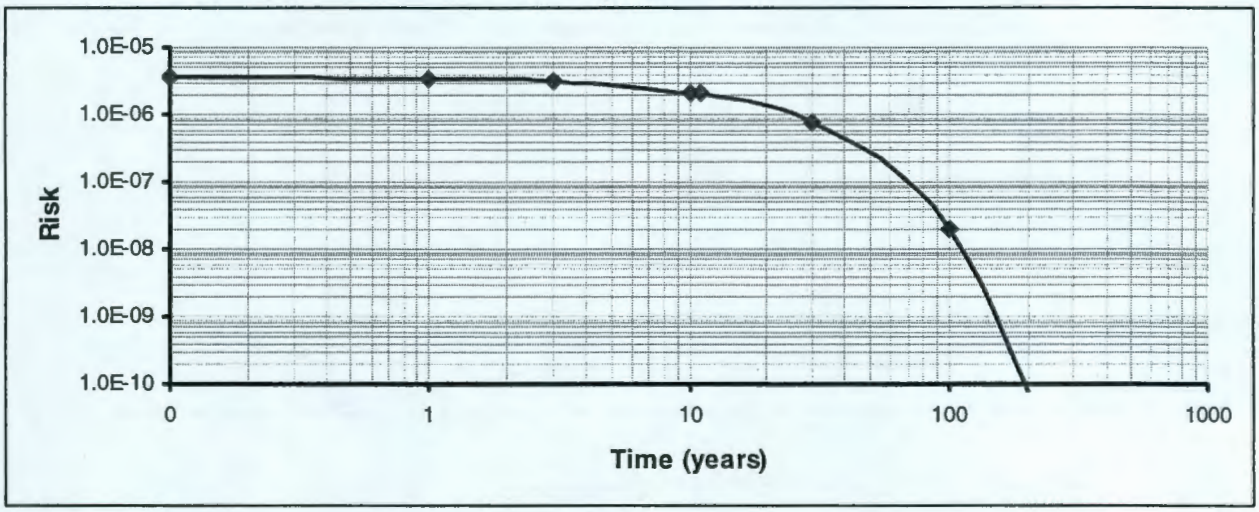


Figure 13. RESRAD Analysis – Radionuclide Risk, All Pathways – Overburden Stockpiles.



Predicted activity levels of cesium-137, cobalt-60, and strontium-90 are all significantly below the single COC/COPC RAGs. Predicted activity levels of tritium associated with soil activities in the SPA, overburden, and BCL soils are also significantly below the single COC/COPC RAGs. Tritium was not included in the overall site model for the excavation footprint, as described in Section 6.5. Tritium associated with the excavation footprint will exceed groundwater and Columbia River RAGs without the additional institutional controls documented in the 118-B-1 ESD (EPA 2007). The peak concentrations for each of these radionuclides are summarized in Table 15, but the tritium comparison is only for the combined SPA, overburden, and BCL soils. The peak concentration is the maximum value, as predicted by RESRAD modeling, from all evaluation areas, with the exception that tritium in the excavation footprint is not included because it is known that tritium will exceed RAGs without the additional institutional controls described in the 118-B-1 ESD (EPA 2007).

Figure 14. RESRAD Analysis – Radionuclide Risk, All Pathways – BCL Stockpiles.

