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REVISION 0

Remaining Sites Verification Package for the 216-N-1 Waste Site Located in the 200-CW-3 Operable Unit

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

U.S. DEPARTMENT OF ENERGY
Richland Operations Office

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Signature 2/7/11 Date

REMAINING SITES VERIFICATION PACKAGE FOR THE 216-N-1 WASTE SITE LOCATED IN THE 200-CW-3 OPERABLE UNIT

EXECUTIVE SUMMARY

This report summarizes the successful completion of the remedial action conducted at the 216-N-1 waste site. This report demonstrates that the 216-N-1 Waste Site, following completion of the interim remedial action, meets the objectives for the selected remedy of removal, treatment and disposal (RTD) specified in the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*, Hanford Site, Benton County, Washington (Remaining Sites ROD) (EPA 1999).

The 216-N-1 waste site, also called the 216-N-1 Swamp, is part of the 200-CW-3 Operable Unit (OU) and is located in the 200 North Area of the Hanford Site. This pond received overflow cooling water from the 212-N Fuel Storage Facility. The field remedial action activities for the 216-N-1 waste site commenced with the initial site investigation in May 2009, progressed through excavation and disposal of contaminated soil, and concluded with verification sampling in December 2009. Evaluation of sampling results in January 2010 leads to the determination that, following completion of the remedial action, the site meets the remedial action goals (RAGs) and remedial action objectives (RAOs). Field work and determination of successful completion were conducted and performed in accordance with DOE/RL-2007-55, *Remedial Design/Remedial Action Work Plan for 200 North Area Waste Sites located in the 200-CW-3 Operable Unit* and DOE/RL-2007-54, *Sampling and Analysis Plan for Remediation of 200 North Area Waste Sites Located in the 200-CW-3 Operable Unit.*

The analytical results show that the residual soil concentration of contaminants of concern (COCs) supports the reasonably anticipated future land use specified in the ROD and the RD/RAWP (for the purposes of this interim action, the RAOs were developed for unrestricted land use). These results also support reclassification of the waste site to "interim closed out" in accordance with the process described in RL-TPA-90-0001, *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)." Finalization of this report constitutes concurrence by the signing parties that the RAOs have been met, and thus backfill and/or, contouring may take place as described in Sections 3.1.2 and 3.1.5 of the RD/RAWP. Once the waste site has been

backfilled and/or contoured, native plant species will be seeded in each area, as applicable, as an interim step towards final revegetation, in accordance with Section 3.5.5 of the RD/RAWP. No institutional controls are required because no deep zone is associated with the 216-N-1 waste site.

This waste site and the data obtained from the subject sampling evolution will be included in the risk assessment and the remedial investigation and feasibility study for final closure of this area.

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TERMS

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DQA	data quality assessment
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
HEIS	Hanford Environmental Information System
MCL	maximum contaminant level
QA	quality assurance
QC	quality control
RAG	remedial action goal
RAO	remedial action objective
RD/RAWP	remedial design/remedial action work plan
RESRAD	RESidual RADioactivity
ROD	Record of Decision
RTD	removal, treatment, and disposal
SAP	sampling and analysis plan
WIDS	Waste Information Data System

REMAINING SITES VERIFICATION PACKAGE FOR THE 216-N-1 WASTE SITE LOCATED IN THE 200-CW-3 OPERABLE UNIT

1.0 STATEMENT OF PROTECTIVENESS

When the removal, treatment, and disposal (RTD) action was selected for the 216-N-1 waste site , soil with contaminant concentrations above removal action goals (RAGs) was excavated to an approximate depth of 3.1 m (10 ft) below ground surface. Contaminant concentrations in the remaining soils were determined through analysis of soil samples collected from the excavated waste site and comparison of the analytical results against established cleanup standards. The results of verification sampling following implementation of the removal, treatment, and disposal (RTD) remedy at the 216-N-1 Waste Site demonstrate that the waste site meets the cleanup standards specified in the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (Remaining Sites Record of Decision [ROD]) (EPA 1999) and the *Remedial Design/Remedial Action Work Plan for 200 North Area Waste Sites located in the 200-CW-3 Operable Unit* (RD/RAWP) (DOE/RL-2007-55). The results summarized in this report demonstrate that residual COC concentrations in the soil in the 216-N-1 waste site area support unrestricted future use of shallow zone soil (i.e., surface to 4.6 meters [15 feet]) and that contaminant levels remaining in the soil are protective of groundwater and the Columbia River. There is no deep zone for the 216-N-1 waste site. Therefore, no institutional controls are required.

The data resulting from this remedial action will be evaluated against the final clean-up standards developed for the Outer Area. Those standards are in development by way of two separate baseline risk assessments. A baseline risk assessment for the river corridor portion of Hanford began in 2004 and includes a more complete quantitative ecological risk assessment than what was developed for the Remaining Sites ROD. Separately, an Ecological Risk Assessment is in development for the final remedial action for the Outer Area. When complete, the risk assessment for the Outer Area will include the 200-CW-3 Waste Sites (including 216-N-1) to support final closure.

2.0 GENERAL SITE INFORMATION AND BACKGROUND

The 200-CW-3 Operable Unit (OU) is located north of the 200 East and West Areas on the Hanford Site in the 200 North Area (Figure 1). Operations in the 200 North Area were mainly related to irradiated nuclear fuel storage. The purpose of the facilities in this area was to provide a storage site for the fuel while the radioisotope decay processes for many of the short-lived radioisotopes were occurring. The 200-CW-3 Waste Site Group includes areas of contamination resulting from the release of cooling water from the fuel storage basins.

The Waste Information Data System (WIDS) describes the 216-N-1 waste site as a pond that received overflow cooling water from the 212-N Fuel Storage Facility via a subgrade pipeline (600-285-PL). The dimensions provided by the WIDS data base for this waste site are 152.4 meters (m) (500 feet [ft]) long and 30.48 m (100 ft) wide. The location/orientation provided is 274 m (900 ft) south, southeast of the 212-N Building (shown in Figure 2), which has been demolished. The pond consisted of a natural depression in the terrain while in operation. The discharged water was dispersed by evaporation to the air and percolation into the ground. The site was backfilled with 0.61 to 1.83 m (2 to 6 ft) of clean soil during previous deactivation activities.

