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Baseline Environmental Analysis Report for the K-1251 Barge Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee

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Baseline Environmental Analysis Report for the K-1251 Barge Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee

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BECHTEL JACOBS COMPANY LLC
managing the
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for the
U. S. DEPARTMENT OF ENERGY

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The results of this report are based on record reviews, site reconnaissance, interviews, and the radiological report reviewed and approved by BJC. SAIC has not made, nor has it been asked to make, any independent investigation concerning the accuracy, reliability, or completeness of such information.

All sources of information on which SAIC has relied in making its conclusions are identified in Chap. 7 of this report. Any information, regardless of its source, not listed in Chap. 7 has not been evaluated or relied upon by SAIC in the context of this report.

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ABBREVIATIONS

bgs	below ground surface
BJC	Bechtel Jacobs Company LLC
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cm^2	square centimeters
COE	U. S. Army Corps of Engineers
cpm	counts per minute
CROET	Community Reuse Organization of East Tennessee
DCGL	derived concentration guideline level
DOE	U. S. Department of Energy
dpm	disintegrations per minute
ELCR	excess lifetime cancer risk
EPA	U. S. Environmental Protection Agency
ESU	exterior survey unit
ETTP	East Tennessee Technology Park
HI	hazard index
HQ	hazard quotient
LSU	land survey unit
NaI	sodium iodide
OREIS	Oak Ridge Environmental Information System
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORO	Oak Ridge Office
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
PRG	preliminary remediation goal
RADCON	Radiological Control (Organization)
RCRA	Resource Conservation and Recovery Act of 1976
RL	remediation level
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SVOC	semivolatile organic compound
TVA	Tennessee Valley Authority
UF_6	uranium hexafluoride
VOC	volatile organic compound

EXECUTIVE SUMMARY

This report documents the baseline environmental conditions of the U. S. Department of Energy's (DOE's) K-1251 Barge Facility, which is located at the East Tennessee Technology Park (ETTP). DOE is proposing to lease the facility to the Community Reuse Organization of East Tennessee (CROET). This report provides supporting information for the use, by a potential lessee, of government-owned facilities at ETTP. This report is based upon the requirements of Sect. 120(h) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

The lease footprint is slightly over 1 acre. The majority of the lease footprint is defined by a perimeter fence that surrounds a gravel-covered area with a small concrete pad within it. Also included is a gravel drive with locked gates at each end that extends on the east side to South First Avenue, providing access to the facility. The facility is located along the Clinch River and an inlet of the river that forms its southern boundary. To the east, west, and north, the lease footprint is surrounded by DOE property.

Preparation of this report included the review of government records, title documents, historic aerial photos, visual and physical inspections of the property and adjacent properties, and interviews with current and former employees involved in the operations on the real property to identify any areas on the property where hazardous substances and petroleum products or their derivatives and acutely hazardous wastes were known to have been released or disposed. Radiological surveys were conducted and chemical samples were collected to assess the facility's condition. The following is a summary of the findings of the evaluation that was performed:

- The primary historical use of the K-1251 Barge Facility was for the storage and transfer of uranium hexafluoride (UF_6) cylinders for or from barge transport. The facility began operating in 1953. It was removed from operation in the early 1990s, and all equipment (e.g., a crane) was removed in 1995. The facility is currently inactive.

- Although it is known that UF_6 cylinders were stored and transferred at the facility, information regarding duration of storage and specific quantities of the chemicals that were stored or transferred is not available. Although the chemical compound UF_6 is not listed as a hazardous substance in 40 *Code of Federal Regulations* (*CFR*) 302.4, the component radionuclides of this chemical compound are included and are subject to reportable quantity (RQ) reporting. Historical information does not indicate that any releases occurred.

- Radiological surveys of the lease footprint have been conducted. The data were analyzed to determine whether any residual contamination was present and might exceed the derived concentration guideline level established for each of the survey units. Survey results show that the K-1251 Barge Facility had no areas of elevated residual radioactivity present above DOE surface contamination limits [i.e., 1,000 disintegrations per minute (dpm)/100 cm^2 for removable alpha and beta-gamma and 5000 dpm/100 cm^2 for total alpha and beta-gamma].

- K-1251 is not located within ETTP Zones 1 or 2, which were established to address the potentially impacted areas of ETTP (DOE 2002); thus, no cleanup levels have been established for areas outside of Zones 1 or 2, which includes the area occupied by K-1251. However, for comparison purposes, Zone 1 remediation levels (RLs) have been used for screening analytical results for soils and concrete at K-1251.

- In 2007, surface and subsurface soil samples were collected from three locations, and two samples were collected from the surface of the concrete pad. The purpose of the sampling was to determine whether any contamination was present due to potential historical releases from the UF_6 cylinders or whether historical releases of hydraulic fluids, lubricating oils, or fuels from operation and maintenance of a large crane used to move the cylinders occurred. Analysis was conducted for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), radionuclides, metals, and polychlorinated biphenyls (PCBs).

- Soil samples from the lease footprint and concrete core samples from the pad in the lease footprint identified VOCs, SVOCs, PCBs, metals, and radionuclides in the soil samples collected from the lease footprint, and PCBs were detected in the samples collected of the concrete pad. Radiological constituents ^{137}Cs, ^{60}Co, ^{239}Pu, ^{226}Ra, ^{230}Th, ^{234}U, ^{235}U, and ^{238}U were detected above background levels in some samples.

- Preliminary remediation goals (PRGs) calculated at the 1E-5 excess lifetime cancer risk (ELCR) or the 1.0 hazard quotient (HQ) levels have been established for the site for screening purposes. Only Cs^{137} exceeded the PRGs calculated at the 1E-5 ELCR level.

- Evaluation of soil and concrete samples from the lease footprint indicates no exceedances of the Zone 1 RLs.

- The U. S. Environmental Protection Agency has established a generally acceptable target risk range of E-04 to E-06 (also expressed as 10^{-4} to 10^{-6}) and a generally acceptable hazard index (HI) of 1. The screening-level risk estimate for the study area soils in the K-1251 Barge Facility footprint indicated that the cumulative risks did not exceed the generally acceptable target risk range of E-04 to E-06 (also expressed as 10^{-4} to 10^{-6}) or an HI above 1; therefore, a full risk calculation was not conducted. The risk screening was considered indicative of the low likelihood of adverse health effects associated with worker exposure.

- Because the radiological survey and all sampling results were below established limits such as RLs, and because the risk screen indicated a low likelihood of adverse health effects associated with exposure to the lease space, the subject facility is suitable for lease.

1. PROPERTY IDENTIFICATION

The area discussed in this baseline environmental analysis report is located in the southern portion of the East Tennessee Technology Park (ETTP) [formerly the Oak Ridge Gaseous Diffusion Plant (ORGDP) or K-25 Site] on the Oak Ridge Reservation (ORR) in Roane County, Tennessee. It includes the K-1251 Barge Facility, including its access road. Figure 1.1 shows the location of the proposed lease footprint, and Fig. 1.2 designates the boundary of the footprint. Figures 1.3 and 1.4 are aerial photographs of the K-1251 Barge Facility site circa 1998 and 2000, respectively.

The lease footprint is slightly over 1 acre. The majority of the lease footprint is defined by a perimeter fence that surrounds a gravel-covered area with a small concrete pad within it. Also included is a gravel drive with locked gates at each end that extends on the east side of the facility to South First Avenue, providing access to the facility. The facility is located along the Clinch River and an inlet of the river that forms its southern boundary.

Past and present operations at the former K-1251 Barge Facility are described in more detail in Chap. 4 of this report.

Preparation of this report included a detailed search of government records, title documents, and historic aerial photos; visual and physical inspections of the property and adjacent properties; and interviews with current and former employees involved in the operations on the real property to identify any areas on the property where hazardous substances and petroleum products or their derivatives were known to have been released or disposed.

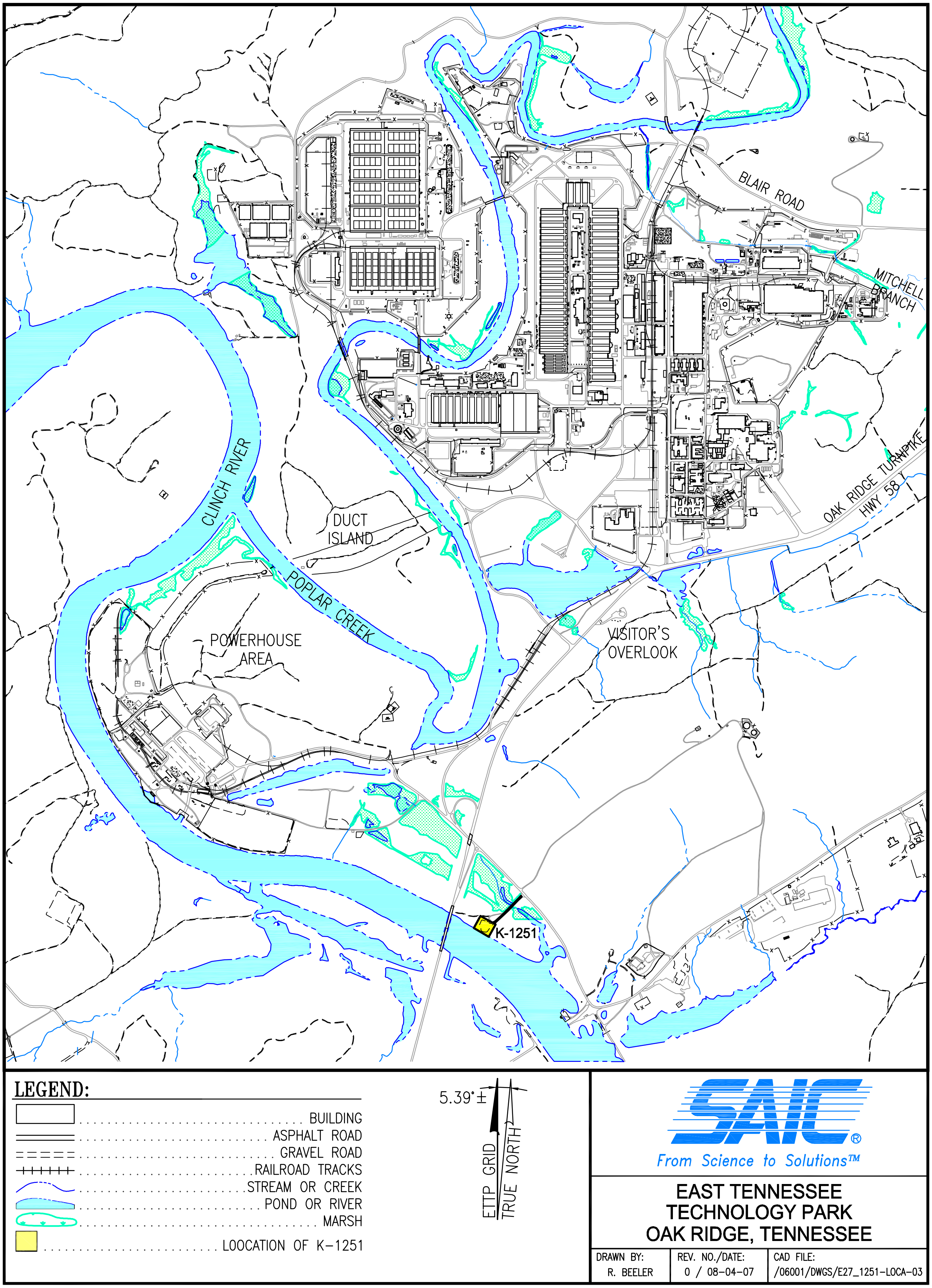

Fig. 1.1. Location of the K-1251 Barge Facility within ETTP.

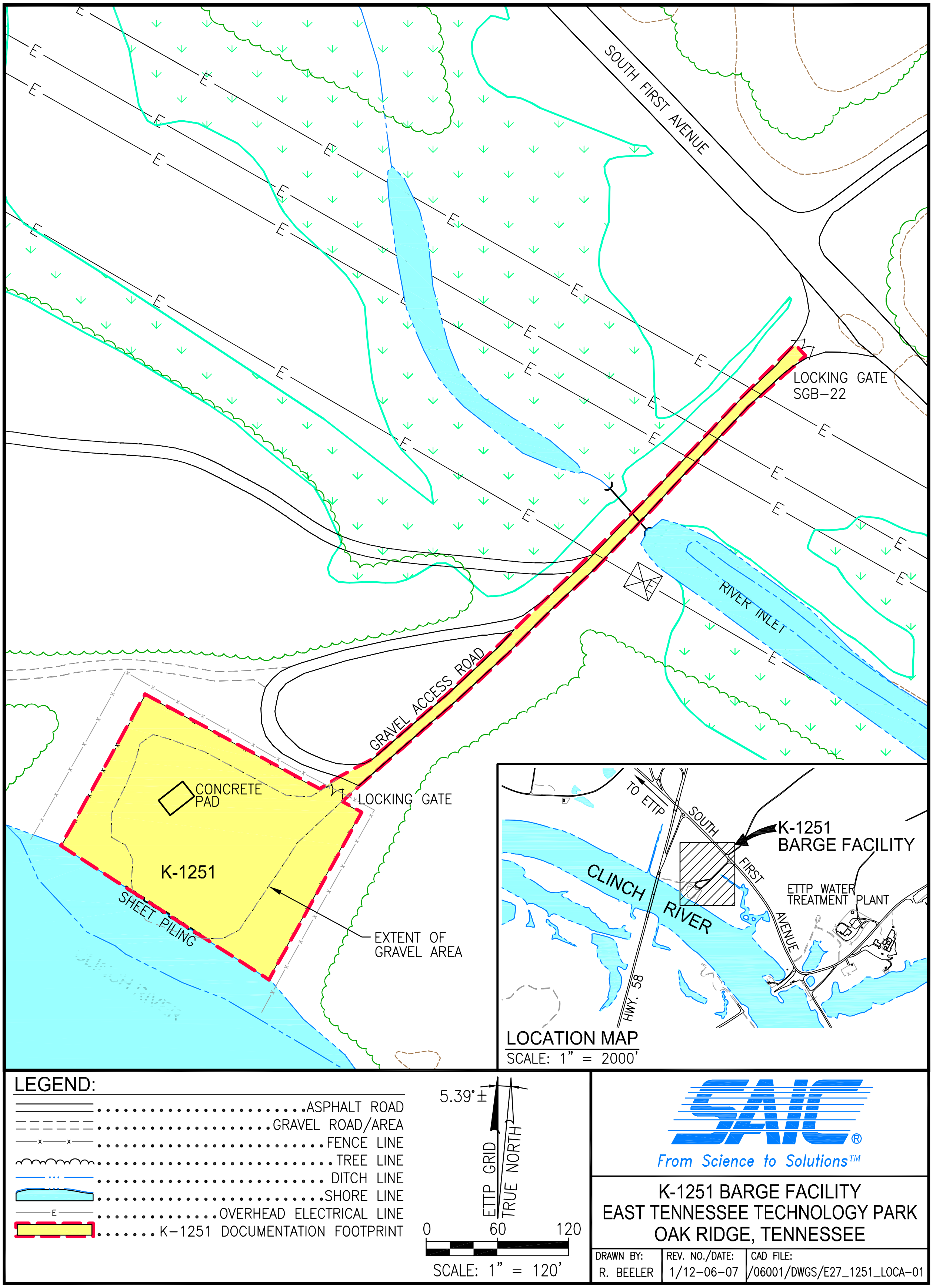

Fig. 1.2. Lease footprint for the K-1251 Barge Facility.