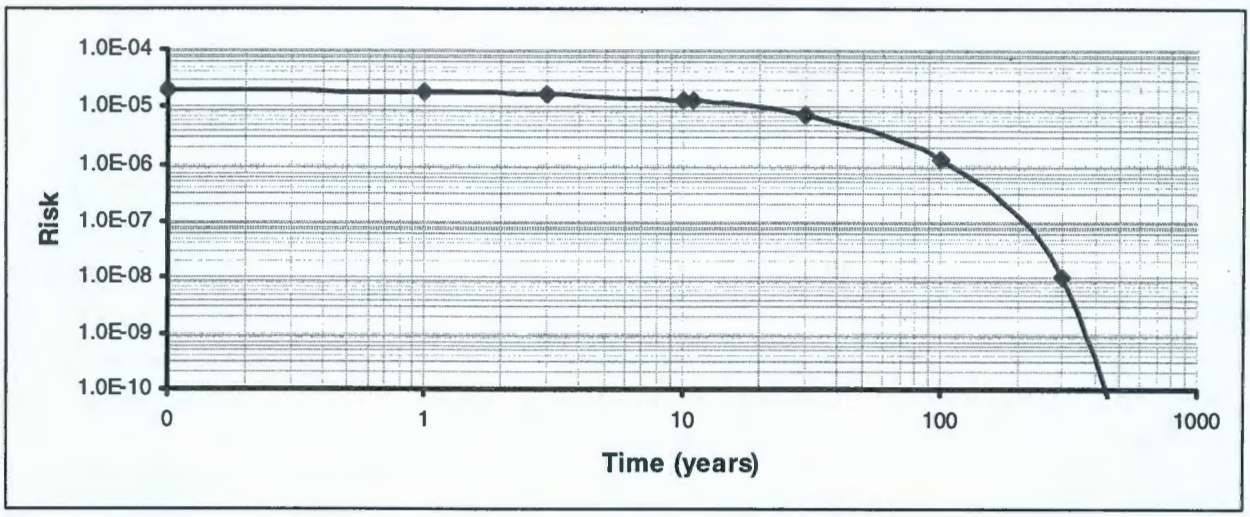
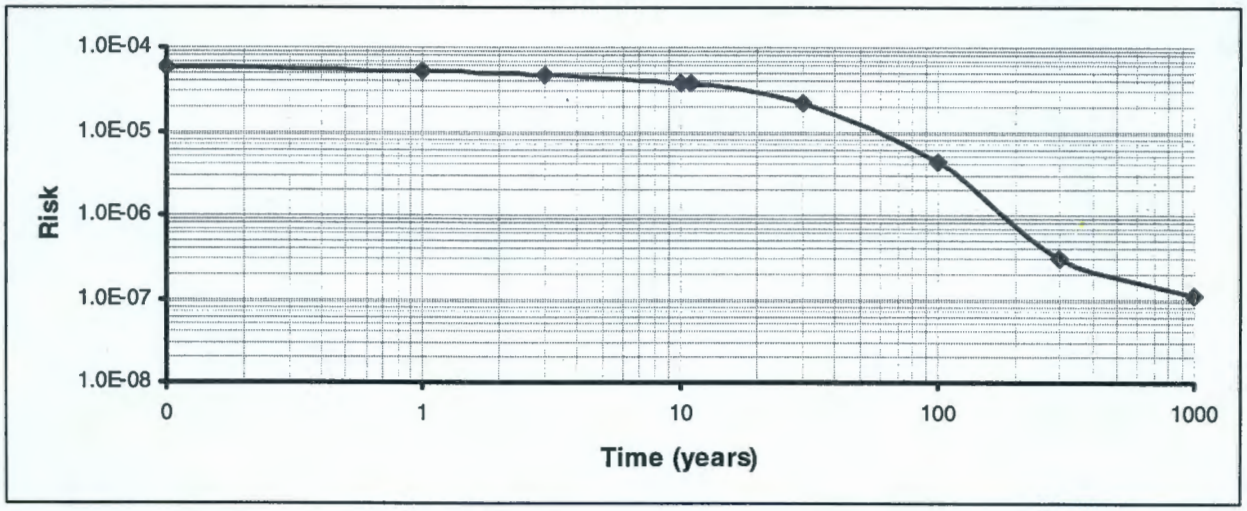


Figure 15. RESRAD Analysis – Radionuclide Risk, All Pathways – SPA Footprint.



The second criterion, attainment of the National Primary Drinking Water Regulations 4 mrem/yr (beta/gamma) above background dose standard to target receptor/organ, is summarized in Figure 16, based on the results of the MCL calculation brief (Appendix C). RESRAD modeling predicts a maximum dose of 0.0786 mrem/yr to any organ (total body, bone, liver, and gastrointestinal track [lower large intestine]) within the 1,000 years of the evaluation period. Therefore, this criterion is attained.

The third criterion, meet drinking water standards for non-uranium alpha-emitters (the more stringent of 15 pCi/L MCL or 1/25th of the derived concentration guide [DOE Order 5400.5]) is demonstrated in the RESRAD calculation briefs in Appendix C. The results indicate that no alpha-emitting COCs/COPCs will impact groundwater within 1,000 years.

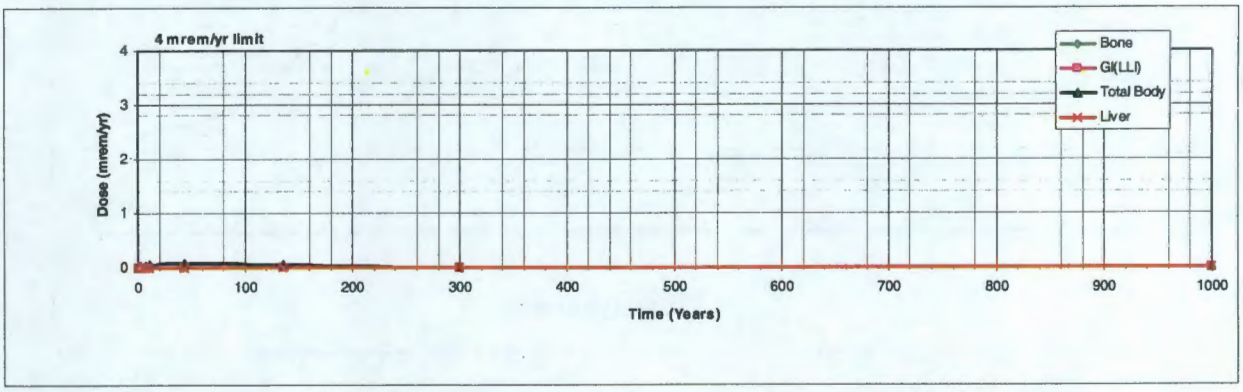
Table 15. Predicted Peak Radionuclide Groundwater Concentrations for the 118-B-1 Burial Ground.