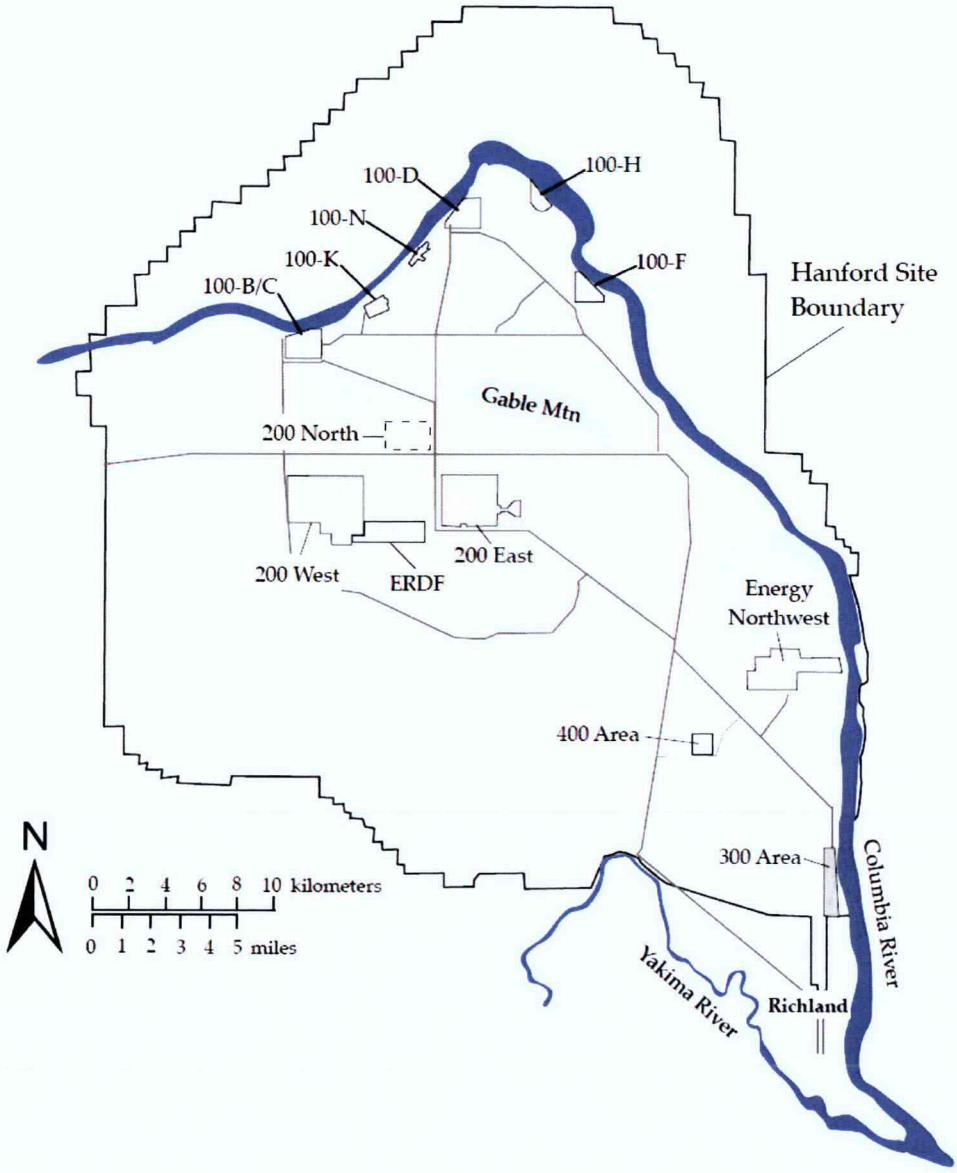

Figure 1. Location of the Hanford Site and the 200 North Area

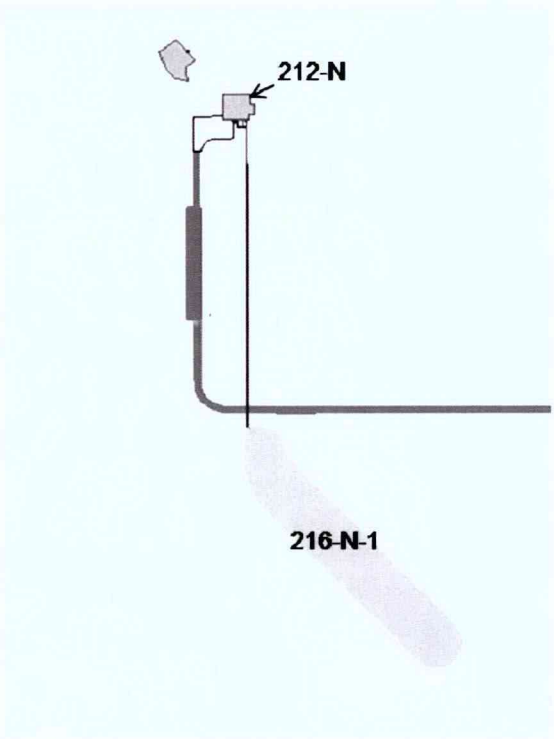

Figure 2. 216-N-1 Waste Site Location Map

3.0 SUMMARY OF REMEDIAL ACTION OBJECTIVES FOR THE 216-N-1 WASTE SITE

The analytical results from sampling evolutions (investigative and verification) of the 216-N-1 waste site indicate compliance with the remedial action goals (RAGs) and thus the remedial action objectives (RAOs) identified in the Remaining Sites ROD (EPA 1999) and the RD/RAWP (DOE/RL-2007-55). The RAOs provided in the Remaining Sites ROD and RD/RAWP are:

- RAO 1: Protect human and ecological receptors from exposure to contaminants in soils, structures, and debris by dermal exposure, inhalation or ingestion of radionuclides, inorganics, or organics.
- RAO 2: Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.

Table 1 provides a summary of the applicable regulatory requirements, the RAGs, the remediation results, and the attainment of the RAOs. Detailed sample analysis data are presented in Appendix G.

Table 1. Summary of Attainment of Remedial Action Objectives for the 216-N-1 Waste Site

Regulatory Requirement	Remedial Action Goals[a]	Results	Remedial Action Objectives Attained?
Direct Exposure – Radionuclides	Attain total dose for radionuclides that does not exceed 15-mrem/year above background over 1,000 years.	Residual concentrations of radionuclide COCs are below background or less than one-tenth the single radionuclide soil concentration equivalent to a 15 mrem/year dose rate calculated by RESRAD. (Appendix A)	Yes
Direct Exposure – Nonradionuclides	Reduce concentration of inorganics and organics to State of Washington MTCA Method B levels.	All individual COC concentrations are below the direct exposure criteria presented in Appendix B.	Yes
Risk Requirements – Nonradionuclides	Attain a hazard quotient of <1 for all individual noncarcinogens.	Zinc was the only noncarcinogenic COC detected above Hanford Specific background value (see Appendix B and Appendix G, Table G-2). Hexavalent chromium, was also detected and is included. The calculated individual hazard quotients were <1. See Appendix C for calculations.	Yes
	Attain a cumulative hazard quotient of <1 for non-carcinogens.	Zinc was the only noncarcinogenic COC detected above Hanford Specific background value (see Appendix B and Appendix G, Table G-2). Hexavalent chromium was also detected and is included. The calculated cumulative hazard quotient was <1. See Appendix C for calculations.	
	Attain an excess cancer risk of $<1 \times 10^{-6}$ for individual carcinogens.	Hexavalent chromium was the only carcinogenic COC detected above background levels (see Appendix B and Appendix G, Table G-2). The excess cancer risk calculated for these constituents meet the $<1 \times 10^{-6}$ criteria. See Appendix C for calculations.	
	Attain a cumulative excess cancer risk of $<1 \times 10^{-5}$ for carcinogens.	Hexavalent chromium was the only carcinogenic COC detected above background levels (see Appendix B and Appendix G, Table G-2). The cumulative excess cancer risk calculated for these constituents meet the $<1 \times 10^{-5}$ criteria. See Appendix C for calculations.	
Groundwater/River Protection – Radionuclides	Attain single COC groundwater and river protection RAGs.	Maximum residual concentrations of radionuclide COCs were detected below groundwater and river protection exposure criteria (Appendix D). Values calculated by RESRAD that are protective of the groundwater are also protective of the Columbia River, since contaminant pathway to the Columbia River is through the groundwater. ***NOTE**: For uranium-233/234 and uranium-238, the groundwater MCL of 21.2 pCi/L corresponds to a soil concentration of 0.185 pCi/g. However, the Hanford specific background for these uranium isotopes is 1.1 pCi/g. The RAG therefore defaults to 1.1 pCi/g.* (Appendix D, Footnote d)	Yes
	Attain national primary drinking water standards 4 mrem/yr (beta/gamma) dose rate to target receptor/organs.	Maximum residual concentrations of beta/gamma radionuclide COCs were detected below groundwater and river protection exposure criteria. (Appendix A, Footnote a)	

Table 1. Summary of Attainment of Remedial Action Objectives for the 216-N-1 Waste Site

Regulatory Requirement	Remedial Action Goals[a]	Results	Remedial Action Objectives Attained?
	Meet drinking water standards [b] for alpha emitters: the most stringent of 15 pCi/L MCL or 1/25th of the derived concentration guides from DOE Order 5400.5. [c]	Maximum residual concentrations of alpha emitting radionuclide COCs were detected below groundwater and river protection exposure criteria (Table 2 and Appendix D). RESRAD calculations predict that the only alpha-emitting radionuclide COCs with the potential to reach groundwater within 1,000 years are the uranium isotopes. ***NOTE**: For uranium-233/234 and uranium-238, the groundwater MCL of 21.2 pCi/L corresponds to a soil concentration of 0.185 pCi/g. However, the Hanford specific background for these two uranium isotopes is 1.1 pCi/g. The RAG therefore defaults to 1.1 pCi/g.* (Appendix D, Footnote d)	Yes
	Meet total uranium standard of 21.2 pCi/L. [d]	For uranium-233/234 and uranium-238, the groundwater MCL of 21.2 pCi/L corresponds to a soil concentration of 0.185 pCi/g (Appendix C). However, the Hanford specific background for these two uranium isotopes is 1.1 pCi/g. The RAG therefore defaults to 1.1 pCi/g. (Appendix D, Footnote d)	
Groundwater/River Protection – Non-radionuclides	Attain individual non-radionuclide groundwater and river cleanup requirements.	Maximum detected results for all nonradionuclides are below the RAGs for protection of groundwater. (Appendix E)	Yes

Notes:

[a] Remaining Sites ROD.

[b] "National Primary Drinking Water Regulations" (40 *Code of Federal Regulations* 141).

[c] *Radiation Protection of the Public and the Environment* (DOE Order 5400.5).

[d] Based on the isotopic distribution of uranium in the 100 Areas, 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*, 0100X-CA-V0038 (BHI 2001).

Abbreviations: COC = contaminant of concern
MCL = maximum contaminant level (drinking water standard)
RAG = remedial action goal

4.0 PRE-REMEDIATION WASTE SITE CHARACTERIZATION AND CONCEPTUAL MODEL SAMPLING

Initial investigative sampling was performed to determine the nature and extent of contaminants in the 216-N-1 waste site soils. These results served three primary purposes: (1) to confirm the selected remedy, (2) to support design of the RTD implementation, and (3) to support waste characterization and disposal. The waste site was characterized in accordance with the remedial RD/RAWP (DOE/RL-2007-55) and SAP (DOE/RL-2007-54). Soil sampling and analysis and radiological screening confirmed that RTD was the appropriate remedy selected for this site.

This section provides geophysical information for the area and waste site, the contaminants of concern (COCs) for the subject waste site, and a summary of the pre-remediation sampling results as applicable to the development of the specific remedial action and verification sampling.

4.1 Geophysical Survey Results

The Hanford Site lies in a sediment-filled basin on the Columbia Plateau in southeastern Washington. The 200-CW-3 operable unit waste sites are located in the 200 North Area which is situated on the 200 Areas Plateau north of a relatively flat prominent terrace (Cold Creek Bar), on a flood channel formed during the late Pleistocene flooding. The elevation in the vicinity ranges from approximately 180 m (593 ft) in the northern part of the unit to about 170 m (560 ft) above mean sea level (msl) in the southern part. There are no natural surface drainage channels within the 200 North Area.

The vadose zone beneath the 200 Areas ranges in thickness from approximately 55 m (180 ft) beneath the former U Pond in the 200 West Area to approximately 104 m (341 ft) in the southern portion of the 200 East Area to 49 m (160 ft) along the western part of the 200 North Area. Basalt of the Columbia River Basalt Group and a sequence of overlying sediments comprise the local geology. Sediments in the vadose zone consist primarily of the Hanford formation, Cold Creek unit/silt-dominated facies of the Cold Creek unit, and Ringold Formation. The caliche or calcic facies of the Cold Creek unit is also present in the 200 West Area.

Groundwater beneath the Hanford Site is found in an upper primarily unconfined aquifer system and in deeper confined aquifers within the basalt. The Columbia River is the primary discharge area for both the unconfined and confined aquifer. The unconfined aquifer in the 200 North Area of the Central Plateau occurs in the Hanford formation. In general, groundwater flowing through the Central Plateau occurs in a predominantly easterly direction from the 200 West Area to the 200 East Area.

The nearest natural surface water body to the 200 North Area is West Lake (the 216-N-8 Pond) located approximately 0.8 km (0.5 mi) east. The potential for natural groundwater recharge within the 200 North Area is limited to precipitation infiltration. Estimates of recharge from precipitation at the Hanford Site range from 0 to 10 cm/yr (0 to 4 in/yr).