Fig. 1.3. Aerial photograph of the K-1251 Barge Facility (circa 1998).

Fig. 1.4. Aerial photograph of the K-1251 Barge Facility during TDOT construction work on the highway bridge (March 2000).

2. TITLE SEARCH

On August 29, 2007, a visit was made to the state of Tennessee Roane County Register of Deeds office to conduct a review of the recorded deeds documenting previous ownership of the land tract H-738 where the K-1251 Barge Facility is located. The deeds contained no information or references to other recorded evidence that, prior to U. S. Department of Energy (DOE) ownership, the property was utilized for the storage of hazardous substances and/or petroleum products or their derivatives. Additionally, no information contained in the deeds would indicate that hazardous substances and/or petroleum products or their derivatives were released from or disposed of on the property. Prior to acquisition by the government, the area was farmland and was a combination of cultivated fields, pastures, and forested areas.

The deeds that conveyed the property from the previous owner to the U. S. Government, and deeds that conveyed the property to that previous owner, were reviewed as a part of the title search. Generally, the deeds from the previous two owners of a particular ORR parcel provide information that goes back to the early 1900s or even earlier. The deeds were reviewed for any references to previous land uses (e.g., homestead, farm, school, business, etc.). Also reviewed were any easements or conveyances referenced in the deeds that might indicate that portions of the land were used for pipelines, power lines, etc. Partial disposal or acquisition conveyance deeds were also reviewed because, in some instances, the land comprising a large farm had been acquired via several separate acquisitions.

In addition, property assessment records from the County Property Assessor's Office were reviewed because these documents may also contain evidence of a particular land use. Survey or subdivision maps referenced in deeds and maintained in the Register of Deeds office were also reviewed for any indications of a previous land use. Furthermore, because the Tennessee Valley Authority (TVA) was the previous owner of several large tracts of ORR land, land acquisition maps prepared by the TVA were also reviewed for prior land use. The U. S. Army Corp of Engineers (COE) was another source of information that was contacted.[1]

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[1] Energy Systems 1996. *Real Estate Section of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sect. 120(h) Review*, authored by W. W. Teer, Jr., Real Estate Manager, Lockheed Martin Energy Systems, Inc., Oak Ridge, TN, August 9, 1996.

3. FEDERAL RECORDS SEARCH

3.1 FEDERAL RECORDS SEARCH

In 1997, the TVA in Knoxville, Tennessee (TVA 1997), and the COE District Office in Nashville, Tennessee (COE 1997), were contacted to determine if they maintained any records reflecting past or present land use relative to the land that is now ETTP. Neither TVA nor COE had any information regarding the history of past or present land use that would indicate if hazardous substances or petroleum products or their derivatives were stored or released on the site.

Aerial photographs readily available from federal, state, and local government agencies may reflect prior use of the real property. Copies of these photographs and maps are maintained on file in the U. S. Department of Energy-Oak Ridge Office (DOE-ORO) Real Estate Office.

Aerial Photographs:

Photograph Nos. and Date	Flight By	Source
No. 130-3-9, dated 1939	Unknown	DOE-ORO, Real Estate Office
Nos. 820-2-20 through -23 and 820-3-20 through -24, dated September 25, 1942	Aero Service Corp. for Stone and Webster	DOE-ORO, Real Estate Office

These photographs, which were taken in 1939 and 1942, show that the land where the study area is located was predominantly used for agricultural purposes. Approximately 90% of the property was used in some type of agricultural pursuit, and the remaining property was wooded. A map depicting pre-World War II structures, archeological sites, and cemeteries that were present in the area of ETTP is included, in Appendix A.

A topographic map of the area, identified as Sect. A–1 of the ORR, was prepared on November 2, 1942, by Aero Services Corporation for Stone and Webster.

A real estate map (sheet 9 of 16) prepared by the U. S. Army on February 19, 1945, shows that Land Tract No. H-738 is the land tract upon which the K-1251 Barge Facility is currently located. This 1945 map and a May 1, 1958, real estate map (sheet 2 of 3) also depict the various land tracts that were purchased by the U. S. Government and upon which the water distribution system is located.

Neither the aforementioned photographs nor maps contained any information regarding the history of the past land use that would indicate that storage or releases of hazardous substances or petroleum products or their derivatives have occurred on the land where Land Tract H-738 is located. Copies of the 1942 topographic map and real estate map are maintained in the DOE-ORO Real Estate Office.

3.2 REGULATORY SUMMARY

As discussed previously, prior to ownership by DOE (and its U. S. Government predecessor agencies), the property was a combination of farmland and forest. Any DOE operations within the footprint of the K-1251 Barge Facility area occurred under DOE's own authority prior to 1984 [DOE became subject to external regulations, including the Resource Conservation and Recovery Act of 1976 (RCRA), in 1984]. Based on interviews with employees and a review of records, there was no evidence found of releases of hazardous substances or petroleum products or their derivatives that would preclude its identification as an uncontaminated parcel.

Records (containing information about spills, permits, or permit violations) and interviews with employees or former employees[2,3] do not indicate that any regulatory actions have occurred within the footprint of the K-1251 Barge Facility. Therefore, no regulatory responses have been invoked.

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[2] BJC 2004a. Personal communications with T. G. Ramsey (formerly employed at the East Tennessee Technology Park) in May.

[3] OMI 2004. Personal communications with J. E. Russell of Operations Management International in May.

4. PAST AND PRESENT ACTIVITIES

4.1 PAST AND PRESENT ACTIVITIES FOR THE REAL PROPERTY PROPOSED FOR LEASE

The former K-1251 Barge Facility is located across the Oak Ridge Turnpike from ETTP, along the Clinch River. [The facility has also been called K-1251 Barge Loading Dock and the K-1251 Barge Unloading Facilities (Stanley 1999; LMES 1997).] The K-1251 Barge Facility was constructed in 1952 and began operations in 1953. Included as part of the facilities were a 383-ft^2 metal frame and metal panel building and a large crane. The facility was removed from operation in the early 1990s. The equipment was removed and the 383-ft^2 metal building was dismantled in 1995. The facility is currently inactive. The K-1251 Barge Facility was used to transfer uranium hexafluoride (UF_6) cylinders. Barges carrying loads of UF_6 cylinders on the Clinch River were unloaded, and the cylinders were stored in an area adjacent to the riverbank. Information about the duration of storage or quantities of UF_6 stored was not available. UF_6 cylinders were transferred (i.e., moved from barges to the storage area and subsequently moved from the storage area to trucks) at the facility

4.2 PAST AND PRESENT ACTIVITIES FOR THE ADJACENT PROPERTY

The nearest non-DOE property to K-1251 is Highway 58/Oak Ridge Turnpike, which is located about 450 ft north of K-1251. At its closest point, the road is elevated above K-1251 as the turnpike crosses the Clinch River (see Figs. 1.3 and 1.4). There is no indication that activities from this non-DOE area would have contributed any contamination to the area to be leased. There are no facilities or other features in close proximity to the K-1251 Barge Facility.

5. RESULTS OF VISUAL AND PHYSICAL INSPECTIONS

5.1 VISUAL AND PHYSICAL INSPECTIONS OF THE PROPERTY FOR LEASE

K-1251 Barge Facility

The major portion of the footprint (except for the access road) is enclosed by a chain-link fence. The fenced area is mostly covered by grass except for the remains of the concrete pad located in the northern portion of the footprint. The concrete pad is broken and has small trees and shrubs growing through the cracks. The footprint is mostly level but contains some lower lying areas that could hold standing water after a rain event. The southwestern edge of the footprint borders the river and contains a barge-docking shelf.

During the visual inspection of the lease space, no other equipment or materials were present within the proposed lease footprint. Small quantities of gravel and/or asphalt rubble were observed; they are from the gravel road and laydown areas inside the fence. Scattered scrap metal pieces were also observed on the ground throughout the study area.

5.2 VISUAL AND PHYSICAL INSPECTION OF ADJACENT PROPERTY

The adjacent areas are owned by DOE and are undeveloped. No adjacent areas are known to have been used for any activities involving hazardous substances or petroleum products or their derivatives.

6. SAMPLING AND SURVEY RESULTS

Based on discussions with the U.S. Environmental Protection Agency (EPA), it has been agreed that the need to collect samples to support lease activities will be determined on a case-by-case basis. Factors such as a facility's past operational history and geographic location will be considered. In addition, the history and knowledge of activities at adjacent properties are evaluated.

Sections 6.1 and 6.2 present the results of the chemical and radiological soil sampling that was performed in the study area. Radiological survey results are discussed in Sect. 6.2.

6.1 CHEMICAL SAMPLING

This section presents and discusses the results of the chemical soil sampling that was performed in the study area. In order to meet data requirements for the risk screening, additional samples were needed to supplement the existing data for the K-1251 study area (see Sect. 6.1.1). Three soil sampling locations indicated in Fig. 6.1 were selected on a judgmental basis. In addition, two samples of the surface of the concrete pad were collected to determine the presence or absence of PCBs at the concrete pad. See Appendix B for the K-1251 soil Sampling and Analysis Plan (SAP).

This section discusses the results of the current sampling and concludes with a summary of the results. K-1251 is not located within ETTP Zones 1 or 2, which were established to address the potentially impacted area of ETTP (DOE 2002); thus, no cleanup levels have been established for areas outside of Zones 1 or 2, which includes the area occupied by K-1251. However, for comparison purposes, Zone 1 remediation levels (RLs) have been used for screening analytical results for soils and concrete at K-1251.

6.1.1 Historical Soil Samples

A search of the Oak Ridge Environmental Information System (OREIS) database showed data are available from only one historical soil sample within the K-1251 footprint. However, this sample (RAD436), collected in 1994, was quantified for radionuclides only. Thus, no historical chemical sample results are available for K-1251. The results for the historical radiological sample are discussed in Sect. 6.2.2.1.

6.1.2 2007 Soil Sampling

In August 2007, eight surface and subsurface soil samples were collected from three locations (see Fig. 6.1) at the K-1251 Barge Facility. Samples were collected in accordance with the approved K-1251 Barge Facility SAP. One sample was collected at each of the following depths at each of the three locations: 0.0 to 0.5 ft below ground surface (bgs), 0.5 to 2.0 ft bgs, and 2.0 to 10 ft bgs, with the exception of location 02 where the 0.0 to 0.5 ft bgs and 0.5 to 2.0 ft bgs depths were sampled. All samples collected from the three soil sampling locations were quantified for VOCs, SVOCs, metals, PCBs, and radionuclides (results for radiological sampling are provided in Sect. 6.2).