Radionuclide	Peak Concentration (pCi/L) [a]	RAG (pCi/L)	RAGs Attained?
Cobalt-60	0.000430	100[b]	Yes
Cesium-137	0.0123	60[b]	Yes
Strontium-90	0.156	8[c]	Yes
Tritium (excluding excavation footprint)	1,440[d]	20,000[c]	Yes

[a] The peak concentration is the maximum predicted value from the remediation footprint, overburden stockpiles, BCL material, and waste staging pile area footprint. Results are presented in the RESRAD and MCL calculation briefs (Appendix C).
[b] Lookup value corresponding to a single-radionuclide dose rate of 4 mrem/yr.
[c] EPA drinking water promulgated MCL (40 CFR 141.66).
[d] Maximum result from RESRAD modeling for the overburden stockpiles, BCL stockpiles, and waste staging pile area. Residual tritium concentrations within the remediation footprint were not considered, because institutional controls will allow for attenuation of residual vadose zone tritium contamination (EPA 2007).

BCL = below cleanup level
CFR = *Code of Federal Regulations*
EPA = U.S. Environmental Protection Agency
MCL = maximum contaminant level (drinking water standard)
RAG = remedial action goal
RESRAD= RESidual RADioactivity (dose-assessment model)

Figure 16. Dose Rate to Organs from Groundwater.



For the fourth and last criterion, meet the total uranium standard of 21.2 pCi/L, no uranium isotopes were detected above background levels in the 118-B-1 Burial Ground verification samples. Therefore, this standard is met.

7.0 DATA QUALITY ASSESSMENT

A DQA is performed to compare the verification sampling approach and resulting analytical data with the sampling and data quality requirements specified by the project objectives and performance specifications.

The DQA for the 118-B-1 Burial Ground established that the data are of the right type, quality, and quantity to support site verification decisions within specified error tolerances. The evaluation verified that the sample design was sufficient for the purpose of clean site verification. The detailed DQA is presented in Appendix E.

8.0 SUMMARY FOR WASTE SITE RECLASSIFICATION

This cleanup verification package demonstrates that remedial action at the 118-B-1 Burial Ground has achieved the remedial action objectives and corresponding RAGs established in the Burial Ground ROD (EPA 2000) and RDR/RAWP (DOE-RL 2005). The remaining soils at this site have been sampled, analyzed, and modeled. The results of verification sampling indicated that vadose zone soils beneath the burial ground contained residual tritium concentrations in excess of remedial action objectives for the protection of groundwater. The 118-B-1 ESD was approved by the Tri-Parties to leave residual tritium-contaminated soil in-place based on consideration of balancing factors, and includes institutional controls to prohibit future irrigation at the 118-B-1 waste site. The results of verification sampling show that residual concentrations of contaminants other than tritium do not preclude any other future uses (as bounded by the rural-residential scenario) of shallow zone soils (i.e., surface to 4.6 m [15 ft] deep). With institutional controls to prevent irrigation, the results also demonstrate that further mobilization of residual tritium-contamination to groundwater and the Columbia River will be minimized. Residual concentrations of non-tritium contaminants are also protective of groundwater and the Columbia River. The acceptability of direct exposure to residual tritium contamination in the deep vadose zone has not been demonstrated; therefore, institutional controls to prevent uncontrolled drilling or excavation into the deep zone are also required.

In accordance with this evaluation, the verification sampling and modeling results support a reclassification of the 118-B-1 Burial Ground to Interim Closed Out.

9.0 REFERENCES

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APPENDIX A

REMEDIATION PHOTOGRAPHS

(See Attached CD for Complete File)

APPENDIX B

SYSTEMATIC RADIOLOGICAL SURVEYS

(See attached CD for Complete File)

APPENDIX C

RESRAD INPUT PARAMETERS AND CALCULATION BRIEF EXCERPTS

(See Attached CD for Complete File)

APPENDIX D

TRITIUM PLUME CHARACTERIZATION SAMPLING RESULTS

(See Attached CD for Complete File)

APPENDIX E

DATA QUALITY ASSESSMENT

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