Waste Site 216-N-1 is a pond that received overflow cooling water from the 212-N Fuel Storage Facility via a pipeline (600-285-PL). The pond consisted of a natural depression in the terrain while in operation. The discharged water was dispersed by evaporation and percolation into the ground. This site was associated with the 600-285-PL operational discharge line from 1944 through 1952 and, as a result, represents the potential time period the surface area soils could have been saturated. The pond was intermittently supplied with liquid discharged as gravity-fed overflow from the 212-N cooling basin during this time period. In addition, the absence of a recurring liquid discharge (or any known liquid discharge) to this area after 1952 would have restricted any additional drivers for vertical migration and distribution of COCs through the sediments of the vadose zone other than the original operational discharges.

4.2 Contaminants of Concern

The COCs for the 216-N-1 waste site were identified based initially on historic/process information for the waste site and the contaminants of potential concern (COPCs) listed in the Remaining Sites ROD. Through the analytical results from the investigative sampling evolution, the COC list was developed and represents the full COPC list presented in the RD/RAWP and SAP. Table 2 provides the COCs for the 216-N-1 waste site.

Table 2. Contaminants of Concern for the 216-N-1 Waste Site

Barium	Americium-241
Antimony	Cesium-137
Arsenic	Cobalt-60
Chromium (III)	Europium-152
Mercury	Europium-154
Chromium (VI)	Europium-155
Cadmium	Plutonium-238
Lead	Plutonium-239/240
Manganese	Nickel-63
Zinc	Tritium-3
Polychlorinated Biphenyls	Strontium-90
	Technetium-99
	Thorium-232
	Uranium-233/234
	Uranium-235
	Uranium-238

4.3 Waste Site Sample Design for Conceptual Model Confirmation and RTD Design

The nature of the 200-CW-3 OU waste sites supports the use of judgment/focused sampling for the waste site investigations, as identified in EPA/240/R-02/005, *Guidance on Choosing a Sampling Design for Environmental Data Collection* (EPA 2002). The function and discharge point of 216-N-1 pond was known. Investigative sampling was performed in a focused manner to determine the extent of contamination. Sampling was initiated at the point where effluent exited the discharge pipe and entered the pond (the northern most end of the waste site), which was expected to contain the highest concentration of COPCs. Sampling continued downgradient (with effluent flow) and laterally to identify the location that the COPCs were above action levels. Per the guidance in the RD/RAWP and SAP, samples were collected at depths below ground surface (bgs) (to a maximum of 15 ft bgs) to determine the vertical extent of contamination.

Due to the presence of radiological constituents in the discharge stream, radiological field surveys were an integral element of the investigative sampling evolution allowing real-time indication of the presence of COPCs (based on radiological indicators) during the sample collection activities.

Investigative sampling was performed May 13 through May 20, 2009. As shown in Figure 3, 18 sample locations were identified. Sample locations 1 through 12 were targeted as the initial phase. Sample locations 1 through 6 were targeted because they are located in the influent stream portion of the pond (lowest elevation) to define the extent of downgradient contamination from the point source. Sample locations 7 through 12 were targeted to define the lateral extent of contamination from the influent stream area. If the extent of contamination could not be determined based on locations 1 through 12, sampling would progress to sample locations 13 through 18. Following this rationale, additional sample locations would be developed based on sample results as needed.

The specific investigative sampling design for the 216-N-1 waste site was developed in accordance with the SAP, and follows the conceptual site model for surface spills developed under the remaining sites ROD. The conceptual model for surface spills includes the physical components and sample media at the site, sampling access, spatial boundaries and spatial distribution of contaminants.

Figure 3. Aerial Image and Sample Locations

4.4 Sample Summary

As per the guidance prescribed in the SAP, discrete soil samples were collected at locations expected to contain highest concentrations of COPCs based on historic/process knowledge and at locations showing radiological and/or visual indicators (such as soil staining). Radiological indicators (dose rate readings above background) were found in one location: sample location 1. Visual indicators (slight soil

discoloration) were identified at three sample locations: 2, 3 and 7 at depths of 3.1 m (10 ft), 1.5 m (5 ft), and 0.3 to 0.9 m (1 to 3 ft) below ground surface, respectively.

Analytical results from investigative sampling are provided in Appendix F and provide the basis for transitioning from a listing of "potential" contaminants (COPCs), to the list of known contaminants (COCs). One constituent (cesium-137) was found above action levels at sample location 1 at a depth of 2.13 to 2.44 m (7 to 8 ft) below ground surface. Contaminants at all other sample locations were below Look-Up Values. The results from the first phase of investigative sampling effectively identified and bounded the extent of the contaminated area to be subject to RTD and reduced the area originally attributed to the waste site to an area of 504 m^2 (Figure 4).

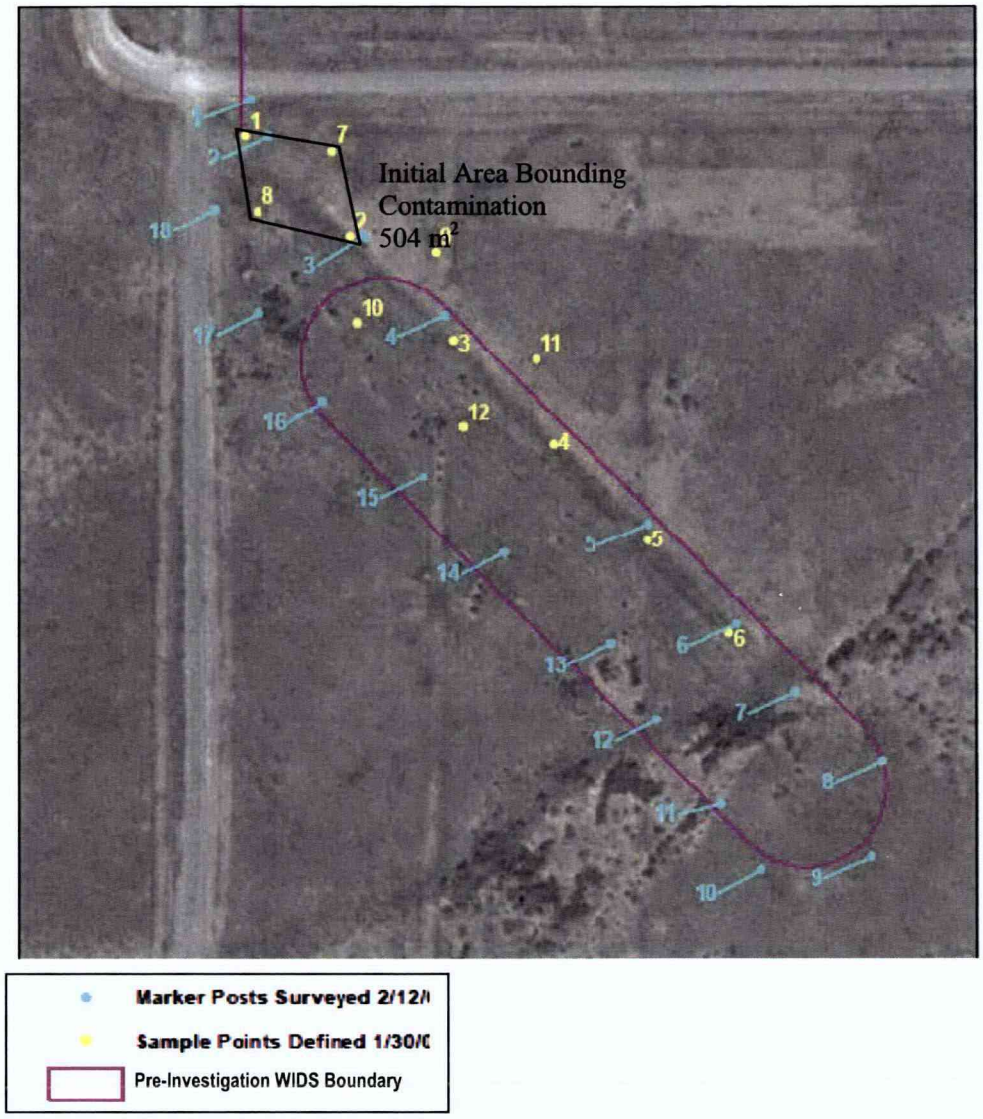

Figure 4. 216-N-1 RTD Area

5.0 WASTE SITE SAMPLING AFTER REMEDIATION ACTIVITIES

The selected remedy of RTD commenced at 216-N-1 waste site on November 5, 2009 and was completed on December 29, 2009. RTD activities involved the removal and disposal of contaminated soil from the 216-N-1 waste site at the Environmental Restoration Disposal Facility (ERDF).

Based on the investigative sampling results summarized in the previous sections of this report and in Tables F-1 and F-2, the excavation activity was planned to occur in stages with the area of highest contaminant concentration in the center (being removed first) and vertical excavation depth set at 3.1 m (10 ft) below ground surface. Soil removal followed by verification sampling was planned to be performed repeatedly until the analytical data showed residual contaminant concentrations in the excavated area were below RAGs demonstrating that RAOs were attained. With the investigative sample results showing the extent of the contaminated area bounded at sample locations 2, 7 and 8 (shown in Figure 4), a maximum of two iterations was anticipated to be required. Ultimately, RAOs were met after only one phase of excavation followed by verification sampling.

As depicted in Figure 5, the final excavation area was 460 m^2 (4,740 ft^2) measured at ground surface with a slope of 1.5 to 1 to a depth of 3.1 m (10 ft). Approximately 1,537 metric tons (1,694 tons) of media (soil) from the site were disposed of at ERDF.

Post excavation verification sampling was performed on January 29, 2010. Laboratory analysis was performed to verify that remediation was complete and to demonstrate quantitatively that RAOs were met. The following sections provide a summary of the results of verification sampling and the attainment of RAOs.