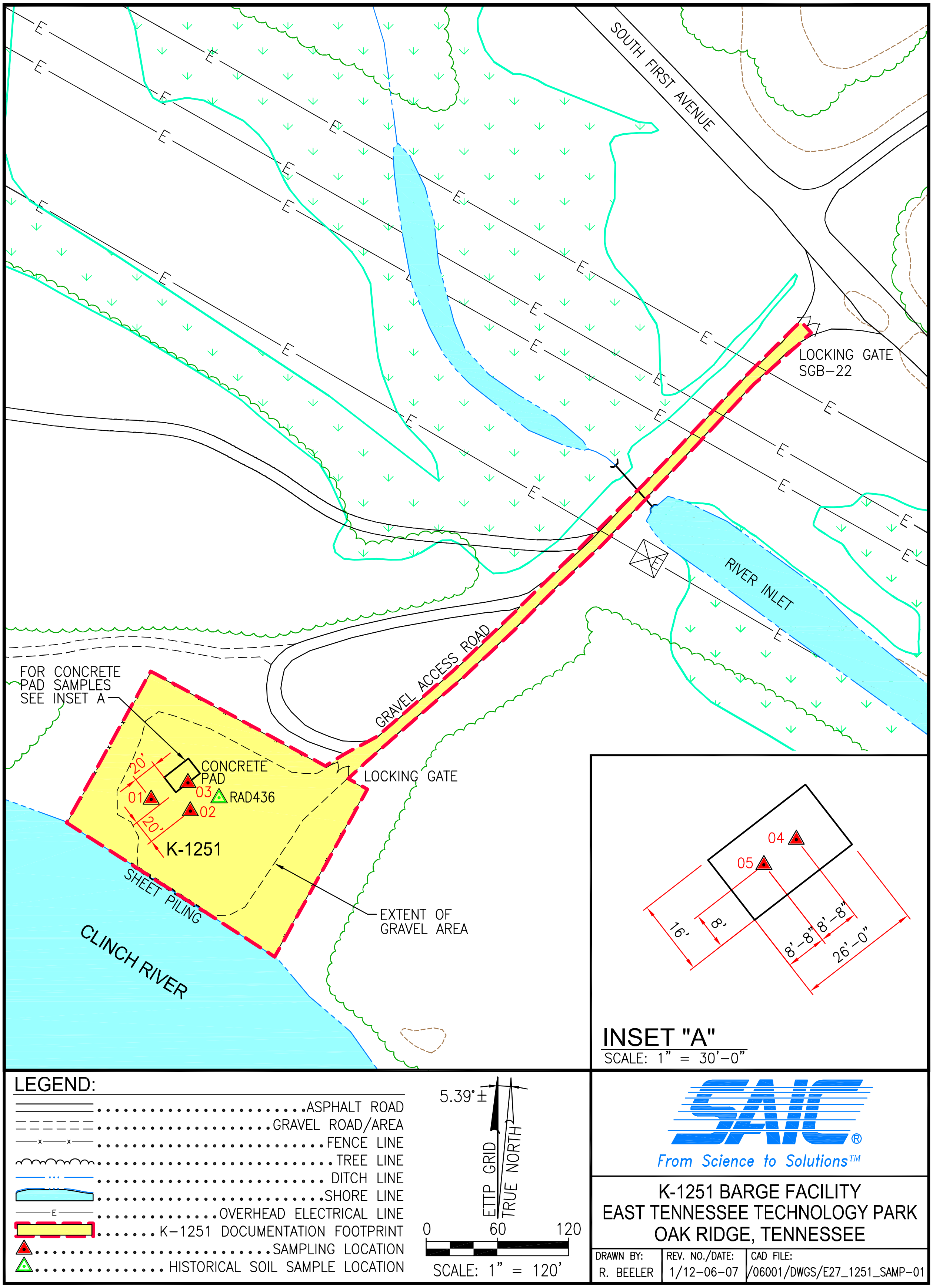

Figure 6.1. K-1251 Barge Facility sampling locations.

6.1.2.1 Soil sampling results

Data Validation

During the data validation process, laboratory data were assigned appropriate data validation flags. These flags were as described below:

"U"	When the material was analyzed for but not detected above the level of the associated value.
"J"	When the associated value was an estimated quantity (indicating there was cause to question the accuracy or precision of the reported data).
"UJ"	When the analyte was analyzed for but not detected above the associated value; however, the reported value was an estimate and demonstrated a decreased knowledge of its accuracy or precision.
"R"	When the analyte value reported was unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity raised significant questions as to the reality of the information presented.
"="	When the analyte value reported was detected. The integrity of the analyte's identification, accuracy, and precision were validated.

Data Validation Summary

Eight soil samples were evaluated, with 1259 discrete analyses (i.e., analytes) validated for the project (EPA 1999; EPA 2004). The samples were collected on August 1, 2007. There were 1233 acceptable results out of a total of 1259. Twenty-six of a total of 587 SVOC results were rejected during validation. The rejected results were tentatively identified compounds with estimated results that were less than 10 times the blank result. Note that estimated values are considered acceptable information for data interpretation. Table 6.1 summarizes the validation results.

Table 6.1. K-1251 Barge Facility non-radiological validation summary

	Number of results		
Analysis type	**Usable (U, J, UJ, and =)**	**Rejected (R)**	**Total**
PCBs	72	0	72
VOCs	384	0	384
SVOCs	561	26	587
Metals	200	0	200
Herbicides	8	0	8
Total	1233	26	1259

PCB = polychlorinated biphenyl.
SVOC = semivolatile organic compound.
VOC = volatile organic compound.
J = estimated concentration.
U = analyte not detected at indicated concentration.
UJ = analyte not detected at indicated concentration, which is an estimated concentration.
"=" = When the analyte value reported was detected. The integrity of the analyte's identification, accuracy, and precision were validated.

Results

The chemical results (see Tables 6.2 through 6.7) were interpreted in the risk screen report (see Appendix E). The sampling results are summarized in Table 6.2, below, by analysis type. For each analysis type, the following information is listed:

- the frequency of detection,
- minimum and maximum detected concentrations,
- location(s) at which detected,
- if detected concentrations exceed Zone 1 RLs, and
- if detected concentrations exceed preliminary remediation goals (PRGs).

Table 6.2. K-1251 Barge Facility chemical analytical results summary

Analysis type	Frequency of detections	Minimum concentration	Maximum concentration	Locations at which detected	Exceeds Zone 1 remediation level?	Preliminary remediation goal exceeded?
PCBs (mg/kg)	3/72	0.0024	0.0073	01 and 02	No	No
VOCs (μg/kg)	11/384	0.297	8.59	01, 02, and 03	NA	No
SVOCs (μg/kg)	49/561	0.26	283	01, 02, and 03	NA	No
Metals (mg/kg)	121/200	0.0129	237,000	01, 02, and 03	No	No

μg/m^3 = micrograms per cubic meter.
mg/kg = milligrams per kilogram.
NA = not applicable.
PCB = polychlorinated biphenyl.
SVOC = semivolatile organic compound.
VOC = volatile organic compound.

The current background evaluation method is based on two documents, one that presents the current background dataset, and a second that outlines the current methodology. The current background dataset consists of the Knox Group and Rome and Chickamauga formation samples from *Soil Background Supplemental Data Set for the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2105&D1) [DOE 2003b]. The methodology for the comparison to background is presented in *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA 540-R-01-003).

There were detected levels for PCBs, VOCs, SVOCs, and metals in soil samples collected at the K-1251 Barge Facility. The chemical concentrations for soils are discussed below.

Chemical Results

In the following discussion, the number of detected sample results and the number of sample locations having detected results might not be the same because samples were collected from multiple depths at all of the sample locations.

PCBs

A total of 72 PCB results were reported, with 3 results (4.17%) detected. The concentration of the PCB results ranged from 0.0024 to 0.0073 mg/kg for Aroclor-1260 (Table 6.3). The detected values were well below the ETTP Zone 1 soil cleanup level for PCBs (10 mg/kg) that was agreed to by DOE and the regulators [*Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-1997/D2 (DOE 2002)]. PCBs have been used for their heat-resistant properties in oils, paints, and other materials subjected to the effects of high temperature. The detected PCB concentrations were detected at locations 01 and 02 [Table 6.3]. The detected PCB concentrations were found in samples collected at a depth of 0.0 to 0.5 ft bgs in both the 01 and 02 sample locations and also at a depth of 0.5 to 2.0 at the 02 sample location. The detected PCB results could be due to the former use of various industrial equipment containing oils with PCBs for heat resistance at the K-1251 Barge Facility.

Table 6.3. K-1251 Barge Facility study area polychlorinated biphenyls results

Analysis type	Frequency of detections	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Locations at which detected	Exceeds Zone 1 remediation level?	Industrial worker soil preliminary remediation goal[a]	Preliminary remediation goal exceeded?
Aroclor-1260	3/8	0.0024	0.0073	01 and 02	No	7.4	No

[a] Based upon U. S. EPA Region 9 published preliminary remediation goals.
mg/kg = milligrams per kilogram.
NA = not applicable.

VOCs

A total of 384 VOC results were reported, with 11 results (2.9%) detected. The concentrations of the VOC results ranged from 0.297 µg/kg for toluene to 8.59 µg/kg for acetone (Table 6.4). Overall, the concentrations of the VOC results were low with all three sample locations having detected results [Table 6.4]. The detected VOCs included 1,1-dichloroethene (locations 01, 02, and 03), acetone (locations 01, 02, and 03), methylene chloride (locations 02 and 03), and toluene (location 01). Acetone was reported for samples collected at a depth of 0.0 to 0.5 ft bgs at all three locations. This compound was also reported for the 0.5 to 2.0 ft bgs sample at the 02 location, and in the 2.0 to 10.0 ft bgs sample collected at the 01 location. Methylene chloride was detected in the 0.5 to 2.0 ft bgs sample at the 02 location and in the 2.0 to 10.0 ft bgs sample at the 03 location. Toluene was detected in the 2.0 to 10.0 ft bgs sample collected at the 01 location. 1,1-dichloroethene was detected in the 0.5 to 2.0 ft bgs sample at the 01 and 02 locations, and in the 2.0 to 10.0 ft bgs sample at the 03 location. VOCs are typically industrial solvents or components of fuel. The detected VOC results could be the result of releases related to industrial equipment use and cleaning at the barge facility and/or incidental spills during material transfers at the K-1251 Barge Facility.

Table 6.4. K-1251 Barge Facility volatile organic compounds results

Analysis type	Frequency of detections	Minimum concentration (µg/kg)	Maximum concentration (µg/kg)	Locations at which detected	Exceeds Zone 1 remediation level?	Industrial worker soil preliminary remediation goal[a]	Preliminary remediation goal exceeded?
1,1-Dichloroethene	3/8	0.595	0.955	01, 02, and 03	NA	413,000	No
Acetone	5/8	2.28	8.59	01, 02, and 03	NA	54,000,000	No
Methylene chloride	2/8	2.35	4.13	02, and 03	NA	205,000	No
Toluene	1/8	0.297	0.297	01	NA	2,200,000	No

[a] Based upon U. S. EPA Region 9 published preliminary remediation goals.
µg/kg = micrograms per kilogram.
NA = not applicable.

SVOCs

A total of 561 SVOC results were reported, with 49 results (8.7%) detected. As stated earlier, 26 SVOC results were rejected during validation and, therefore, were not used. The concentrations of the SVOC results ranged from 0.26 μg/kg for 1,4-dichlorobenzene to 283 μg/kg for fluoranthene (Table 6.5). SVOCs are used in various industries and found in lubricants and as components of fuel. The detected SVOC results were found at all three sample locations and at all depths. The greatest frequency of detects occurred in the surface (0.0 to 0.5 ft bgs) and shallow subsurface (0.5 to 2.0 ft bgs) soil samples. Ten of the highest SVOC results came from the surface soil sample (0.0 to 0.5 ft bgs) at location 03. Sample location 03 is located adjacent to the southeast side of the concrete pad (Fig. 6.1). The detected SVOC results could be the result of the use of diesel fuel and/or lubricating oils at the K-1251 Barge Facility.

Table 6.5. K-1251 Barge Facility semivolatile organic compounds results

Analysis type	Frequency of detections	Minimum concentration (μg/kg)	Maximum concentration (μg/kg)	Locations at which detected	Exceeds Zone 1 remediation level?	Industrial worker soil preliminary remediation goal[a]	Preliminary remediation goal exceeded?
1,4-Dichlorobenzene	8/8	0.26	0.859	01, 02, and 03	NA	78,700	No
Acenaphthene	2/8	11.3	24.2	03	NA	29,200,000	No
Anthracene	3/8	18.7	65.5	02 and 03	NA	238,000,000	No
Benz(*a*)anthracene	3/8	59.2	129	02 and 03	NA	21,000	No
Benzo(*a*)pyrene	4/8	66.3	139	01,02, and 03	NA	2,100	No
Benzo(*b*)fluoranthene	3/8	70.5	213	01and 02	NA	21,000	No
Benzo(*k*)fluoranthene	1/8	26.8	26.8	01	NA	211,000	No
Carbazole	1/8	55.3	55.3	03	NA	862,000	No
Chrysene	3/8	52.4	119	02 and 03	NA	2,100,000	No
Fluoranthene	7/8	14	283	01,02, and 03	NA	22,000,000	No
Fluorene	2/8	13.3	30.1	03	NA	26,300,000	No
Indeno(*1,2,3-cd*)pyrene	5/8	128	163	01, 02, and 03	NA	21,000	No
Naphthalene	1/8	13.5	13.5	02, and 03	NA	187,000	No
Pyrene	6/8	21.5	221	01, 02, and 03	NA	29,100,000	No

[a] Based upon U. S. Environmental Protection Agency Region 9 published preliminary remediation goals.
μg/kg = micrograms per kilogram.
NA = not applicable.

Metals

A total of 200 metal results were reported, with 121 results (60.5%) detected. The concentrations of the metal results ranged from 0.0129 mg/kg for mercury to 237,000 mg/kg for calcium (Table 6.6). Zone 1 cleanup levels have been established only for arsenic, beryllium, and mercury. The detected arsenic, beryllium, and mercury results did not exceed Zone 1 RLs (see Table 6.2). All sample locations were found to have detected metals results, which is to be expected because soil generally has a measurable content of metals in nature. There is no evident correlation between sample location and elevated metal results. The highest metal results were for the macronutrient elements aluminum, calcium, iron, magnesium, and potassium, which are all naturally occurring. No metal results were found to exceed industrial worker soil PRGs. Five metals were found at concentrations above background concentrations established for the ETTP. These metals include antimony, barium, cadmium, lead, and zinc. With the exception of lead, all of the detected metals concentrations above background were found in samples collected from surface soils (0.0 to 0.5 ft bgs) or the shallow subsurface soils (0.5 to 2.0 ft bgs). Lead exceeded background at all three sample depths at the 01 location. However, the subsurface soil sample from the 2.0 to 10.0 ft bgs depth at location 01 exceeded background by less than a factor of 2. As mentioned previously metals are ubiquitous in natural soils, and given the nature of the activities conducted at the barge facility and the presence of scattered scrap metal objects throughout the study area, it is not unexpected that slightly elevated metal concentrations occur in the shallow soils.