5.1 Verification Sampling

Focused or discrete samples were collected from the remediated area using a combination of statistical and judgmental sampling design. The number of samples and sample locations were determined using Visual Sample Plan™ (VSP) software and a statistical sampling design with random start and 95% upper confidence limit. Two biased samples (labeled V-1 and V-2 on Figure 5) are included outside the boundary of the initial area bounding contamination in a north-northwest direction. These locations were selected in order to increase the confidence that the scope of the remedial action activities were sufficient. (The locations took into account the potential of the liquid discharge stream pooling from the high volumes of liquid being discharged at the end of the pipe. The area of pooled water would have a slight reverse flow direction during discharge activities and had the potential to back up alongside the exterior of the pipe and thus contaminate the soil above the discharge area.) A map of sample locations is provided in Figure 5, with coordinates provided in Table 3.

The excavated area of the RTD is depicted in Figure 5. As described in the SAP, results from radiological field screening for detectable radiological contamination or cesium-137, an "indicator" constituent, conducted during excavation aided in defining the extent of the excavation area. At each sample location, soil samples were collected at the following depths:

- At the "surface" where surface is 0 to 0.3 m (0 to 1 ft) from the remediated ground level (the floor of the excavation area)
- At a depth of 15 ft below ground surface where the ground surface is the original grade.

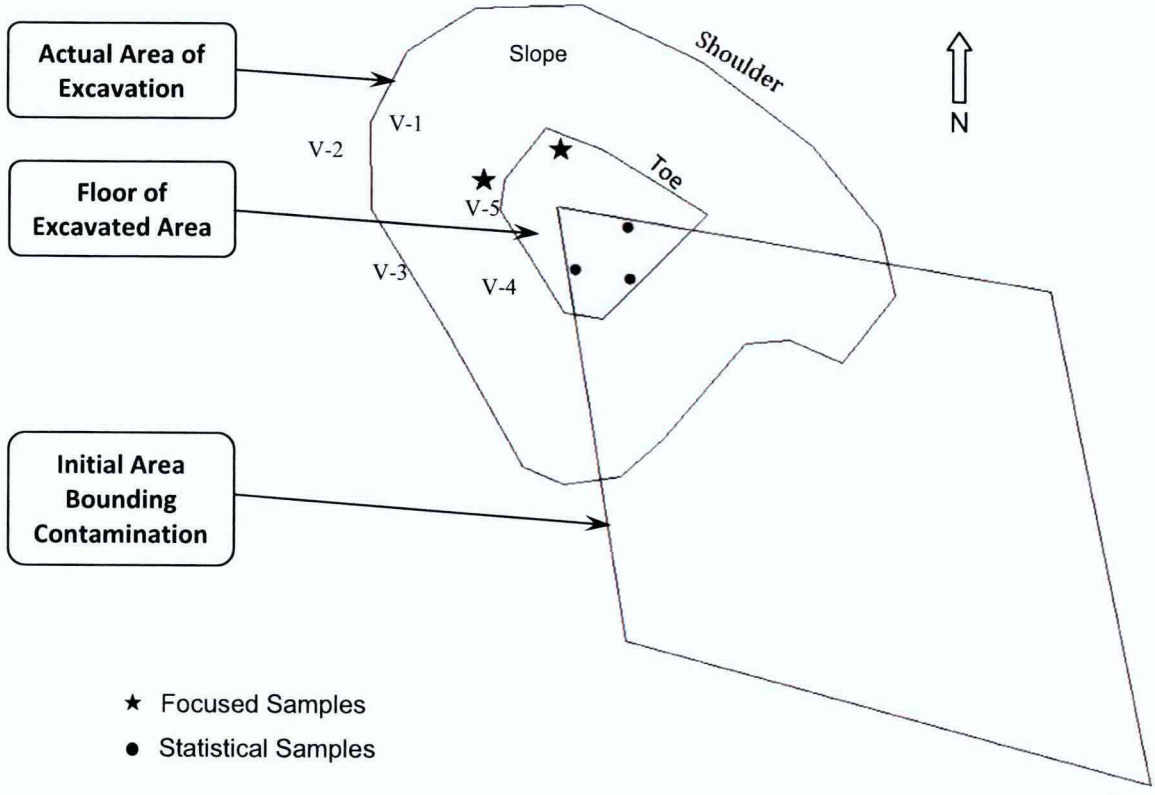

Figure 5. Verification Sampling Locations

Verification sampling results were used to quantitatively demonstrate that residual concentrations of COCs remaining in the soil are below the RAGs and meet RAOs.

Photographs and analytical data for the 216-N-1 Waste Site post-remediation sampling and analysis are provided in Appendix G.

Table 3. GPS Coordinates for 216-N-1 Verification Sampling

Sample Location	Northing	Easting
V-1	140036.67	569884.15
V-2	140034.86	569881.28
V-3	140030.33	569885.04
V-4	140029.86	569887.98
V-5	140032.58	569887.83

5.2 Radiological Survey Field Screening

Radiological field screening was performed over the entire surface of the remediated area. Due to process knowledge that comingled radiological and chemical constituents, field screening for radiological contamination was used as an indicator to locate areas of chemical contamination. The survey was

performed using standard radiological survey instruments in accordance with approved practices and procedures to obtain dose and contamination measurements with sufficient sensitivity to meet clean-up levels. Radiological screening was also performed during the collection of focused samples.

Radiological field screening of the remediated surface and the samples collected indicated no detectable dose rates above background.

6.0 DATA EVALUATION

Results for the 216-N-1 waste site sampling and analysis for verification of remedy completion are provided in Appendix G. As shown in Table 4, all detected analytes were reported at concentrations below direct exposure, groundwater protection, and river protection RAGs, or below the Hanford Specific Background default value RAGs in the case of uranium-233/234 and uranium-238.

Nonradionuclide risk requirements for the 216-N-1 waste site include an individual and cumulative hazard quotient of less than 1.0, individual contaminant carcinogenic risks of less than 1×10^{-6}, and a cumulative carcinogenic risk of less than 1×10^{-5}. Risk values are not calculated for constituents that are either not detected or are detected at concentrations below Hanford Site or Washington State background values (Appendix G).

- The individual hazard quotients for noncarcinogenic constituents were less than 1.0. Zinc and hexavalent chromium were the only constituents detected above its Hanford Specific Background value. Therefore, zinc and hexavalent chromium were the only constituent used in the hazard quotient calculation. See Appendix C.

- The cumulative hazard quotient for all noncarcinogenic constituents was less than 1.0. Zinc and hexavalent chromium were the only constituents detected above its Hanford Specific Background value. Therefore, zinc and hexavalent chromium were the only constituents used in the hazard quotient calculation. See Appendix C.

- The individual carcinogenic risk values for carcinogenic constituents above background are all below 1×10^{-6}. Hexavalent chromium was the only constituent detected above its Hanford Specific Background value. Therefore, hexavalent chromium was the only constituent used in the individual excess carcinogenetic risk calculation. See Appendix C.

- The cumulative excess carcinogenic risk values for carcinogenic constituents above background are all below 1×10^{-5}. Hexavalent chromium was the only constituent detected above its Hanford Specific Background value. Therefore, hexavalent chromium was the only constituent used in the cumulative excess carcinogenetic risk calculation. See Appendix C.

7.0 DATA QUALITY ASSESSMENT

A data quality assessment (DQA) review was performed to compare the sampling approach and analytical data with the sampling and data requirements specified by the SAP (DOE/RL-2007-54). This review involves evaluation of the data to determine if they are of the right type, quality, and quantity to support the intended use (EPA 2000). The assessment review completes the data life cycle (i.e., planning, implementation, and assessment) that was initiated by the data quality process.

Level C data validation as defined in the contractor's validation procedures, which are based on EPA functional guidelines (e.g., *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* [Bleyler 1988a]; *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses* [Bleyler 1988b]), was performed for the entire sampling and analysis data package for the

investigative and verification samples collected for 216-N-1. Level C validation is a review of the quality control (QC) data and specifically requires verification of deliverables and requested versus reported analyses and qualification of the results based on: (a) analytical holding times, (b) method blank results, (c) matrix spike/matrix spike duplicate, (d) surrogate recoveries, (e) duplicates, and (f) analytical method blanks.

Specific data quality objectives for the site are found in the SAP (DOE/RL-2007-54). All samples were collected per the sample design described in Section 5.1. The COCs for 216-N-1 are in listed Table 2.

All of the sampling and analysis data generated from the verification sampling of 216-N-1 waste site is tracked through the following Hanford Environmental Information System (HEIS) numbers: B23WM1, B23WM2, B23WM3, B23WM4, B23WM5, B23WM6, B23WP4, B23WP5, B23WP6, B23WP7, B23WP8 and B23WL9 (equipment blank). All of the 216-N-1 sampling and analysis data were found to be useable for decision-making purposes as provided in the following summary:

HEIS Identification Numbers: B23WM1, B23WM2, B23WM3, B23WM4, B23WM5, B23WM6, B23WP4, B23WP5, B23WP6, B23WP7, B23WP8 and B23WL9 (equipment blank)

Blanks: Trip, field, and equipment blanks with complete analyses were acceptable.

Field Duplicates: All duplicates were acceptable.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) and Laboratory Control Standard/Laboratory Control Standards Duplicate (LCS/LCSD): MS/MSD and LCS/LCSD were run to an acceptable percentage recovery test as a result for calculation or relative percent difference (RPD) for QC purposes based on laboratory QA/QC procedures.

Radiochemistry, ICP Metals, PCB, and Chromium (VI) Analyses: Analytical reports submitted for validation and verified for completeness based on the percentage of data determined to be valid (i.e., not rejected). The completion percentage was 100%. The data has been determined to be useable for decision-making purposes.

Field Screening: Relative to analytical data in sample media, physical data and/or field screening results are of lesser importance in making inferences of risk. Because of the secondary importance of such data, no validation for physical property data and/or field screening results was performed. However, field quality assurance/quality control (QA/QC) was reviewed to ensure that the data are useable. Field instrumentation, calibration, and QA checks were performed in accordance with the following:

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

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

The review and approval of completed field radiation surveys by the radiological controls organization represents the data validation and usability review for handheld field radiological measurements.

The DQA review for these waste sites found the analytical results to be accurate within the standard errors associated with the methods, including sampling and sample handling. The data are of the correct type, quality, and quantity to support the intended use. Detection limits, precision, accuracy, and sampling data group completeness were assessed to determine if any analytical results should be rejected as a result

of quality assurance and quality control deficiencies. All analytical data were found acceptable for decision-making purposes. All of the sampling analytical data are stored in the HEIS and are summarized in Appendix G. All qualifiers have also been added accordingly into the data for Appendix G.

8.0 SUMMARY SUPPORTING INTERIM CLOSED OUT RECLASSIFICATION

In January 2010, discrete soil samples were collected from the 216-N-1 waste site using a statistically based sampling approach with additional samples collected from locations judgmentally selected from process and sampling knowledge. The analytical results were compared to the Deep and Shallow Zone Look-Up Values to determine whether further remediation was required. The analytical results from the soil samples are below the applicable Look-Up Values.

The analytical results from the soil samples meet the RAGs for direct exposure, groundwater protection, and river protection. In accordance with this evaluation, the sampling results support reclassification of the 216-N-1 waste site to 'interim closed out' status, as recorded on the Waste Site Reclassification Form (2010-33). Per TPA-MP-14, 'interim closed out' status indicates that a waste site meets cleanup standards specified in an Interim Action Record of Decision or Action Memorandum and related work plan(s), but for which a Final Record of Decision has not been issued. Final remedial action evaluations and decisions for this waste site will be made under the final remedial action process for the Outer Area.

Finalization of this report constitutes concurrence by the signing parties that the RAOs have been attained, thus backfill and/or contouring may take place, as described in Sections 3.1.2 and 3.1.5 of the RD/RAWP. Backfilling prior to finalization of this report may be necessary where worker safety or other issues warrant that action. Once the waste site has been backfilled and/or contoured, native plant species will be seeded in the area, as applicable, as an interim step toward final revegetation, in accordance with Section 3.5.5 of the RD/RAWP.

Table 4. Comparison of Maximum Soil Analyses to Remedial Action Goals for the 216-N-1 Waste Site [f]

Radiological Contaminant of Concern	Hanford Site-Specific Background Activity (pCi/g)	Maximum Soil Analyses (pCi/g)	Remedial Action Goals			Does the Maximum Exceed RAGs?
			Direct Exposure (pCi/g)	Soil Cleanup Level for Groundwater Protection (pCi/g)	Soil Cleanup Level for River Protection (pCi/g)	
Americium-241	N/A	U	31.1	1,577,000	1,577,000	No
Cesium-137	1.1	2.25	6.2	NA [c]	NA [c]	No
Cobalt-60	0.008	U	1.4	NA [c]	NA [c]	No
Europium-152	N/A	0.516	3.3	NA [c]	NA [c]	No
Europium-154	0.033	U	3.0	NA [c]	NA [c]	No
Europium-155	0.054	U	125	NA [c]	NA [c]	No
Nickel-63	N/A	U	4,026	NA [c]	NA [c]	No
Plutonium-238	0.004	U	37.4	1,123	1,123	No
Plutonium-239/240	0.025	0.127	33.9	718,600	718,600	No
Strontium-90	0.18	U	4.5	NA [c]	NA [c]	No
Technetium-99	N/A	U	15	15 [b]	15 [b]	No
Throium-232	1.3	0.451	1.3	NA [c]	NA [c]	No
Tritium (H-3)	N/A	U	510	35.5	106.7	No
Uranium-233/234	1.1	0.862	1.1	1.1 [a]	1.1 [a]	No
Uranium-235	0.11	U	1.0	1.0 [b]	1.0 [b]	No
Uranium-238	1.1	0.693	1.1	1.1 [a]	1.1 [a]	No

Non-Radiological Contaminant of Concern	Hanford Site-Specific Background Concentration (mg/kg)	Maximum Soil Analyses (mg/kg)	Remedial Action Goals			Does the Maximum Exceed RAGs?
			Direct Exposure (mg/kg)	Soil Cleanup Level for Groundwater Protection (mg/kg)	Soil Cleanup Level for River Protection (mg/kg)	
Antimony	5 [d]	2.3	32	6.0 [b]	6.0 [b]	No
Arsenic	6.5	U	6.5 [d]	6.5 [d]	6.5 [d]	No
Barium	132	130	5,600	NA [c]	NA [c]	No
Cadmium [f]	0.81 [d]	0.62	80	NA [c]	NA [c]	No
Chromium Total	18.5	8.4	80,000	NA [c]	NA [c]	No
Chromium (VI)	N/A	0.221	400	8.0	2.2	No
Lead	10.2	6.1	353	NA [c]	NA [c]	No
Manganese	512	394	11,200	NA [c]	NA [c]	No
Mercury	0.33	U	24	NA [c]	NA [c]	No
Zinc	67.8	111	24,000	NA [c]	NA [c]	No
Polychlorinated Biphenyls	N/A	U	0.5	NA [c]	NA [c]	No

Notes:

[a] The calculated soil concentration cleanup level of 0.185 pCi/g is below the Hanford Specific Background Activity of 1.1 pCi/g. Therefore the soil concentration protection of groundwater defaults to 1.1 pCi/g.

[b] The remedial action goal is below the practical quantitation limit (PQL). The value presented is the PQL.

[c] NA = Not Applicable. RESRAD predicts constituent will not reach groundwater within 1,000 years based on 100 Area generic site model using soil column layers and depths.

[d] Where cleanup levels are less than background or required detection limit (RDLs), cleanup levels default to background or RDLs per Ecology 1996, WAC 173-340-700(4)(d) and WAC 173-340-707(2), respectively. The arsenic cleanup level of 20 mg/kg has been agreed to by the Tri-Party Agreement Project Managers Managers (the basis is documented in DOE/RL-96-17, Rev 5, 2.1.2.1).

[e] The maximum plutonium-239/240 result of 2.4 pCi/g exceeds the Hanford Site-Specific background of 0.025 pCi/g. However, the RESRAD calculation predicts that Plutionium-239/240 will not reach groundwater within 1,000 years based on the 100 Area generic site model using soil column layers and depths.

f Site RAGs are taken from the RD/RAWP (DOE/RL-2007-55), where available, without further consideration of updated toxicity data or amendments (2004) to cleanup regulations in WAC 173-340.

Abbreviations: NA = Not Applicable (see note c above) N/A = Not Available RAG = Remediation Action Goal
U = Analyte was not detected above detection limits. Detection limits are below RAGs.

9.0 SUMMARY OF PROJECT COSTS

For the purposes of reporting costs of remedial action for the 216-N-1 Waste Site, costs are pro rated utilizing an activity/schedule-based methodology. This method is not considered to be audit quality data. Actual costs for waste site clean-up will continue to be collected for each operable unit or closure area in accordance with the current cost tracking methodology. These costs will then be included, in accordance with CERCLA requirements, in the remedial action report for the 200-CW-3 operable unit prior to the final remedial action of the closure area.

Table 5. Cost Summary

Cost Item	Actual Cost FY 2009 ($$)	Actual Cost FY 2010 ($$)	Actual Total Cost ($$)
RA Capital (Construction) Costs	0	0	0
RA Operating Costs	$268,100	$240,000	$508,100
Total RA Cost	$268,100	$240,000	$508,100
Projected Yearly O&M Cost	0	0	0

FY = fiscal year
O&M = operation and maintenance
RA = remedial action

10.0 REFERENCES

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Appendix A

Comparison of Maximum Sample Analyses to 100 Area Radionuclide Soil Concentrations Corresponding to an Equivalent Dose of 15 mrem/yr

APPENDIX A

Table A-1 shows the soil activity for a 15 mrem/yr dose (pCi/g) compared to Hanford Specific Background Activity and the maximum results for each radionuclide listed.

Table A-1. Comparison of Maximum Soil Analyses to 100 Area Radionuclide Soil Concentrations Corresponding to an Equivalent Dose of 15 mrem/yr

Radionuclide	Soil Activity for 15 mrem/yr Dose (except as noted) (pCi/g)	Hanford Specific Background Activity (pCi/g)	Source of Single Radionuclide Soil Concentration	Maximum Results (pCi/g)
Americium-241	31.1	N/A	WDOH/320-015 [c]	U
Cesium-137	6.2	1.1	WDOH/320-015 [c]	2.25
Cobalt-60	1.4 [a]	0.008	WDOH/320-015 [c]	U
Europium-152	3.3 [a]	N/A	WDOH/320-015 [c]	0.516
Europium-154	3.0 [a]	0.033	WDOH/320-015 [c]	U
Europium-155	125 [a]	0.054	RESRAD Calc [b]	U
Nickel-63	4,026 [a]	N/A	RESRAD Calc [b]	U
Plutonium-238	37.4	0.004	RESRAD Calc [b]	U
Plutonium-239/240	33.9	0.025	WDOH/320-015 [c]	0.127
Strontium-90	4.5 [a]	0.18	WDOH/320-015 [c]	U
Technetium-99	8.5 [a]	N/A	WDOH/320-015 [c]	U
Thorium-232	1.0	1.3	RESRAD Calc [b]	0.451
Tritium (H-3)	510 [a]	N/A	RESRAD Calc [b]	U
Uranium-233/234	0.78	1.1	RESRAD Calc [b]	0.862 (<BG)
Uranium-235	0.84	0.11	RESRAD Calc [b]	U
Uranium-238	0.84	1.1	RESRAD Calc [b]	0.693

Notes:

[a]Radionuclide concentrations for beta/gamma in water corresponding to a 4 mrem/yr dose (C4 mrem/yr) from *Soil Screening Guidance for Radionuclides: User's Guide*, EPA/540-R-00-007, U.S. Environmental Protection Agency, Office or Radiation and Indoor Air, Washington D.C.

[b]Per Table 2-2, DOE/RL-96-17, *Remedial Design Report / Remedial Action Work Plan for the 100 Area* , Rev. 5, November 2004.