Table 6.6. K-1251 Barge Facility metals results

Analysis type	Frequency of detections	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Locations at which detected	Exceeds Zone 1 remediation levels?	Industrial worker soil preliminary remediation goal[a]	Preliminary remediation goal exceeded?
Aluminum	8/8	3,450	12,400	01, 02, and 03	NA	921,000	No
Antimony	4/8	3.74	12.6	01 and 03	NA	409	No
Arsenic	8/8	2.32	5.41	01, 02, and 03	No	16	No
Barium	8/8	24.5	151	01, 02, and 03	NA	66,600	No
Beryllium	8/8	0.279	1.23	01, 02, and 03	No	1,940	No
Boron	8/8	2.18	25.4	01, 02, and 03	NA	200,000	No
Cadmium	4/8	0.151	1.53	01 and 02	NA	451	No
Calcium	8/8	17,700	237,000	01, 02, and 03	NA	NA	NA
Chromium	8/8	11.5	89.9	01, 02, and 03	NA	4,500	No
Cobalt	8/8	3.08	10.1	01, 02, and 03	NA	13,300	No
Copper	8/8	7.95	16.7	01, 02, and 03	NA	40,900	No
Iron	8/8	9,480	21,900	01, 02, and 03	NA	306,400	No
Lead	8/8	24.1	2,260	01, 02, and 03	NA	NA	NA
Magnesium	8/8	1,580	7,600	01, 02, and 03	NA	NA	NA
Manganese	8/8	153	561	01, 02, and 03	NA	19,500	No
Mercury	8/8	0.0129	0.0326	01, 02, and 03	No	306	No
Nickel	8/8	7.9	20.3	01, 02, and 03	NA	20,400	No
Potassium	8/8	514	1,530	01, 02, and 03	NA	NA	NA
Selenium	1/8	0.944	0.944	01	NA	5,100	No
Silver	0/8	NA	NA	NA	NA	5,100	No
Sodium	6/8	83.5	637	01, 02, and 03	NA	NA	NA
Thallium	0/8	NA	NA	NA	NA	67	No
Vanadium	8/8	4.8	18.2	01, 02, and 03	NA	1,020	No
Zinc	8/8	28.5	581	01, 02, and 03	NA	306,400	No

[a] Based upon U. S. EPA Region 9 published preliminary remediation goals.
mg/kg = milligrams per kilogram.
NA = not applicable.

6.1.3 Concrete Pad Sample Results

Two samples of the concrete pad were collected in August 2007 at the K-1251 Barge Facility. These samples, collected from the top 3 in. of the concrete surface, were analyzed for PCBs. The results, summarized in Table 6.7, indicate that PCBs were detected in the concrete. Aroclor-1254 and Aroclor-1260 were detected at concentrations ranging from 0.002 to 0.0067 mg/kg. These concentrations are well below the established RL of 10 mg/kg for PCBs in Zone 1 of the ETTP and the industrial worker PRG. As previously mentioned, PCBs were commonly used for their heat-resistant properties in oils, paints, and other materials. The industrial nature of the activities conducted at the barge facility likely account for the presence of PCBs on the concrete pad.

Table 6.7. Analytical results for concrete samples collected at the K-1251 Barge Facility

Analysis type	Frequency of detections	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Locations at which detected	Exceeds Zone 1 remediation levels?	Industrial worker soil preliminary remediation goal[a]	Preliminary remediation goal exceeded?
PCB-1254	2/2	0.002	0.0067	04 and 05	No	7.4	No
PCB-1260	1/2	0.0041	0.0041	04	No	7.4	No

mg/kg = milligram per kilogram.
PCB = polychlorinated biphenyl.

6.2 RADIOLOGICAL SURVEYS AND SAMPLING

This section presents and discusses both historical and recent radiological survey data and the radiological soil sampling results collected from the study area. The historical survey data are presented, followed by a discussion of the survey methodology and results used to supplement the historical data. The final subsection presents a summary of the 2007 soil sample data.

The process history of the ETTP Site indicates uranium (natural, depleted, and/or enriched) is the most prominent radiological contaminant potentially present in the K-1251 land parcel as a result of tracking contamination from on-site buildings, from environmental release, or from handling UF_6 cylinders at the barge-unloading facility. Uranium-235 enrichment levels from operations since the early 1960s are expected between 0.2 and 5.0%. Potential contamination would be expected to be by enrichments of less than 3%.[4]

Other radionuclides detected on-site at ETTP are ^{60}Co, ^{137}Cs, ^{90}Sr, ^{237}Np, ^{99}Tc, and $^{238/239/240}$Pu. These other radionuclides originated from the introduction of contaminated materials from ORNL and/or from the Hanford and Savannah River reactor returns program and could have been present in UF_6 cylinder heels.

In summary, as will be described below, the radiological survey results show that all surface survey readings are less than the DCGLs. Results of the radiological soil analyses show that no residual contamination in excess of the Zone 1 remediation goals was found. (Although K-1251 is not in Zone 1, the Zone 1 remediation goals were used for comparative purposes.).

6.2.1 Radiological Surveys

The K-1251 parcel consisted of one land survey unit (LSU) and one exterior survey unit (ESU). The classification of the survey units and the performance of the survey were completed in accordance with ETTP Radiation Control (RADCON) procedures[5] and the survey design document[6] and are discussed in the survey plan (see Appendix C). The LSU was classified as a Class 2 survey unit and consisted of the area enclosed by the fence adjacent to the Clinch River and the access road. Historical documentation indicates this area (except for the access road) was once utilized as a UF_6 cylinder storage area. There are

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[4] Contracted Health Physics Technician Training handouts, K-25 Site, 1993.

[5] Primarily EH-4516, "Radioactive Contamination Control and Monitoring," found in BJC-EH-4000, *Radiation Protection Program Description for Bechtel Jacobs Company LLC, Oak Ridge, Tennessee.*

[6] *Design of Radiological Survey and Sampling to Support Title Transfer or Lease of Property on the Department of Energy Oak Ridge Reservation,* BJC/OR-554-R1, Bechtel Jacobs Company LLC, Oak Ridge, TN, August 2006.

no data indicating that spills or accidental releases occurred in this area; thus, contamination levels were not expected to exceed the derived concentration guideline level (DCGL). The ESU, a concrete pad, was classified as a Class 2 survey. Historical knowledge indicates that this area may have once been posted as a radiological contamination area. However, since it has been downposted, no residual contamination in excess of the DCGL was expected.

6.2.1.1 Historical surveys

A search of the Bechtel Jacobs Company LLC (BJC) RADCON electronic survey data collected between 1996 and 2006 showed one characterization survey associated with the K-1251 facility. The survey, performed in 2000 (20000216KA36147001), consisted of an area survey with a sodium iodide (NaI) detector. The survey results revealed all areas to be less than twice background. Only two locations were time counted. The highest count rate was obtained in the ditch on the north and east sides of the fenced area where a count rate of 1000 counts per minute (cpm) was obtained (background was 5400 cpm). No other radiological survey data were found.

6.2.1.2 2007 Exterior survey unit

The Class 2 ESU consisted of the concrete pad. One exterior radiological surface survey was conducted in the footprint (survey number 20070710WCUDESK001). The survey was performed on July 12, 2007, in accordance with the survey plan (Appendix C). The slab was scan-surveyed over the accessible area that was not covered by moss, weeds, and vegetation with 50% coverage. Twelve measurements of total and removable activity were taken (alpha and beta-gamma) at locations given by the fixed survey grid provided in the survey plan. A summary of the survey results is shown in Table 6.8.

All readings taken in the ESU were less than 1250 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) total activity. Because all results were less than the respective screening levels, no further statistical analysis was performed. Based on an inspection of the individual surveys, including quality assurance/quality control surveys, all total activities were less than 1 dpm/100 cm^2 total alpha and less than 91 dpm/100 cm^2 total beta-gamma, with all removable contamination results less than 4 dpm/100 cm^2 removable alpha and less than 15 dpm/100 cm^2 removable beta-gamma. The maximum tissue-equivalent dose rate was 4 μrem/hour, which is in the background range for the site.

Results of the radiological surveys performed in the study area indicate that the concrete surfaces are below the DOE surface contamination limits and within the acceptable dose-equivalent rate range for exterior surfaces. Because all results were less than the DCGL, the survey units can be released from a surface contamination standpoint.

6.2.1.3 Land survey unit

The Class 2 LSU consisted of the area enclosed by the fence adjacent to the Clinch River and the access road. A separate sampling plan was executed to evaluate soil contamination. Many of the radionuclides found in the Oak Ridge Reservation have natural background concentrations; therefore, background subtraction will be required for all direct field measurements and laboratory analyses. Some comparison to background levels is required for the scanning because only a gross signal was measured.

Table 6.8. Summary of contamination and dose rates

Location	Alpha total		Alpha removable		Beta-gamma total		Beta-gamma removable		Dose equivalent rate (μrem/h)
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Exterior survey units – Class 3									
ESU 1	< -23	< 0	< -0.43	3.49	< -542.34	90.39	< -3.13	14.1	4
DOE contamination limits		5000		1000		5000		1000	20,000

Notes: All readings are in units of disintegrations per minute (dpm)/100 cm^2.
A "<" preceding a value indicates that the result cannot be distinguished from background at the 95% confidence level.
This table does not include results from quality assurance/quality control surveys.
DOE = U. S. Department of Energy.
ESU = exterior survey unit.
NR = not recorded.

One land radiological survey was conducted in the footprint (survey number 20070725WCUDESK002). The surveys of the fixed grid assessment points were performed on July 25, 2007, in accordance with the survey plan (see Appendix C).

NaI walkover survey judgment scans were performed according to the survey plan (Appendix C). Emphasis was placed on road bed areas, suspect areas of soil or vegetation discoloration, and other areas based on professional judgment. NaI survey measurements were performed at the fixed-grid assessment points. No anthropogenic, groundwater runoff, and sediment collection areas were recognized during the NaI walkover, and no scan areas were determined to have elevated readings. A 10-ft-diameter surface area was scanned at each of the fixed grid points with the NaI detector. The measurements recorded at each point included only timed, 1-min-count NaI and dose-rate measurements at the location of the highest scan reading.

Because the DCGLs for surface measurements do not apply to soil areas and soil samples were collected in these areas for analysis, direct readings are not used in the dose and risk assessments for soil areas. Therefore, no upgrade of any LSUs would be made based on the timed NaI measurements. However, upgrades could be necessary based on the results of the soil sampling and analysis discussed below.

The results of the fixed-timed NaI measurements are shown in Table 6.9. A total of 14 NaI measurements were made at fixed grid locations in LSU 1 per Appendix C, Fig. C.2. No NaI measurements were greater than two times a field-determined background appropriate for the geological and topographical conditions. NaI background count rates ranged from 3296 cpm to 6490 cpm. Based on an inspection of the individual surveys, all NaI readings were less than 7162 cpm. The maximum tissue-equivalent dose rate was 6 μrem/hour, which is in the background range for the site.

Table 6.9. Fixed-timed measurements

Location	No. of Measurements	NaI Min. cpm	NaI Max. cpm	Dose equivalent (μrem/h)
LSU 1 Grid APs	14	3096	7162	3 to 6

Note: Sodium iodide (NaI) fixed-timed measurements are reported in counts per minute (cpm) and are not background-corrected.

AP = assessment point.

LSU =land survey unit.

6.2.2 Radiological Sampling

6.2.2.1 Historical samples

A search of the OREIS database showed data are available from only one historical soil sample within the K-1251 footprint. The sample from station RAD436 was collected in 1994 and quantified for radionuclides. The results are shown in Table 6.10. All detected radionuclide results were below their respective background values.

Table 6.10. Historical radiological soil sample data from K-1251

Sample ID	Sample depth (ft)	^{241}Am (pCi/g)	^{60}Co (pCi/g)	^{137}Cs (pCi/g)	^{237}Np (pCi/g)	^{238}Pu (pCi/g)	$^{239/240}$Pu (pCi/g)	^{228}Ra (pCi/g)	^{99}Tc (pCi/g)	^{228}Th (pCi/g)	^{230}Th (pCi/g)	^{232}Th (pCi/g)	^{234}Th (pCi/g)	^{234}U (pCi/g)	^{235}U (pCi/g)	^{238}U (pCi/g)
RAD436	0–0.5	NA	0.004 U	0.397	0.02 U	0.00 U	0.009 U	0.21	0.00 U	0.268	0.95	0.309	0.44 U	0.303	0.091	0.32

NA = data not available.

Bold = detected value exceeds radionuclide background data set. Background concentration as defined by Bechtel Jacobs Company LLC in DOE 2003. The background data set that the Environmental Management Program is using has values for only ^{40}K, ^{226}Ra, ^{228}Th, ^{230}Th, ^{232}Th, ^{234}U, and ^{238}U. However, the U. S. Environmental Protection Agency (EPA) report on the September 2001 sampling of the Scarboro community (SESD Project No. 01-1222, April 2003) denotes that, in some cases, the preliminary remediation guide (PRG) values are far below the background values. As an example, the EPA report mentions that the ^{137}Cs background is approximately 1 picocurie per gram (pCi/g), but the PRG is far lower. For this report, a background of 1.0 pCi/g is used for ^{137}Cs. Evaluation of the ^{228}Ra result assumes equilibrium with ^{232}Th background levels.

Validation qualifier definitions:

J denotes the analyte was positively identified; the associated result is the approximate concentration of the analyte in the sample.

U denotes the analyte was analyzed for, but was not detected above the reported sample quantitation limit.

UJ denotes the analyte was not detected above the reported detection limit, which is approximated due to quality deficiency.

6.2.2.2 2007 Soil Samples

The 2007 sample results described below are from the judgmental soil samples that were collected in accordance with the SAP included in Appendix B. In order to meet data requirements for the risk screening, additional samples were needed to supplement the existing data. Based on the history of the K-1251 Barge Facility, if any radiological contamination was present, it was expected to be localized near the crane pad. The three sampling locations indicated in Fig. 6.1 were selected on a judgmental basis. The concrete was not sampled because any contamination would be assumed to be on the surface and not at depth. Therefore, surface limits rather than concentration limits apply.