[c]From *State of Washington Department of Health Interim Regulatory Guidance: Hanford Guidance for Radiological Cleanup*, WDOH/320-015, Rev. 1 (WDOH 1997) Washington State Department of Health, Richland, Washington.

Abbreviations:

BG = Hanford Site-Specific Background
U = Analyte not detected above detection limits. Detection limits below RAGs.
N/A = Not applicable

Appendix B

Comparison of Maximum Sample Analyses to Nonradionuclide Direct Exposure Cleanup Levels

APPENDIX B

Table B-1 compares the maximum sample analyses to the nonradionuclide direct exposure cleanup levels.

Table B-1. Comparison of Maximum Sample Analyses to Nonradionuclide Direct Exposure Cleanup Levels

Contaminant	Hanford Site Specific Background [g] (mg/kg)	RDL (mg/kg)	Direct Exposure Cleanup Levels [a] (mg/kg)		Direct Exposure Cleanup Level (mg/kg)	Maximum Results (mg/kg)
			Carcinogen	Noncarcinogen		
Metals						
Antimony	5 [b]	0.6	N/A	32	32	2.3
Arsenic	6.5	10	0.667	24	20 [c]	U
Barium	132	2	N/A	5,600	5,600	130
Cadmium	0.81 [b]	0.5	13.9 [d]	80	13.9	0.62
Chromium, Total	18.5	1	N/A	80,000	80,000	8.4
Chromium VI	NA	0.5	2.1 [d]	400	400	0.221
Lead	10.2	5	N/A	353 [e]	353	6.1
Manganese	512	5	N/A	11,200	11,200	394
Mercury	0.33	0.2	N/A	24	24	U
Zinc	67.8	1	N/A	24,000	24,000	111
PCBs						
Polychlorinated Biphenyls [f]	NA	0.017	0.5	N/A	0.5	U

Notes:

[a] Calculated using the appropriate formulas from Ecology 1996, WAC 173-340-740, with toxicity values updated through July 2004, from the EPA Integrated Risk Information System (IRIS) at http://www.epa.gov/iris or from the Risk Assessment Information System (RAIS) database of the Oak Ridge National Laboratory (ORNL) on the Internet at http://risk.lsd.ornl.gov.

[b] Hanford Site-specific background not available. Value is from Ecology, 1994, *Natural Background Soil Metals Concentrations in Washington State*, Publication No. 94-115, Washington State Department of Ecology, Olympia, Washington.

[c] The arsenic cleanup level of 20 mg/kg has been agreed to by the Tri-Party Agreement Project Managers (the basis is documented in DOE/RL-96-17, Rev 5, 2.1.2.1).

[d] Carcinogenic cleanup level calculated based on the inhalation exposure pathway; WAC 173-340-750(3), 1996.

[e] Calculated using EPA, 1994, *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, EPA/540/R-93/081, Publication No. 9285.7, U.S. Environmental Protection Agency, Washington, D.C.

[f] The soil cleanup value for PCBs is based on the formula presented in WAC 173-340-740(3)(a)(iii)(B), Ecology 1996, and the cancer potency factor for ingestion of PCBs of 2.0 kg-day/mg (soils) from the EPA Integrated Risk Information System (IRIS) on the internet at http://www.epa.gov/iris on January 3, 2006.

[g] Unless otherwise noted, background concentrations are 90th percentile values of the log normal distribution of site-wide soil background data. Source: Hanford Site Background: Part 1 Soil Background for Nonradionuclide Analytes (DOE-RL-92-24).

Abbreviations:

BG = Hanford Site-Specific Background
N/A = Not Applicable
NA = Not Available
RDL = Required Detection Limit
U = Analyte not detected above detection limits. Detection limits below RAGs

Appendix C

Hazard Quotients and Excess Carcinogenic Risk

APPENDIX C

PURPOSE:

Provide documentation to support the calculation of the hazard quotient (HQ) and carcinogenic (excess cancer) risk values for the 216-N-1 Waste Site remedial action. In accordance with the remedial action goals (RAGs) in the *Remedial Design/Remedial Action Work Plan for 200 North Area Waste Sites located in the 200-CW-3 Operable Unit* (DOE/RL-2007-55), the following criteria must be met:

1) An HQ of <1.0 for all individual noncarcinogens
2) A cumulative HQ of <1.0 for noncarcinogens
3) An excess cancer risk of $<1 \times 10^{-6}$ for individual carcinogens
4) A cumulative excess cancer risk of $<1 \times 10^{-5}$ for carcinogens

GIVEN/REFERENCES:

DOE/RL-2007-55, *Remedial Design/Remedial Action Work Plan for 200 North Area Waste Sites located in the 200-CW-3 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code*, 1996.

SOLUTION:

1) Calculate an HQ for each noncarcinogenic constituent detected above background and compare it to the individual HQ of <1.0 (DOE/RL-2007-55).

2) Sum the HQs and compare to the cumulative HQ criterion of <1.0.

3) Calculate an excess cancer risk value for each carcinogenic constituent detected above background and compare it to the individual excess cancer risk criterion of $<1 \times 10^{-6}$ (DOE/RL-2007-55).

4) Sum the excess cancer risk values and compare to the cumulative cancer risk criterion of $<1 \times 10^{-5}$.

METHODOLOGY:

Hazard quotient and carcinogenic risk calculations were computed using the data from Appendix G, Table G-2. Of the contaminants of concern listed in Appendix G, Table G-2, zinc and hexavalent chromium requires the HQ and risk calculations because these analytes were detected above the Hanford Site background value. An explanation of the HQ and risk calculations is presented in the following.

1) For example, the maximum value for zinc is 111 mg/kg, divided by the RAG value of 24,000 mg/kg, is 0.0046. The maximum value for hexavalent chromium is 0.221 mg/kg, divided by the RAG value of 240 mg/kg, is 0.00092. Comparing these values to the requirement <1.0, this criteria is met.

2) After the HQ calculations are completed for the appropriate analytes, the cumulative HQ is obtained by summing the individual values. Comparing this value to the requirement of <1.0.

3) To calculate the excess cancer risk, the maximum value is divided by the carcinogenic RAG value, then multiplied by 1×10^{-6}. Three constituents in the COC list are carcinogens: arsenic, cadmium and hexavalent chromium. Because results for arsenic indicate undetectable amounts and results for

cadmium indicate results below background in the sampled soil, the cumulative excess cancer risk is not applicable. Results for hexavalent chromium showed levels that are detectable. There is no background value for hexavalent chromium thus the risk is evaluated below.

RESULTS:

1) List individual noncarcinogens and corresponding HQs >1.0: None.
2) List the cumulative noncarcinogenic HQ >1.0: None.
3) List individual carcinogens and corresponding excess cancer risk >1 x 10^{-6}: None.
4) List the cumulative excess cancer risk for carcinogens >1 x10^{-5}: None.

Table C-1 shows the results of the calculation:

Table C-1. Hazard Quotient and Excess Cancer Risk Results

Contaminants of Concern	Maximum Value [a] (mg/kg)	Noncarcinogen RAG [b] (mg/kg)	Hazard Quotient	Carcinogen RAG (mg/kg)	Carcinogen Risk
Metals					
Chromium (VI)	0.221	240	0.00092	2.2	1.00×10^{-7}
Zinc	111	24,000	0.0046	NA	NA
Totals					
Cumulative Hazard Quotient:			**0.00552**		
Cumulative Excess Cancer Risk:					**1.00×10^{-7}**

Notes:
[a] From Appendix G, Table G-2.
[b] Value obtained from Washington Administrative Code (WAC) 173-340-740(3), Method B, 1996, unless otherwise noted.

Abbreviations:
N/A = Not Applicable
RAG = Remedial Action Goal

CONCLUSION:

This calculation demonstrates that the 216-N-1 Waste Site meets the requirements for the hazard quotients and carcinogenic (excess cancer) risk as identified in RD/RAWP (DOE/RL-2007-55).

Appendix D

Comparison of Maximum Sample Analyses to Soil Activities Calculated by RESRAD to be Protective of 100 Area Groundwater

APPENDIX D

Table D-1 shows the comparison of the maximum sample analyses to the soil activities calculated by RESRAD.

Table D-1. Comparison of Maximum Sample Analyses to Soil Activities Calculated by RESRAD to be Protective of 100 Area Groundwater

Radionuclide	Groundwater MCL [a] (pCi/L)	Soil Concentration Protective of Groundwater [b] (pCi/g)	Maximum Results (pCi/g)
Americium-241	1.2	1,577,000	U
Cesium-137	60	NA [c]	2.25
Cobalt-60	100	NA [c]	U
Europium-152	200	NA [c]	0.516
Europium-154	60	NA [c]	U
Europium-155	600	NA [c]	U
Nickel-63	50	NA [c]	U
Plutonium-238	1.6	1,123	U
Plutonium-239/240	1.2	718,600	0.127
Strontium-90	8	NA [c]	U
Technetium-99	900	15	U
Thorium-232	2	NA [c]	0.451 (<BG)
Tritium (H-3)	20,000	35.5	U
Uranium-233/234	21.2	1.1 [d]	0.862 (<BG)
Uranium-235	21.2	1.0	U
Uranium-238	21.2	1.1 [d]	0.693 (<BG)

Notes:

[a] MCL = Maximum contaminant level calculated from National Bureau of Standards (NBS Handbook 69) maximum permissible concentration (MPC) as cited in EPA/540-R-00-007, the RAG from the RD/RAWP (DOE/RL-2007-55), or the MCL from 40 CFR 141.66.

[b] From DOE/RL-2007-55, Remedial Design/Remedial Action Work Plan for 200 North Area Waste Sites Located in the 200-CW-3 Operable Unit.

[c] RESRAD predicts constituent will not reach groundwater within 1,000 years based on 100 Area generic site model using soil column layers and depths.

[d] The calculated soil concentration cleanup level of 0.185 pCi/g is below the Hanford Specific Background Activity of 1.1 pCi/g. Therefore the soil concentration protection of groundwater defaults to 1.1 pCi/g.