All samples collected from the sampling locations indicated below were quantified for total activity, isotopic uranium, ^{99}Tc, ^{90}Sr, gamma-emitting isotopes (including but not limited to ^{60}Co, ^{137}Cs, ^{234m}Pa, and ^{234}Th), transuranic isotopes (i.e., ^{237}Np, ^{238}Pu, ^{239}Pu, and ^{241}Am), and isotopic thorium (^{228}Th, ^{230}Th, and ^{232}Th). In addition, ^{226}Ra and ^{228}Ra were reported based on the measurement of their progeny from the gamma spectrometry analyses. A total of eight soil samples from the three locations were sampled in the study area for radiological analysis during this effort to determine the presence of contamination as shown in Table 6.11. An equipment rinsate blank mentioned in the SAP was not collected due to the sampling method used. During the data validation process, laboratory data were assigned appropriate data validation flags. Refer to Sect. 6.1.2.1 for the validation flags and their definitions.

Table 6.11. Summary of K-1251 surface and subsurface soil samples for radiological analyses

Sample number	Sample depth
NS-01-01-1251	0.0–0.5
NS-01-02-1251	0.5–2.0
NS-01-03-1251	2.0–10.0
NS-02-01-1251	0.0–0.5
NS-02-02-1251	0.5–2.0
NS-03-01-1251	0.0–0.5
NS-03-02-1251	0.5–2.0
NS-03-03-1251	2.0–10.0

6.2.2.3 Sample data analysis

Data Validation Summary

Eight surface, near-surface, and subsurface soil samples were validated. During the data validation process, laboratory data were assigned appropriate data validation flags. Refer to Sect. 6.1.2.1 for the validation flags and their definitions. All individual total activity results were qualified as unusable (R) due to a negative bias resulting from improper background subtraction. These are not of concern because the results are only used for intercomparisons during the data validation process and are not critical to the risk assessment. All thorium and uranium isotopic results by alpha spectroscopy were qualified as estimated (J) due to the uncertainty in the chemical recovery being greater than the allowable limit and all ^{90}Sr, ^{237}Np, $^{238,239/240}$Pu, ^{241}Am, and total activity results being qualified as estimated (J) since the leaching procedure may not remove all of the analytes of concern from the sample matrix, causing an unknown amount of negative bias on the results as shown on Table 6.12. In addition, the ^{226}Ra results should be considered estimated since they assume equilibrium with a radon daughter that may not be in equilibrium due to emanation. Note that estimated values are considered acceptable information for data interpretation.

Table 6.12. 2007 Radiological soil sample data from the K-1251 Barge Facility

Sample ID	Sample depth (ft)	^{241}Am (pCi/g)	^{60}Co (pCi/g)	^{137}Cs (pCi/g)	^{237}Np (pCi/g)	^{238}Pu (pCi/g)	$^{239/240}$Pu (pCi/g)	$^{89/90}$Sr (pCi/g)	^{99}Tc (pCi/g)	^{228}Th (pCi/g)	^{230}Th (pCi/g)	^{232}Th (pCi/g)	^{234}U (pCi/g)	^{235}U (pCi/g)	^{238}U (pCi/g)
NS01-01-1251-04	0–0.5	0.033 UJ	0.00659 U	0.642	-0.017 UJ	-0.102 UJ	-0.0447 UJ	-2.61 UJ	-1.01 U	0.43 J	0.496 J	0.352 J	0.431 J	0.037 UJ	0.565 J
NS01-02-1251-04	0.5–2	0.0119 UJ	-0.00669 U	0.638	-0.00671 UJ	0.00228 UJ	0.00228 UJ	-1.45 UJ	6.89 U	0.501 J	0.83 J	0.57 J	0.679 J	0.035 UJ	0.53 J
NS01-03-1251-04	2–10	0.0895 UJ	-0.00305 U	0.00429 U	-0.0091 UJ	-0.112 UJ	0.0164 UJ	0.403 UJ	4.44 U	0.771 J	0.876 J	0.811 J	0.844 J	**0.089 J**	0.646 J
NS02-01-1251-04	0–0.5	0.0782 UJ	0.00113 U	**3.14**	-0.00382 UJ	-0.0744 UJ	0.118 UJ	-1.83 UJ	2.48 U	1.37 J	**2.14 J**	1.5 J	**1.7 J**	**0.265 J**	**1.56 J**
NS02-02-1251-04	0.5–2	-0.0558 UJ	**0.0159**	**1.12**	-0.0256 UJ	-0.0542 UJ	**0.17 J**	-1.12 UJ	6.82 U	0.947 J	1.15 J	0.965 J	**1.52 J**	**0.104 J**	1.01 J
NS03-01-1251-04	0–0.5	-0.0255 UJ	0.00836 U	**1.87**	-0.0224 UJ	-0.127 UJ	0.0306 UJ	-1.71 UJ	0.511 U	0.43 J	0.536 J	0.45 J	0.843 J	-0.005 UJ	0.458 J
NS03-02-1251-04	0.5–2	-0.0171 UJ	**0.00205**	0.703	-0.0168 UJ	-0.0508 UJ	-0.0613 UJ	-1.33 UJ	0 U	0.715 J	0.718 J	0.658 J	0.796 J	0.001 UJ	0.612 J
NS03-03-1251-04	2–10	0.0335 UJ	-0.00139 U	0.016	-0.0055 UJ	0.0261 UJ	0 UJ	-0.836 UJ	2.55 U	1.1 J	1.02 J	0.871 J	0.984 J	0.031 UJ	0.733 J

NA = Data not available.

Bold = detected value exceeds radionuclide background data set. Background concentration as defined by Bechtel Jacobs Company LLC in DOE 2003. The background data set that Environmental Management is using has values for only ^{40}K, ^{226}Ra, ^{228}Th, ^{230}Th, ^{232}Th, ^{234}U, and ^{238}U. However, the U. S. Environmental Protection Agency (EPA) report on the September 2001 sampling of the Scarboro community (SESD Project No. 01-1222, April 2003) denotes that, in some cases, the PRG values are far below the background values. As an example, the EPA report mentions that the ^{137}Cs background is approximately 1 pCi/g, but the PRG is far lower. For this report, a background of 1.0 pCi/g is used for ^{137}Cs.

Validation qualifier definitions:

J denotes the analyte was positively identified; the associated result is the approximate concentration of the analyte in the sample.

U denotes the analyte was analyzed for, but was not detected above the reported sample quantitation limit.

UJ denotes the analyte was not detected above the reported detection limit, which is approximated due to quality deficiency.

The sum of the analytical results, including daughters assumed in equilibrium and ^{40}K results found in the raw data, was compared with the total activity results for each sample. The comparison showed agreement with all samples.

Results

The results are summarized along with historical data in Table 6.13. For each analysis type, the following information is listed:

- frequency of detection above background screening level,
- minimum and maximum concentrations,
- arithmetic mean,
- comparison to Zone 1 RLs, and
- comparison to PRG calculated at the 10^{-5} risk level.

The current background evaluation method is based on DOE (2003) and EPA (2002b). Although some individual sample results for certain radionuclide analytes (^{137}Cs, ^{60}Co, ^{239}Pu, ^{226}Ra, ^{230}Th, ^{234}U, ^{235}U, and ^{238}U) exceeded their background values and some (^{137}Cs, ^{226}Ra, ^{228}Ra, ^{228}Th, ^{232}Th) exceeded the PRG, as shown in Table 6.13, no individual results were greater than the Zone 1 maximum RLs and no averages were above average RLs. Therefore, no residual contamination in excess of the Zone 1 remediation goals was found. (Although K-1251 is not in Zone 1, the Zone 1 remedial goals are used for comparison purposes.)

Table 6.13. K-1251 summary statistics for radionuclides with historical data

Analyte	Frequency of detections	Minimum detected concentration (pCi/g)	Maximum detected concentration (pCi/g)	Average detected concentration (pCi/g)	Background reference level[a] (pCi/g)	Frequency of detections exceeding background	Maximum RL	Frequency of detects exceeding maximum RL	Average Zone 1 remediation level (pCi/g)	Exceed Zone 1 average remediation level?	Industrial worker soil preliminary remediation goal (pCi/g)	Frequency of detects exceeding preliminary remediation goal
Americium-241	0/9	ND	ND	ND	NA	0/9	NA	NA	NA	NA	5.70E+01	0/9
Cesium-137	8/9	0.016	3.14	1.07	1	3/9	20	0/9	2	No	1.12E+00	2/9
Cobalt-60	1/9	0.0159	0.0159	0.02	NA	1/9	NA	NA	NA	NA	5.96E-01	0/9
Neptunium-237	0/9	ND	ND	ND	NA	0/9	50	0/9	5	No	2.70E+00	0/9
Plutonium-238	0/9	ND	ND	ND	NA	0/9	NA	NA	NA	NA	1.66E+02	0/9
Plutonium-239	1/9	0.17 J	0.17 J	0.17	NA	1/9	NA	NA	NA	NA	1.45E+02	0/9
Radium-226 [c]	8/8	0.362	1.46	0.65	1.25	1/8	15	0/8	5	No	2.55E-01	8/8[b]
Radium-228 [d]	9/9	0.21	1.28	0.67	1.86	0/9	NA	NA	NA	NA	1.58E-02	9/9[b]
Strontium-90	0/8	ND	ND	ND	NA	0/8	NA	NA	NA	NA	1.07E+02	0/8
Technetium-99	0/9	ND	ND	ND	NA	0/9	NA	NA	NA	NA	8.94E+03	0/9
Thorium-228	9/9	0.268	1.37 J	0.73	1.86	0/9	NA	NA	NA	NA	1.58E-02	9/9[b]
Thorium-230	9/9	0.496 J	2.14 J	0.97	1.2	1/9	NA	NA	NA	NA	2.11E+02	0/9
Thorium-232	9/9	0.309	1.5 J	0.73	1.95	0/9	15	0/9	5	No	1.58E-02	9/9[b]
Uranium-234	9/9	0.303	1.7 J	0.9	1.47	2/9	7000	0/9	700	No	3.34E+02	0/9
Uranium-235	3/8	0.0885 J	0.265 J	0.15	NA	3/8	80	0/8	8	No	3.94E+00	0/8
Uranium-238	9/9	0.32	1.56 J	0.84	1.47	1/9	500	0/9	50	No	1.79E+01	0/9

[a] The background data set that is being used has values for only ^{40}K, ^{226}Ra, ^{228}Th, ^{230}Th, ^{232}Th, and ^{238}U. However, the U. S. Environmental Protection Agency (EPA) report on the September 2001 sampling of the Scarboro community (SESD Project No. 01-1222, April 2003) denotes that, in some cases, the PRG values are far below the background values. As an example, the EPA report mentions that the ^{137}Cs background is approximately 1 pCi/g, but the PRG is far lower. For this report, a background of 1.0 pCi/g is used for ^{137}Cs. In addition, a background for ^{288}Ra has been assumed based on equilibrium with ^{228}Th and for ^{234}U based on equilibrium with ^{238}U. Background values for other radionuclides for which data is not available are assumed to be zero.

[b] PRG not applicable for this radionuclide, due to an exception in the Zone 1 Record of Decision. The exception takes background levels for these radionuclides into consideration.

[c] Assumed to be in equilibrium with measured radon progeny, ^{214}Bi.

[d] Assumed to be in equilibrium with measured progeny, ^{228}Ac.

NA = Not applicable, not available or insufficient data to calculate the statistic.

ND = Not detected

pCi/g = picocuries per gram.

RL = remediation level.

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APPENDIX A

STUDY AREA MAPS FROM RECORDS SEARCH

PROPOSED REAL ESTATE ACTION, OAK RIDGE RESERVATION, TN FILES RESEARCH FOR HAZARDOUS SUBSTANCE ACTIVITY

The following statement is provided in support of guidance promulgated under Section 120(h) of the Comprehensive Environmental Response, Compensation and Liability Act, as amended (CERCLA) 42 U.S.C. 9620(h) and in support of regulations issued by the Environmental Protection Agency at 40 CFR Part 373.

The undersigned has made a complete search of existing and available Department of Energy (DOE) records, documentation, and data within the real estate files relating to the property that is subject to the proposed lease action of Parcel K-1251 (Barge Facility) at the East Tennessee Technology Park (ETTP) within the Oak Ridge Reservation, Tennessee. The proposed action would result in a lease to the Heritage Center, LLC. The search conducted was considered reasonable with a good faith effort expended to identify whether any hazardous substances were known to have been released or disposed of on the property. The available real estate records of this office do not reflect any determinable reference that hazardous substance activity as defined by Section 101(14) of CERCLA took place on or in the property during the time the property was owned by the United States of America.

Lands affected by this action are identified as portions of the following original acquisition tracts in which the United States of America acquired title, (having been acquired for the Atomic Energy Commission as a forerunner of the Department of Energy) by Civil Action No. 429 filed in the United States District Court for the Eastern District of Tennessee, Northern Division:

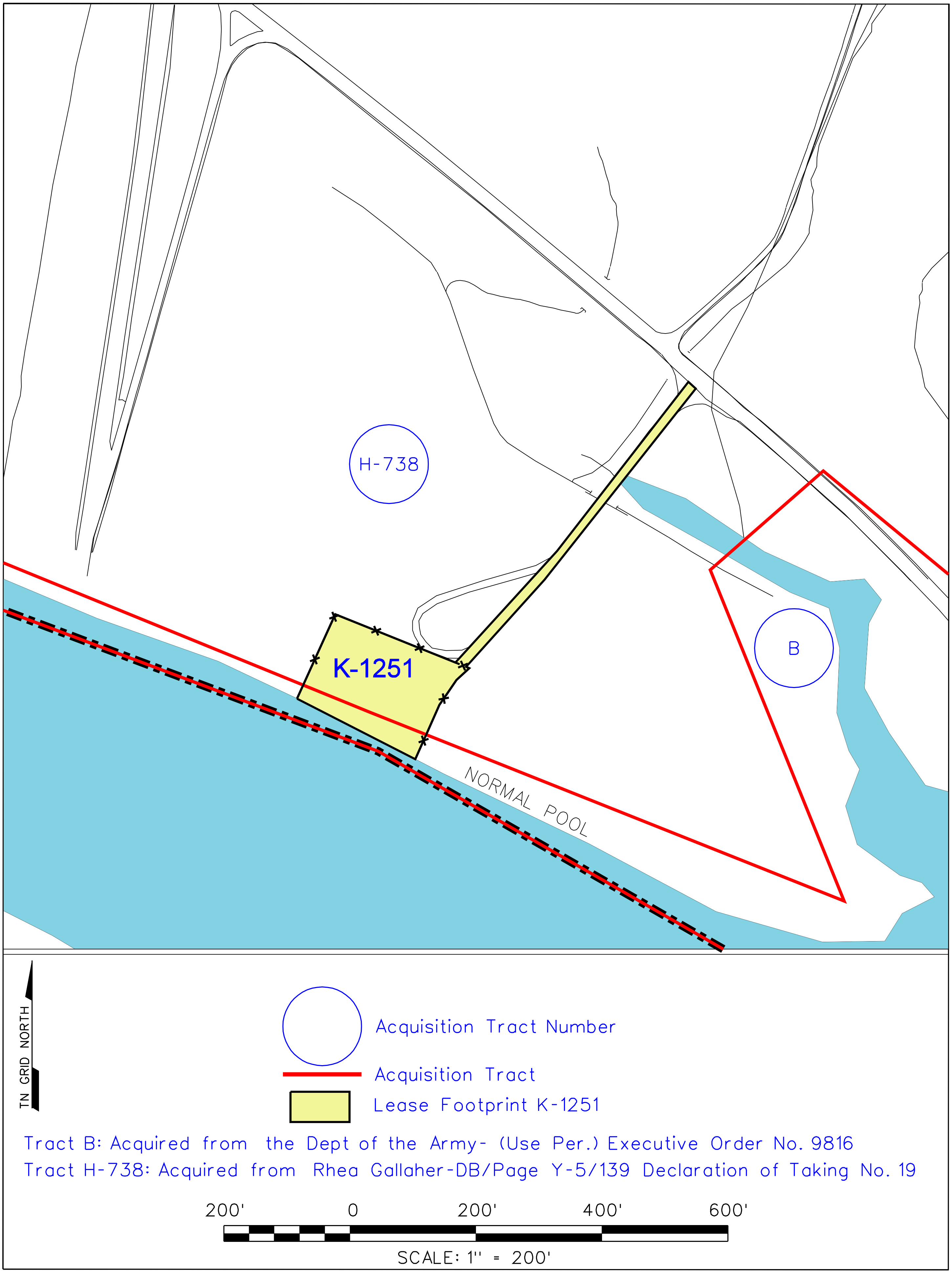
> Parcel K-1251 is located on a portion of Tract H-738. Title to this land was vested in the United States of America by Declaration of Taking No. 19. Judgment on Declaration of Taking was filed for public record on February 23, 1943, in Vol. Y-5, Page 139, in the Roane County Register's Office, Tennessee.
>
> Parcel K-1251 is located on a portion of Tract B, acquired from the Department of Army under a Use Permit, Executive Order Number 9816.

This record shall be made a part of the CERCLA report currently being prepared.

Cindy Hunter 11/20/07

Cindy Hunter, Realty Officer
Oak Ridge Office
U. S. Department of Energy

Attachment
Acquisition Tract Map



Tract B: Acquired from the Dept of the Army- (Use Per.) Executive Order No. 9816

Tract H-738: Acquired from Rhea Gallaher-DB/Page Y-5/139 Declaration of Taking No. 19

APPENDIX B

SAMPLING AND ANALYSIS PLAN FOR THE K-1251 BARGE FACILITY

BJC/OR-2813
FINAL

Sampling and Analysis Plan for the K-1251 Barge Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee

This document is approved for public release per review by:

BJC ETTP Classification and Information Control Office

7/2/07
Date

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not
be considered an eligible contractor for its review.

BJC/OR-2813
FINAL

Sampling and Analysis Plan for the K-1251 Barge Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee

Date Issued—July 2007

Prepared by
Science Applications International Corporation
Oak Ridge, Tennessee
under subcontract 23900-BA-PR007U
under work release 000700

Prepared for the
U. S. Department of Energy
Office of Nuclear Fuel Supply

BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at the
East Tennessee Technology Park
Y-12 National Security Complex Oak Ridge National Laboratory
under contract DE-AC05-98OR22700
for the
U. S. DEPARTMENT OF ENERGY

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ACRONYMS

bgs	below ground surface
DCGL	derived concentration guideline level
MDL	method detection limit
NaI	sodium iodide
PCB	polychlorinated biphenyl
PID	photoionization detector
SAP	Sampling and Analysis Plan
SOP	standard operating procedure
SSC	sampling subcontractor
SVOC	semivolatile organic compound
UF_6	uranium hexafluoride
UO_2F_2	uranyl difluoride
VOA	volatile organic analysis (or analyte)
VOC	volatile organic compound

B.1. INTRODUCTION

This Sampling and Analysis Plan (SAP) describes the sampling activities to assess the potential for chemical or radiological contamination within soils in the vicinity of the K-1251 Barge Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee. Additionally, this SAP describes sampling activities to determine if polychlorinated biphenyl (PCB) contamination is present upon the former crane pad in the subject area. The constituents selected for analysis are those compounds identified in Chap. B.5 of this plan.

B.2. SITE DESCRIPTION AND HISTORY

B.2.1 OPERATIONS CONDUCTED AT THE FORMER K-1251 BARGE FACILITY

The K-1251 barge unloading facility began operations in 1953. The facility was removed from operation in the early 1990s and the equipment removed in 1995. It is located along the Clinch River and an inlet of the river, which forms its southern boundary. It is bounded to the north, by Highway 58. As depicted in Fig. B.2.1, the footprint for the subject area is defined by security fencing that surrounds a concrete pad and a gravel-covered area.

The K-1251 barge unloading facility was used to transfer uranium hexafluoride (UF_6) cylinders. The K-1251 facility is currently inactive and all equipment, including a large crane, has been removed. Although UF_6 cylinders were transferred at this facility, historical information does not indicate that any releases occurred. In addition to potential radionuclide contamination that may have resulted from releases from the UF_6 cylinders, historical releases of hydraulic fluids, lubricating oils, or fuels from operation and maintenance of the crane may have contributed volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and PCBs.

B.3. HISTORICAL DATA

Only one historical sample is available from the K-1251 footprint. The activities of all detected radionuclides were below their respective background values. No radionuclides were detected with activities that exceeded their respective derived concentration guideline levels (DCGLs).

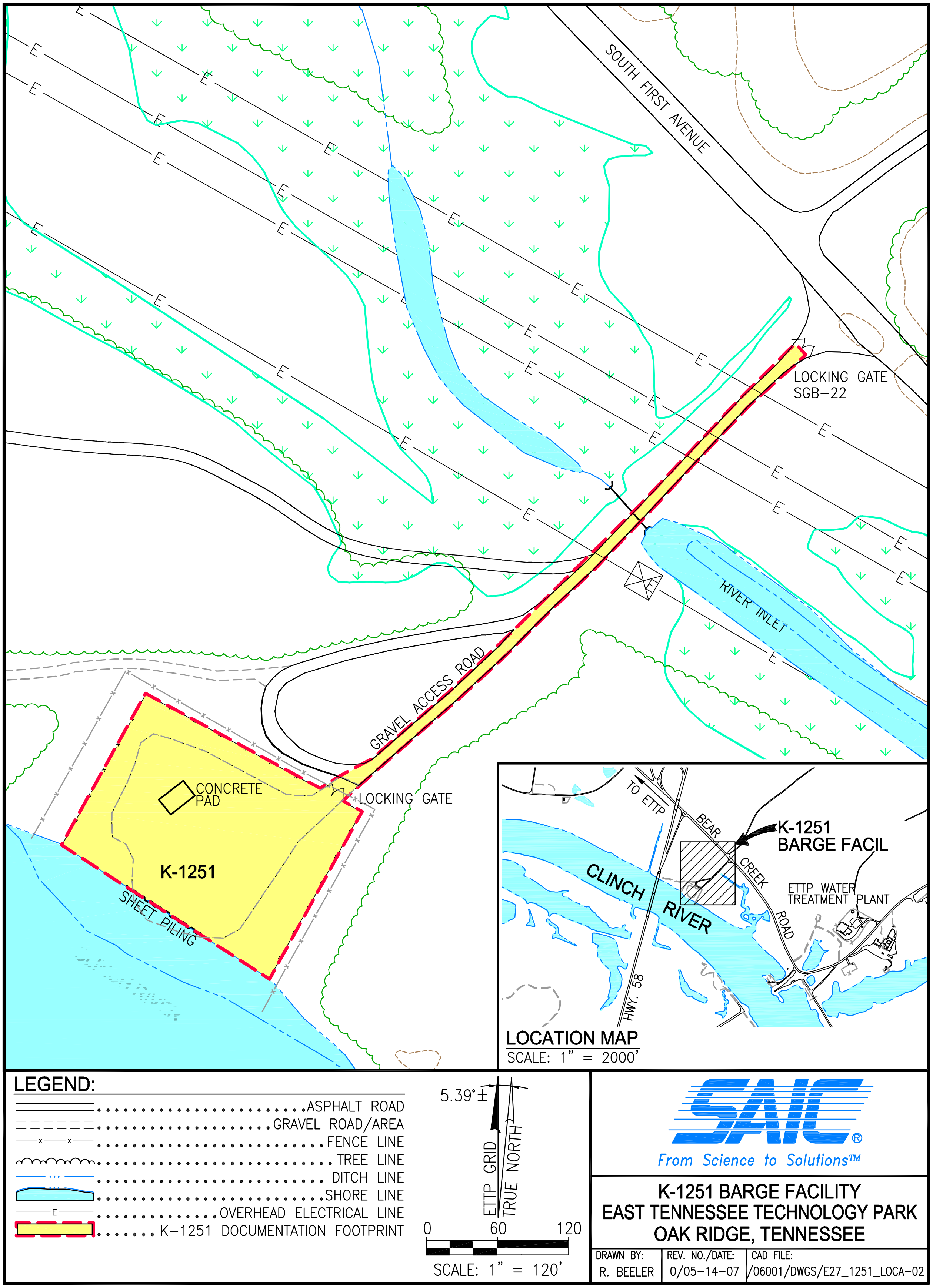

Fig. B.2.1. K-1251 Barge Facility location map.

B.4. SCOPE

The overall scope of this SAP is to determine: (1) the potential for contamination (radiological and chemical) within soils located inside the footprint area, and (2) whether PCB contamination is present upon the concrete pad (formerly used with the crane operation) in the footprint area. The first overall objective will be met by sampling the soils within the footprint at near surface [0 to 0.5 ft below ground surface (bgs)] and at depth (0.5 to 2.0 ft bgs and 2.0 ft to 10 ft bgs or to the top of the water table). The second objective will be achieved by collection of concrete coring samples from the crane pad in the footprint. Specific sampling locations and rationale are discussed within Chap. B.5 of this SAP.

B.5. SOIL SAMPLING RATIONALE AND DESIGN

B.5.1 SAMPLING OBJECTIVES FOR THE SOIL AND CONCRETE PAD

In order to facilitate lease of the property, it is necessary to demonstrate that contamination from past activities has not occurred or is not present within the footprint of the property at levels that would constitute a risk due to potential exposures. Based on the history of site operations, only a limited number of samples near the concrete crane pad are necessary to demonstrate that contamination is not present in soils in the footprint. Only a limited number of samples from the pad itself are needed to demonstrate the absence of PCB contamination on this structure. Therefore, the sampling design is judgmental in nature.

B.5.2 SAMPLING DESIGN

B.5.2.1 Sampling Design for Collection of Soil Samples

The history of the K-1251 barge facility indicates that the area was used for transfer of UF_6 cylinders for or from barge transport. No releases of UF_6 during operations have been documented. However, any release that may have occurred during operations would not transport any significant distance because the UF_6 would have immediately hydrolyzed to uranyl difluoride (UO_2F_2) upon contact with air. The resultant UO_2F_2 particles would have precipitated rapidly from the gas phase, and deposition would tend to be localized. Any chemical contamination in the area is expected to have resulted from releases of fuel or hydraulic fluids incidental to operation of the crane and would be localized in its vicinity. Therefore, if any chemical or radiological contamination is present, it is likely to be localized near the crane pad. Three sampling locations indicated in Fig. B.5.1 were selected on a judgmental basis.

All samples taken from these locations will be analyzed for radioactive and chemical contamination. Soil samples will be collected near surface (0.0 to 0.5 ft bgs) and at depth (0.5 ft to 2.0 ft bgs and 2.0 to 10.0 ft bgs or to the top of the water table). This information is presented in Table B.5.1.