Abbreviations:

BG = Hanford Site-Specific Background
U = Analyte not detected above detection limits. Detection limits below RAGs.

Appendix E

Summary of Comparison of Maximum Sample Analyses to 100 Area Nonradionuclide Cleanup Levels for Protection of Groundwater and the Columbia River

APPENDIX E

Table E-1 provides a comparison of the maximum sample analyses to the 100 Area nonradionuclide cleanup levels established to protect groundwater and the Columbia River.

Table E-1. Summary of Comparison of Maximum Sample Analyses to 100 Area Nonradionuclide Cleanup Levels for Protection of Groundwater and the Columbia River

Contaminant	Soil Cleanup Levels (mg/kg)		Maximum Results (mg/kg)
	Protective of Groundwater	Protective of the Columbia River	
Metals			
Antimony	6.0 [a]	6.0 [a]	2.3
Arsenic	6.5 [b]	6.5 [b]	U
Barium	NA [c]	NA [c]	130
Cadmium	NA [c]	NA [c]	0.62
Chromium, Total	NA [c]	NA [c]	8.4
Chromium (VI)	8.0	2.2	0.221
Lead	NA [c]	NA [c]	6.1
Manganese	NA [c]	NA [c]	394
Mercury	NA [c]	NA [c]	U
Zinc	NA [c]	NA [c]	111
PCBs			
Polychlorinated Biphenyl	NA [c]	NA [c]	U

Notes:

[a] The remedial action goal is below the practical quantitation limit (PQL). The value presented is the PQL.

[b] The remedial action goal is below background. The value presented is background.

[c] The RESRAD model predicts the contaminant will not reach the groundwater within a 1,000 year time frame (DOE/RL-2007-55, Table 2-1).

Abbreviations:

NA = Not Applicable

U = Analyte not detected above detection limits. Detection limits below RAGs

Appendix F

Pre-Remediation Waste Characterization and Conceptual Model Verification Sampling Data Summary

APPENDIX F

This appendix provides a data summary of the pre-remediation waste characterization and conceptual model verification sampling data (Table F-1 and F-2).

Figure F-1. 216-N-1 Investigative Sampling Location

NOTE: Field work was performed based on investigative sample data and historical knowledge, with consideration of potential radiological and hazardous contaminant concerns. Field screening of potential contaminants confirmed planning assumptions and ensured protection of personnel.

Table F-1. Pre-Remediation Investigative Results for Shallow Zone 216-N-1 Sample Locations for Radionuclide COCs

COCs	Look-Up Values Summary Remedial Action Goal – Shallow Zone[<4.6 Meters (15 Feet)] (pCi/g)	Hanford Specific Background Activity (pCi/g)	HEIS# B20L90 Sample Location #1 2.1-2.4 Meter (7-8 Foot) Depth (pCi/g)	HEIS # B20L91 Sample Location #1 2.1-2.4 Meter (7-8 Foot) Depth Duplicate (pCi/g)	HEIS #B20L92 Sample Location #1 4.6-Meter (15-Foot) Depth (pCi/g)	HEIS# B20L97 Sample Location #7 0.3-0.9 Meter (1-3-Foot) Depth (pCi/g)	HEIS# B20L98 Sample Location #7 4.6 Meter (15 Foot) Depth (pCi/g)	HEIS# B20L99 Sample Location #8 0.3-0.9 m (1-3-Foot) Depth (pCi/g)	HEIS #B20LB0 Sample Location #8 4.6 Meter (15-Foot) Depth (pCi/g)	HEIS #B20L93 Sample Location #2 3-Meter (10-Foot) Depth (pCi/g)	HEIS #B20L94 Sample Location #2 4.6-Meter (15-Foot) Depth (pCi/g)	HEIS #B20V99 Sample Location #3 1.5-Meter (5-Foot) Depth (pCi/g)	HEIS #B20VB0 Sample Location #3 4.6-Meter (15-Foot) Depth (pCi/g)
Americium-241	31.1	NA	0.561	0.612	U	U	U	U	U	U	0.0470	0.0480	0.0780
Cesium-137	6.2	1.1	56.0	48.9	0.674	U	U	0.0423	U	2.80	2.10	U	U
Cobalt-60	1.4	0.008	0.00391	U	U	U	U	U	U	U	U	U	U
Europium-152	3.3	NA	1.16	1.15	0.0763	U	U	U	U	0.531	U	U	U
Europium-154	3.0	0.033	U	U	U	U	U	U	U	U	U	U	U
Europium-155	125	0.054	U	U	U	U	U	U	U	U	U	U	U
Nickel-63	4,026	NA	U	U	U	U	U	U	U	U	U	U	U
Plutonium-238	37.4	0.004	U	0.150	U	U	U	U	U	U	U	U	U
Plutonium-239/240	33.9	0.025	5.00	5.40	0.0750	0.0130	U	U	U	0.0910	0.0260	U	U
Strontium-90	4.5	0.18	2.20	1.90	U	U	U	U	U	U	U	0.460	U
Technetium-99	15[b]	NA	U	U	U	U	U	U	U	U	U	U	U
Thorium-232[d]	1.3	1.3	0.280	0.336	0.233	0.319	0.252	0.319	0.329	0.296	0.261	0.303	0.320
Tritium (H-3)	35.5	NA	U	U	U	U	U	U	U	U	U	U	U
Uranium-233/234	1.1[c]	1.1	0.240	0.200	0.150	0.160	0.130	0.130	0.130	0.170	0.150	0.140	0.160
Uranium-235	1.0[b]	0.11	U	0.0120	U	U	0.150	0.0170	0.0170	U	U	0.00750	U
Uranium-238	1.1[c]	1.1	0.230	0.210	0.150	0.120	0.120	0.110	0.130	0.170	0.180	0.120	0.130

[a] In the shallow zone, cleanup must achieve the direct exposure remedial action objectives (RAO) and the groundwater/Columbia River RAO; therefore, the lowest value among the "protection from Direct Exposure," "Protective of Groundwater," and "Protective of the Columbia River" values is the applicable look-up value.
[b] The remedial action goal is below the practical quantitation limit (PQL). The value presented is the PQL.
[c] The remedial action goal is below background. The value presented is background.
[d] Thorium conversion:

1 mg/kg = 1 µg/g
Th-232 Specific Activity – 1.09E-07 Ci/g*
pCi/g = (Result µg/g)(SpA Ci/g)(1 g/10^6 µg)(10^{12} pCi/1 Ci)
**Handbook of Health Physics and Radiological Health*, Bernard Shleien, Lester A. Slaback, Jr., and Brian Kent Birky, 1998, Williams and Wilkins Co.

U = Analyte was not detected above limiting criteria
NA = Not Available
HEIS = Hanford Environmental Information System

Soil samples	Test Results	Converted Test Results
W090000210/B20L90	2.55 mg/kg	0.280 pCi/g
W090000211/B20L91	3.06 mg/kg	0.336 pCi/g
W090000212/B20L92	2.12 mg/kg	0.233 pCi/g
W090000221/B20L97	2.91 mg/kg	0.319 pCi/g
W090000222/B20L98	2.30 mg/kg	0.252 pCi/g
W090000220/B20L99	2.91 mg/kg	0.319 pCi/g
W090000223/B20LB0	3.00 mg/kg	0.329 pCi/g
W090000230/B20L93	2.70 mg/kg	0.296 pCi/g
W090000231/B20L94	2.38 mg/kg	0.261 pCi/g
W090000246/B20V99	2.76 mg/kg	0.303 pCi/g
W090000247/B20LB0	2.92 mg/kg	0.320 pCi/g

Table F-2. Pre-Remediation Investigative Results for Shallow Zone 216-N-1 Sample Locations for Nonradionuclide COCs

COCs	Look-Up Values Summary Remedial Action Goal – Shallow Zone[<4.6 Meters (15 Feet)][a] (mg/kg)	Hanford Specific Background Activity (mg/kg)	HEIS# B20L90 Sample Location #1 2.1-2.4 Meter (7-8-Foot) Depth (mg/kg)	HEIS #B20L91 Sample Location #1 2.1-2.4 Meter (7-8-Foot) Depth Duplicate (mg/kg)	HEIS #B20L92 Sample Location #1 4.6-Meter (15-Foot) Depth (mg/kg)	HEIS #B20L97 Sample Location #7 0.3-0.9 Meter (1-3-Foot) Depth (mg/kg)	HEIS #B20L98 Sample Location #7 4.6 Meter (15 Foot) Depth (mg/kg)	HEIS #B20L99 Sample Location #8 0.3-0.9 Meter (1-3-Foot) Depth (mg/kg)	HEIS #B20LB0 Sample Location #8 4.6 Meter (15-Foot) Depth (mg/kg)	HEIS #B20L93 Sample Location #2 3-Meter (10-Foot) Depth (mg/kg)	HEIS #B20L94 Sample Location #2 4.6 Meter (15-Foot) Depth (mg/kg)	HEIS #B20V99 Sample Location #3 1.5-Meter (5-Foot) Depth (mg/kg)	HEIS #B20VB0 Sample Location #3 4.6-Meter (15-Foot) Depth (mg/kg)
Antimony	6.0[b]	5[d]	0.38	0.440	U	U	U	U	U	U	U	U	U
Arsenic	6.5[c]	6.5	4.35	3.90	3.33	2.67	3.03	3.83	5.20	5.24	3.70	2.85	5.51
Barium	5,600	132	75.5	85.9	54.3	99.0	50.7	64.8	51.1	60.8	52.8	66.7	59.0
Cadmium	80	0.81[d]	0.420	0.360	U	0.110	U	U	U	0.150	0.100	U	U
Chromium (III)[e]	80,000	18.5	62.2	56.7	6.45	6.92	3.38	6.76	5.93	7.01	4.14	7.65	6.35
Chromium (VI)	2.2	NA	0.700	0.700	U	U	U	U	U	U	U	U	U
Lead	353	10.2	106	80.9	6.66	4.42	3.98	5.17	5.39	7.08	4.00	4.63	5.51
Manganese	11,200	512	331	339	329	326	309	360	360	329	308	300	362
Mercury	24	0.33	U	U	U	U	U	U	U	U	U	U	U
Zinc	24,000	67.8	140	136	55	36.3	44.2	43.3	41.8	97.7	70.5	36.6	44.1
Polychlorinated Biphenyl	0.5	NA	U	U	U	U	U	U	U	U	U	U	U

Notes:

[a] In the shallow zone, cleanup must achieve the direct exposure remedial action objectives (RAO) and the groundwater/Columbia River RAO; therefore, the lowest value among the "protection from Direct Exposure," "Protective of Groundwater," and "Protective of the Columbia River" values is the applicable look-up value.

[b] The remedial action goal is below the practical quantitation limit (PQL). The value presented is the PQL.

[c] The remedial action goal is below background. The value presented is background.

[d] Hanford-specific background not available; therefore values were taken from *Natural Background Soil Metals Concentrations in Washington State*, Publication No. 94-115, Washington State Department of Ecology, Olympia, Washington (Ecology 1994).

[e] The Chromium (III) result was obtained by subtracting the Chromium (IV) result from the Total Chromium result.

Abbreviations:

NA = Not Available
U = Analyzed for but not detected above limiting criteria
HEIS = Hanford Environmental Information System

Appendix G

Post-Remediation Waste Characterization and Conceptual Model Sampling Data Summary

APPENDIX G

This appendix provides a data summary of the post-remediation waste characterization and conceptual model verification sampling data (Table G-1 and G-2).

Figure G-1. 216-N-1 Verification Sampling Locations

NOTE: Field work was performed based on investigative sample data and historical knowledge, with consideration of potential radiological and hazardous contaminant concerns. Field screening of potential contaminants confirmed planning assumptions and ensured protection of personnel.

Figure G-2. 216-N-1 Verification Depth Sampling

NOTE: Fieldwork was performed based on investigative sample data and historical knowledge, with consideration of potential radiological and hazardous contaminant concerns. Field screening of potential contaminants confirmed planning assumptions and ensured protection of personnel.

Table G-1. 216-N-1 Verification Sampling Radiological Results

Contaminant of Concern	Remedial Action Goal – Shallow Zone [<4.6 m (15 ft)][a] pCi/g	Hanford Specific Background Activity[d] pCi/g	Required Detection Limit [e] pCi/g	Laboratory Minimum Detection Limit pCi/g	HEIS# B23WM1 V-1 Surface pCi/g	HEIS# B23WM2 V-2 Surface pCi/g	HEIS# B23WM3 V-3 Surface pCi/g	HEIS# B23WM4 V-4 Surface pCi/g	HEIS# B23WM5 V-5 Surface pCi/g	HEIS# B23WM6 V-2 Surface Duplicate pCi/g	HEIS# B23WP4 V-1 15 ft pCi/g	HEIS# B23WP5 V-2 15 ft pCi/g	HEIS# B23WP6 V-3 15 ft pCi/g	HEIS# B23WP7 V-4 15 ft pCi/g	HEIS# B23WP8 V-5 15 ft pCi/g	HEIS# B23WL9 Equipment Blank pCi/g
Americium-241	31.1	NA	1	0.393	U	U	U	U	U	U	U	U	U	U	U	U
Cesium-137	6.2	1.1	0.05	0.111[f]	0.629	0.824	0.426	1.84	0.366	2.25	0.909	0.873	1.72	U	U	U
Cobalt-60	1.4	0.008	0.05	0.09[f]	U	U	U	U	U	U	U	U	U	U	U	U
Europium-152	3.3	NA	0.1	0.25[f]	U	U	U	0.516	U	U	U	U	U	U	U	U
Europium-154	3	0.033	0.1	0.282[f]	U	U	U	U	U	U	U	U	U	U	U	U
Europium-155	125	0.054	0.1	0.203[f]	U	U	U	U	U	U	U	U	U	U	U	U
Nickel-63	4,026	NA	30	2.78	U	U	U	U	U	U	U	U	U	U	U	U
Plutonium-238	37.4	0.004	1	0.184	U	U	U	U	U	U	U	U	U	U	U	U
Plutonium-239/240	33.9	0.025	1	0.184	0.127	0.074	0.035	0.063	0.034	0.103	U	0.110	U	U	U	U
Strontium-90	4.5	0.18	1	0.338	U	U	U	U	U	U	U	U	U	U	U	U
Technetium-99	15[e]	NA	1	0.452	U	U	U	U	U	U	U	U	U	U	U	U
Thorium-232	1.3	1.3	1	0.293	U	0.328	0.424	0.451	0.421	0.359	U	0.426	0.365	U	0.369	U
Tritium (H-3)	35.5	NA	30	7.94	U	U	U	U	U	U	U	U	U	U	U	U
Uranium-233/234	1.1[f]	1.1	1	0.239	0.454	0.515	0.652	0.496	0.862	0.604	0.573	0.397	0.394	0.431	0.422	U
Uranium-235	1.0[e]	0.11	1	0.289	U	U	U	U	U	U	U	U	U	U	U	U
Uranium-238	1.1[f]	1.1	1	0.239	0.606	0.365	0.693	0.496	0.431	0.479	0.397	0.430	0.415	0.496	0.511	0.000084

Notes:

[a] In the shallow zone, cleanup must achieve the direct exposure remedial action objectives (RAO) and the groundwater/Columbia River RAO; therefore, the lowest value among the "protection from Direct Exposure," "Protective of Groundwater," and "Protective of the Columbia River" values is the applicable look-up value.

[b] The remedial action goal is below the practical quantitation limit (PQL). The value presented is the PQL.

[c] The remedial action goal is below background. The value presented is background.

[d] Unless otherwise noted, background concentrations are 90th percentile values of the log normal distribution of the site-wide solid background data.

[e] Detection limits are taken from DOE/RL-2007-54 unless otherwise noted.

[f] Laboratory minimum detection limit is above detection limit required by DOE/RL-2007-54. Both detection limits are below RAG.

Abbreviations:

U = Analyzed for but not detected above laboratory Method Detection Limit (MDL).HEIS=Hanford Environmental Information System

NA=Not Available

Table G-2. 216-N-1 Verification Sampling Non-Radiological Results

Contaminant of Concern	Remedial Action Goal – Shallow Zone[a]	Hanford Specific Background Concentration[e]	Required Detection Limit[f]	Laboratory Minimum Detection Limit	HEIS# B23WM1 V-1 Surface	HEIS# B23WM2 V-2 Surface	HEIS# B23WM3 V-3 Surface	HEIS# B23WM4 V-4 Surface	HEIS# B23WM5 V-5 Surface	HEIS# B23WM6 V-2 Surface Duplicate	HEIS# B23WP4 V-1 15 ft	HEIS# B23WP5 V-2 15 ft	HEIS# B23WP6 V-3 15 ft	HEIS# B23WP7 V-4 15 ft	HEIS# B23WP8 V-5 15 ft	HEIS# B23WL9 Equipment Blank
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Antimony	6.0[b]	5[d]	0.6	0.23	1.4	1.6	1.6	2.0	1.1	1.7	2.3	1.7	1.7	1.8	2.1	U
Arsenic	6.5[c]	6.5	0.5	3.6[g]	U	U	4.0	U	U	U	U	U	U	U	U	U
Barium	5,600	132	0.2	0.28[g]	75.7	70.2	75.6	64.4	68.0	61.7	130	58.2	45.9	50	49.5	0.00292
Cadmium	80	0.81[d]	0.1	0.057	0.57	0.59	0.59	0.62	0.52	0.54	0.57	0.52	0.47	0.58	0.62	U
Chromium Total	80,000	18.5	1	0.35	6.7	7.2	8.3	8.2	6.9	8.4	3.6	5.4	3.5	3.3	5.6	U
Chromium (VI)	2.2	NA	0.5	0.154	U	0.221	U	0.218	0.199	0.195	U	U	U	U	U	U
Lead	353	10.2	0.5	2[g]	4.8	3.5	4.7	6.1	4.4	3.9	3.1	5.3	2.5	3.0	3.3	0.000228
Manganese	11,200	512	0.5	0.17	340	300	394	384	362	331	354	354	306	336	389	0.0125
Mercury	24	0.33	0.05	0.0057	U	U	U	U	U	U	U	U	U	U	U	U
Zinc	24,000	67.8	1	2.2[g]	58.1	61.6	68.0	111	59.9	66.3	90.4	68.7	88.4	69.8	65.1	0.00285
Polychlorinated Biphenyls	0.5	NA	0.5	0.0037	U	U	U	U	U	U	U	U	U	U	U	U

Notes:

[a] In the shallow zone, cleanup must achieve the direct exposure remedial action objectives (RAO) and the groundwater/Columbia River RAO; therefore, the lowest value among the "protection from Direct Exposure," "Protective of Groundwater," and "Protective of the Columbia River" values is the applicable look-up value.

[b] The remedial action goal is below the practical quantitation limit (PQL). The value presented is the PQL.

[c] The remedial action goal is below background. The value presented is background.

[d] Hanford-specific background not available; therefore values were taken from Natural Background Soil Metals Concentrations in Washington State, Publication No. 94-115, Washington State Department of Ecology, Olympia, Washington (Ecology 1994).

[e] Unless otherwise noted, background concentrations are 90th percentile values of the log normal distribution of the site-wide solid background data. Source: Hanford Site Background: Part 1 Soil Background for Nonradionuclide Analytes (DOE/RL-92-24).

[f] Detection limits are taken from DOE/RL-2007-54 unless otherwise noted.

[g] Laboratory minimum detection limit is above detection limit required by DOE/RL-2007-54. Both detection limits are below RAG.

Abbreviations:

HEIS = Hanford Environmental Information System
NA = Not Available
U = Analyzed for but not detected above laboratory Method Detection Limit (MDL)