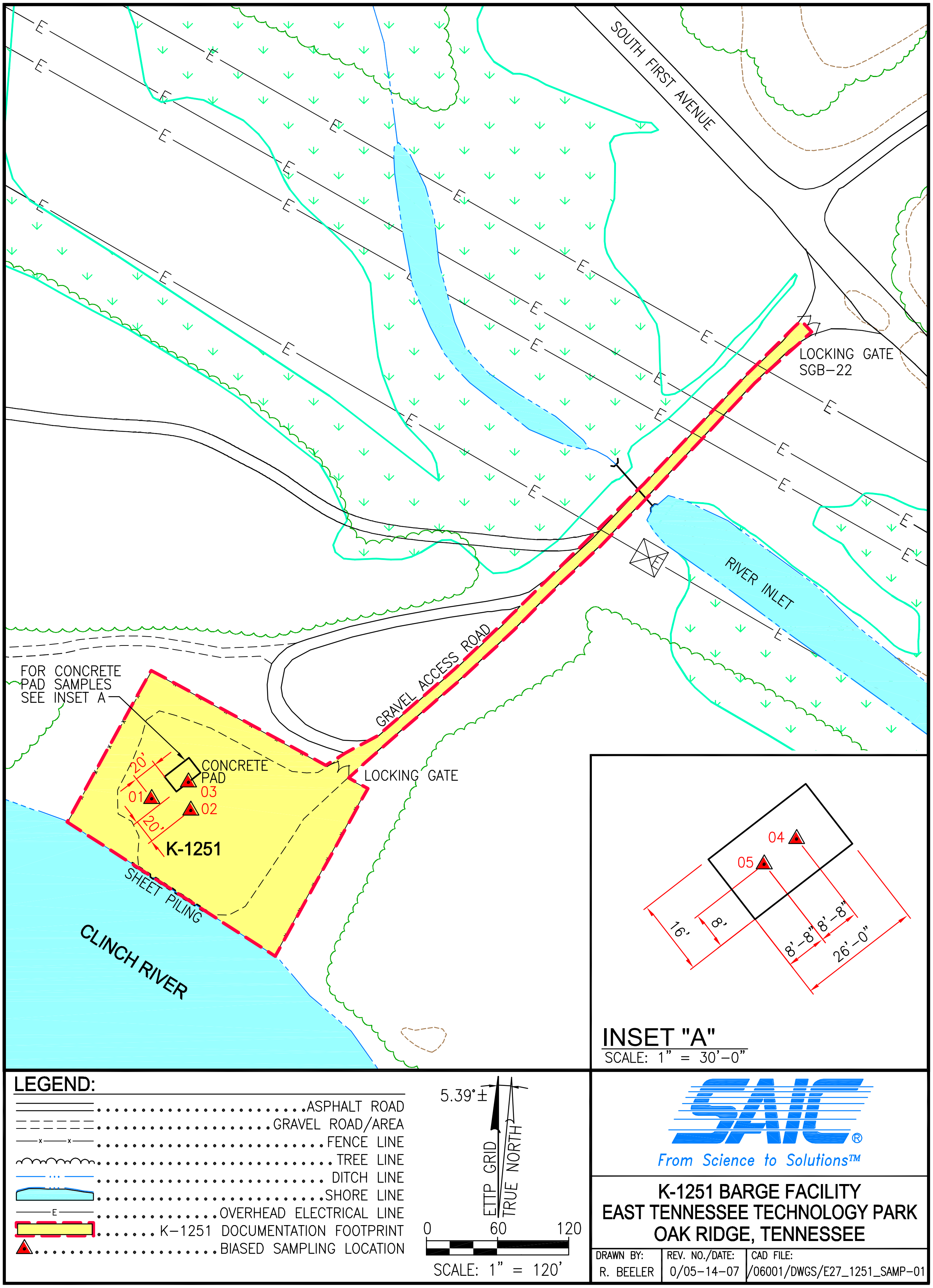

Fig. B.5.1. Biased sampling locations at the K-1251 Barge Facility.

Table B.5.1. Summary of analyses for surface and subsurface soil samples in the K-1251 footprint

Sample number	Sample depth	Metals[a]	VOCs[b]	SVOCs[b]	PCBs	Baseline radionuclides[c]	Total activity	TRU isotopes[d]
NS-01-01-1251	0.0–0.5	X	X[e]	X	X	X	X	X
NS-01-02-1251	0.5–2.0	X	X[e]	X	X	X	X	X
NS-01-03-1251	2.0–10.0	X	X[e]	X	X	X	X	X
NS-02-01-1251	0.0–0.5	X	X[e]	X	X	X	X	X
NS-02-02-1251	0.5–2.0	X	X[e]	X	X	X	X	X
NS-03-01-1251	0.0–0.5	X	X[e]	X	X	X	X	X
NS-03-02-1251	0.5–2.0	X	X[e]	X	X	X	X	X
NS-03-03-1251	2.0–10.0	X	X[e]	X	X	X	X	X
NS-ER-01-1000[f]	NA	X	X	X	X	X	X	X
NS-TB-01-1000[f]	NA		X					
NS-FB-01-1000[f]	NA		X					

[a] Total metals include Al, As, Sb, Ba, Be, B, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Na, Si, Se, Ag, Tl, V, and Zn.

[b] Target Compound List (TCL)–VOCs and TCL–SVOCs are to be quantified.

[c] Baseline radionuclides include uranium isotopes (^{234}U, ^{235}U, and ^{238}U), ^{99}Tc, ^{90}Sr, and gamma-emitting isotopes, including but not limited to ^{60}Co, ^{137}Cs, ^{234m}Pa, and ^{234}Th. Uranium-235 shall be quantified by both alpha and gamma spectroscopy.

[d] Transuranic (TRU) isotopes include plutonium isotopes (^{238}Pu, ^{239}Pu, and ^{240}Pu), ^{241}Am, and ^{237}Np. Thorium isotopes (^{228}Th, ^{230}Th, and ^{232}Th) shall also be quantified in these samples.

[e] VOC sample shall be an aliquot collected prior to compositing remaining sample material. For the 0.5- to 2.0-ft and 2.0- to 10.0-ft intervals, the aliquot shall be collected from the portion of the coring with the most elevated photoionization detector (PID) reading.

[f] Samples designated NS-ER, NS-TB, and NS-FB are equipment rinsates, trip blanks, and field blanks, respectively.

NA = not applicable.
PCB = polychlorinated biphenyl.
SVOC = semivolatile organic compound.
VOC = volatile organic compound.

B.5.2.2 Sampling Design for Collection of Concrete Pad Samples

Any chemical contamination remaining on the pad likely resulted from releases of fuel or hydraulic fluids incidental to operation of the crane. Visual inspection of the pad on May 7, 2007, did not indicate any residual staining and, therefore, the two sampling locations indicated in the inset to Fig. B.5.1 were selected to be equidistant from the edge of the pad. The sample identification numbers for these samples are provided in Table B.5.2.

Table B.5.2. Summary of analyses for concrete pad samples at K-1251

Sample Number	Sample depth (in.)	PCBs
NS-04-01-1251	0–2.5	X
NS-05-01-1251	0–2.5	X

PCB = polychlorinated biphenyl.

B.5.3 SAMPLING PLAN

B.5.3.1 Soil Sampling Plan

Surface and sub-surface soil samples shall be collected in accordance with the sampling subcontractor's (SSC's) contract specifications, "Exhibit E, Standard Specifications for Environmental Sampling." The following description of the field sampling methods is provided as a general synopsis and does not supercede the contract requirements.

Surface soil samples collected at each of the locations specified in Fig. B.5.1 shall be manually collected using either a shovel or hand-held auger to obtain a soil sample from the 0.0- to 0.5-ft below ground surface (bgs) interval. Near-surface soil samples (0.5- to 2.0-ft bgs) collected at each of the locations specified in Fig. B.5.1 may be collected using either a hand-held auger or through the use of direct-push techniques (DPT) such as a Geoprobe®[1] drilling rig. Subsurface soil samples (2.0- to 10-ft bgs) will be collected at the specified locations using DPT (e.g., Geoprobe®) to advance 1.5-in. outside diameter (OD) probe rods with a solid, 1.125-in.-diameter drive point from 2.0 to 10 ft bgs. A 48-in.-long, 2.125-in.-OD sampler with acetate liner will be used to collect the soil core from the designated sampling depths.

VOC samples shall be collected as discrete samples from within the designated sample intervals. Following collection of a discrete sample for VOC analysis from the surface soil sample, the remaining soil material for metal, SVOC, PCB, and radionuclide analyses shall be obtained by transferring the collected surface soil material to a stainless steel mixing bowl and homogenizing the material for placement in the sample containers indicated in Table B.5.3. Upon opening the sample liner used for collection of the subsurface soil samples, and near-surface, if applicable, the soil core shall be scanned using a photoionization detector (PID) and a sodium iodide (NaI) detector. Samples for VOC analysis shall be collected from the portion of the sample that exhibits elevated PID readings from the center of the sample core. If no portion of the sample exhibits an elevated reading, the VOC sample shall be selected randomly from the collected material at the center of the sample core. Samples for VOC analyses may be obtained using Encore®[2] samplers or Method 8260B sampling tubes. Samples for SVOC analysis shall also be obtained from the portion of the soil core that exhibits elevated PID readings, if applicable.

Samples for both metals and radionuclides shall be collected from the portion of the soil core that exhibited the most elevated NaI readings upon retrieval of the soil core. If no portion of the core exhibited elevated PID or NaI readings, the sample material for SVOC, PCB, radionuclide, and metal analyses shall be obtained by transferring the soil core from the designated sample interval to a stainless steel mixing bowl and homogenizing the material for placement in the sample containers indicated in Table B.5.3. Sample containers shall be managed as indicated above and in accordance with the SSC's SOPs. Sampling equipment shall be decontaminated between stations in accordance with the SSC's SOPs.

B.5.3.2 Concrete Pad Sampling Plan

Samples from the concrete pad shall be collected at each of the locations specified in the inset to Fig. B.5.1. Core samples of the concrete pad shall be collected using a pre-cleaned, hand-held, power-driven corer with a 2.0-in.-diameter coring bit that is driven into the floor to a depth of ~ 2.5 in. Once the coring bit has reached the specified depth, the bit shall be vibrated to break the concrete sample loose from the slab. The material will be crushed at the laboratory for extraction and analysis. Upon collection of each sample, it shall be transferred to the sample containers indicated in Table B.5.3. Upon filling each container, it shall be sealed, wiped clean, and the lid secured in accordance with the SSC's SOPs. Sampling equipment shall be decontaminated between stations as required by the SSC's SOPs.

---

[1] Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof of its contractors or subcontractors.

[2] Ibid.

Table B.5.3. Container, preservation, and holding time requirements for the K-1251 samples

Sample location	Parameters of concern	Container type/volume	Preservation	Holding time
Locations 01, 02, and 03	Total metals[a]	8-oz glass – Teflon™ closure	Cool 4°C	180 days[a]
	Mercury[a]	Taken from above	Cool 4°C	28 days[a]
Locations 01, 02, and 03	Total volatile organics[b]	Three pre-marked sample tubes extruded to 3- × 40-mL pre-preserved VOA vials or 3 Encore® samplers	One vial Methanol – Cool 4°C One vial Methanol – Cool 4°C One vial $NaHSO_3$ – Cool 4°C	14 days
Locations 01, 02, and 03	Total semivolatile organics[c]	8-oz A-glass – Teflon™ closure[c]	Cool 4°C	14 days[d]
Locations 01, 02, and 03	PCBs (Aroclors)	Taken from above	Cool 4°C	14 days[d]
Locations 01, 02, and 03	Uranium isotopes	1500-g glass – Teflon™ closure	Cool 4°C	180 days
	^{235}U	Taken from above	Cool 4°C	180 days
	Gamma-emitting isotopes[e]	Taken from above	Cool 4°C	180 days
	^{90}Sr	Taken from above	Cool 4°C	180 days
	^{99}Tc	Taken from above	Cool 4°C	180 days
	Total alpha/beta activity	Taken from above	Cool 4°C	180 days
	Total gamma activity	Taken from above	Cool 4°C	180 days
Locations 01, 02, and 03	Pu Isotopes	1500-g glass – Teflon™ closure	Cool 4°C	180 days
	^{241}Am, ^{237}Np	Taken from above	Cool 4°C	180 days
	^{228}Th, ^{230}Th, and ^{232}Th	Taken from above	Cool 4°C	180 days
Locations 04 and 05	PCBs (Aroclors)	8-oz A-glass – Teflon™ closure[c]	Cool 4°C	14 days[d]
Equipment rinsates	Volatile organics	(3) 40-mL VOA vials	pH<2, Cool to 4°C[f]	14 days
	Semivolatile organics	(2) 1-L A-glass – Teflon™[c]	Cool 4°C	7 days[g]
	PCBs	Taken from above	Cool 4°C	7 days
	Total metals	1-L Polybottle	pH<2, Cool 4°C[h]	180 days
	Uranium isotopes	(2) 1-gal Polybottles	pH<2, Cool 4°C[h]	180 days
	^{99}Tc	Taken from above	pH<2, Cool 4°C[h]	180 days
	^{90}Sr	Taken from above	pH<2, Cool 4°C[h]	180 days
	Gamma Isotopes	Taken from above	pH<2, Cool 4°C[h]	180 days
	Total activity	Taken from above	pH<2, Cool 4°C[h]	180 days
Trip blanks	Volatile organics	(3) 40-mL VOA vials	Pre-preserved	14 days
Field blanks	Volatile organics	(3) 40-mL VOA vials	Pre-preserved	14 days

[a] Total metals include Al, As, Sb, Ba, Be, B, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Na, Se, Si, Ag, Tl, V, and Zn. Holding time for mercury is 28 days.

[b] Volatile organic sample shall be an aliquot – collected before compositing material from the specific depth interval. Analytes to be quantified are Target Compound List (TCL)–volatile organic compounds (VOCs).

[c] Analytes to be quantified are TCL–semivolatile organic compounds (SVOCs). A-glass = amber glass.

[d] Holding time is 14 days to extraction and 40 days from extraction to analyses.

[e] Gamma isotopes include ^{234}Th, ^{234m}Pa, ^{137}Cs, ^{60}Co, and other gamma-emitting radionuclides detected above the minimum detectable activity. Uranium-235 shall be quantified by both alpha and gamma spectroscopy.

[f] Preservation requirement for water samples for volatile organic compound analysis is addition of HCl to pH<2 and cool 4°C.

[g] Holding time is 7 days to extraction and 40 days from extraction to analyses.

[h] Preservation requirement for water samples for metals and radionuclides is addition of HNO_3 to pH<2 and cool 4°C.

PCB = polychlorinated biphenyl.

VOA = volatile organic analysis (or analyte).

B.6. ANALYTICAL REQUIREMENTS

Analytical protocols for the analyte groups specified for the samples collected under this SAP are indicated in Table B.6.1. Samples for chemical analyses will be measured by the relevant SW-846 Methods (EPA 1993). Uranium isotopes will be analyzed by alpha spectroscopy except that ^{235}U will also be measured by gamma spectroscopy. Thorium isotopes will be analyzed by alpha spectroscopy; however, ^{234}Th will be measured by gamma spectroscopy. Transuranic isotopes may be measured by alpha or gamma spectroscopy as appropriate. Scintillation counting will be used for quantitation of ^{89}Sr, ^{90}Sr and ^{99}Tc.

Table B.6.1. Analytical requirements for the K-1251 soil samples

Parameters of concern	Analytical protocols
Total metals[a]	6010B
Mercury	7471
Total volatile organics	8260B
Total semivolatile organics	8270C
PCBs (Aroclors)	8082
^{228}Th, ^{230}Th, and ^{232}Th	Alpha spectroscopy
Uranium isotopes	Alpha spectroscopy
^{235}U	Gamma spectroscopy
Gamma-emitting isotopes[b]	Gamma spectroscopy
^{99}Tc	Beta scintillation counting
^{90}Sr	Beta scintillation counting
Pu Isotopes	Alpha spectroscopy
^{241}Am, ^{237}Np	Alpha spectroscopy
Total alpha/beta activity	Radiochemical counting method
Total gamma activity	Gamma scan non-destructive, spectrum method

[a] Total metals include Al, As, Sb, Ba, Be, B, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Na, Si, Se, Ag, Tl, V, and Zn.

[b] Gamma isotopes include ^{234}Th, ^{234m}Pa, ^{137}Cs, ^{60}Co, ^{235}U, and other gamma-emitting radionuclides detected above the minimum detectable activity.

PCB = polychlorinated biphenyl.

Detection limits for chemical analytes of concern are those specified within the relevant SW-846 Method (EPA 1993). Minimum detectable activities for the various radionuclides that must be met by the analytical laboratory are specified in Table B.6.2. Additional analytical quality assurance/quality control and reporting requirements are provided in Appendix A.

Table B.6.2. Potential target radionuclides and reporting requirements

Analysis	Method	MDL Water (pCi/L)	MDL Soil, sludge, floor sweepings (pCi/g)
^{3}H	Radiochemical separation/liquid scintillation counting	580	1100
^{14}C	Radiochemical separation/beta count	31	270
^{60}Co	Gamma spectrometry	0.25	0.0045
Total radioactive Sr	Radiochemical separation/beta count	0.085	1.4
^{99}Tc	Radiochemical separation/beta count	3.4	57
^{137}Cs	Gamma spectrometry	0.15	0.1
^{228}Ac	Gamma spectrometry	1	1
^{228}Th	Radiochemical separation/alpha spectrometry	0.021	0.1
^{230}Th	Radiochemical separation/alpha spectrometry	0.13	0.1
^{232}Th	Radiochemical separation/alpha spectrometry	0.25	0.1
^{234}Th	Gamma spectrometry	1	1
^{234m}Pa	Gamma spectrometry	1	1
^{234}U	Radiochemical separation/alpha spectrometry or TI/MS	0.11	0.1
^{235}U	Radiochemical separation/alpha spectrometry or TI/MS	0.1	0.05
^{238}U	Radiochemical separation/alpha spectrometry or TI/MS	0.077	0.1
^{237}Np	Radiochemical separation/alpha spectrometry	0.016	0.091
^{238}Pu	Radiochemical separation/alpha spectrometry	0.016	0.27
^{239}Pu	Radiochemical separation/alpha spectrometry	0.015	0.25
^{241}Am	Radiochemical separation/alpha spectrometry	0.015	0.22
Total activity	Liquid scintillation ^{99}Tc calibration	10	10

MDL = method detection limit.
MS = mass spectrometry.
pCi/L = picocuries per liter.
Tc = technetium.
TI = thermal ionization.

B.7. DATA MANAGEMENT AND REPORTING

Data obtained from this sampling event shall be managed in accordance with the requirements of the *Data Management Implementation Plan for the Reindustrialization Program, Oak Ridge, Tennessee* (BJC/OR-865, Rev. 2). Results will be provided to the U. S. Environmental Protection Agency, Region 4, and to the Tennessee Department of Environment and Conservation U. S. Department of Energy-Oversight Office.

B.8. REFERENCES

BJC (Bechtel Jacobs Company LLC) 2006. *Data Management Implementation Plan for the Reindustrialization Program, Oak Ridge, Tennessee*, BJC/OR-865, Rev. 2, Oak Ridge, TN, August.

EPA (U. S. Environmental Protection Agency) 1993. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846*, Third Edition (November 1986; Rev. 1, July 1992; Rev. 2, November 1992; and Update 1, August 1993), Office of Solid Waste, Washington, D.C., August.

APPENDIX A

ADDENDUM TO THE BASIC ORDERING AGREEMENT ATTACHMENT 1 STATEMENT OF WORK MINIMUM REQUIREMENTS FOR RADIOCHEMISTRY FOR BECHTEL JACOBS COMPANY, LLC REINDUSTRIALIZATION PROJECT

09 May 2007

A.1. INTRODUCTION

It is the purpose of this addendum to supplement the technical requirements in the Bechtel Jacobs Company, LLC Sample Management Office (BJC SMO) Analytical Support Agreement to provide guidance for radiological analyses on air filter, soil, sludge, floor sweepings, vegetation, animal tissue, and water samples for the Bechtel Jacobs Company, LLC Reindustrialization Project (BJCRP). These samples will be analyzed for the presence of the radionuclides listed in the Target Radionuclide List (TRL) Tables 1, 2, and 3 (Attachment I of this addendum) found at the end of this addendum. BJC SMO retains sole responsibility and authority for authorization/requesting of services. The Subcontractor will be responsible for all authorized/requested analytical activities. The Subcontractor shall expect to receive samples starting FY 2001.

The Subcontractor shall provide the analytical services described above in the context of work elements. These elements, as further explained below, include: radiochemistry analyses, sample accountability and integrity, results reporting, quality assurance/quality control (QA/QC) programs, audits, and technology transfer. These elements and individual activities identified in connection with them are subject to revision to reflect any changes in regulatory or programmatic requirements during the course of contract performance.

A.2. SCOPE

The subcontractor laboratory shall provide analytical services for the determination of radionuclide constituent activities in the following media: air filter, soil, sludge, floor sweepings, vegetation, animal tissue, and water samples. A project-specific TRL is found in Tables 1, 2, and 3 (Attachment I of this addendum) at the end of this addendum. BJCRP reserves the right to amend the TRL at any time during the period of performance.

Throughout this Addendum, the term *shall* indicates a requirement, *should* indicates a recommendation, and *may* indicates an acceptable practice (neither a requirement, nor a recommendation). The bidder shall explicitly accept all requirements, or list all exceptions to any requirements of this addendum.

The sampling team will appropriately identify all samples and will submit chain of custody (COC) and analytical request forms with the samples. Because samples may contain radioactive materials, project personnel will perform radiological field surveys of all samples. Any samples that show elevated radiation exposure rates will be identified on individual sample tags. No samples that violate U.S. Department of Transportation (DOT) or U.S. Department of Energy (DOE) regulations will be shipped. In addition, any sample containing greater than 70 Bq per gram of all radionuclides shall be clearly classified, packaged, and shipped according to DOT regulations.

A.3. ORDER RELEASES AND DELIVERY OF RESULTS

The sample management office (SMO) will place all order releases for sample analyses, under any resulting subcontract by using an appropriate Request for Analysis form. Samples will be delivered or shipped, freight prepaid, to the subcontract laboratory. Analysis results shall be provided to SMO and Science Applications International Corporation (SAIC) within the applicable determination and reporting time. Final data packages shall be provided within 21 calendar days from sample receipt based on turn around time needs and interim status reports shall be provided within 11 calendar days respectively of sample receipt. Analysis results shall be sent to the attention of both:

Ms. Robin Crabtree
105 Mitchell Road Suite 202
Oak Ridge, TN 37831

Ms. Teresa Yearwood/
Ms. Tammy Presley
SAIC
301 Laboratory Road
Oak Ridge, TN 37831

A.4. RADIOLOGICAL ANALYSIS ANALYTICAL SUPPORT SERVICES

This section of the addendum addresses the processing of air filter, soil, sludge, floor sweepings, vegetation, animal tissue, and water samples for the BJCRP. Processing encompasses sample handling, storage, analysis, data review, and reporting.

In support of site investigation activities being conducted by BJCRP, radioanalytical services are being requested through the ICPT and this addendum. These services will include the following:

- COC receipt return and management of samples and results according to an approved QA program for all laboratory analytical facilities;
- sample preparation capabilities for soils and floor sweepings before sample interim storage and sample analysis;

- radiological analyses for all sample media to include radionuclide-specific analyses and spectral analyses as described in this addendum;
- post-analysis sample storage and proper waste material disposition; and
- hard copy and electronic transmittal by disk of analysis results in accordance with specified format and QA requirements. Further details on the analytical and QA requirements in support of this effort are provided below.

A.4.1 ANALYTICAL SERVICES

The laboratory will be approved by BJCRP for participation under this addendum. BJCRP approval will be given based on results of a procedure review and gamma spectrometry radionuclide library review of SMO certified laboratories. The laboratory needs to provide a copy of all technical procedures and the proposed gamma spectrometry radionuclide library for this review prior to award of subcontract.

Follow the guidance found in Sect. 1.1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry" with the addition of the following. Analyses identified in the TRL (Tables 1, 2, and 3, Attachment I of this addendum) shall be conducted in accordance with the specified EPA-600/4-80-032 *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, August 1980; EPA SW-846 *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, December 1987; EPA 520/5-84-006 *Eastern Environmental Radiation Facility Radiochemistry Procedures Manual*, August 1984; EML HASL-300 *Environmental Measurements Laboratory Procedure Manual*, 26th or 27th editions; LA-10300-M *Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance*, October 1996; ISBN-157477-021-7 *DOE Methods for Evaluating Environmental and Waste Management Samples – 1997 edition*; any appropriate ASTM methods; or any additional project-approved methods. Maximum holding times, QC measures, detection limits, preservation of samples, and data reporting shall comply strictly with those found in Sect. A.4.2 and in Tables 1, 2, and 3 (Attachment I of this addendum). All laboratory analyses must be performed within the allowable holding times established by the applicable analytical procedure and the addendum.

All results for soil and sediment samples will be reported on a dry-weight basis. The percent moisture will be reported for all solid samples replacing Sect. 1.6.2 of Attachment J to Basic

Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.

The sample preparation method to be used for this project is total sample dissolution for all analyses except for gamma spectrometry which the samples will be analyzed as is, replacing Sect. 1.6.2 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry."

This paragraph replaces Sect. 3.1.2.2 of the "Basic Ordering Agreement Attachment 1 Statement of Work Laboratory Analytical Services." Upon receipt at the laboratory, the samples will be examined immediately to determine damage or loss during transport. If problems with samples are determined, this shall be noted on the COC form; otherwise, the COC form shall be marked "RECEIVED IN GOOD CONDITION." The sample condition will be indicated on a Sample Receiving Report (SRR). If samples are damaged or otherwise compromised, the laboratory immediately shall notify Ms. Crabtree by phone (865)241-1368. The samples will be logged in and appropriately maintained in the laboratory until submitted for analyses. After the appropriate laboratory information and required signatures have been added to the COC and SRR, within 5 working days the laboratory will return signed copies to BJC SMO to the Project Data Coordinator, and the Project QAOs. In addition, a laboratory-generated report including project sample number, laboratory sample number, and analyses to be performed must be provided with the COC documentation (see also Sect. A.4.3.4 of this addendum). The COC form will be accompanied by an analyses request form.

Upon written notification from the SMO at the end of the project, the laboratory will return copies of all original documentation (excluding magnetic tape) generated as part of the project. All project documentation will be neatly inventoried, listed, page numbered, and boxed.

This paragraph replaces Sect. 3.1.3.4 of the "Basic Ordering Agreement Attachment 1 Statement of Work Laboratory Analytical Services." Samples will be archived for 6 months from the submittal of the laboratory analytical report. If storage beyond this timeframe is necessary it will be communicated to the laboratory prior to samples disposal.

A.4.2 QUALITY CONTROL AND DATA REDUCTION REQUIREMENTS

The following is a description of the minimum QC requirements for laboratory analyses. In this document, "batch" is defined as the group of samples processed at one time in the same area of the laboratory, using the same method. The number of samples in a batch shall not exceed 20 samples. The number of samples in a data package also shall not exceed 20 samples.

A.4.2.1 Holding Times and Preservative Requirements

(In addition to Sect. 1.2 of Part 1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.")

Holding time is the time between sample collection and sample analysis. Technical requirements for sample holding times and preservatives have been established. Preservatives are required for water but not for soil matrices. Holding times and preservative requirements for water and soil matrices are as follows:

- Tritium solutions: 6 months, cool to 4 °C with no preservative and stored in glass.
- Cesium: 6 months; water matrices, preserved to pH <2 in hydrochloric acid
- Plutonium: 6 months, water matrices, when preserved in 2M nitric acid.
- Other radionuclides: 6 months; water matrices, preserved to pH <2 in nitric or hydrochloric acid.

In addition the maximum sample holding time shall not exceed five half-lives of an unsupported nuclide of interest when five half-lives are shorter than 180 days. Sample specific guidance/requirements may be provided by the SMO for specific isotopes or for very short-lived isotopes.

A.4.2.2 Calibration

(In addition to the calibration section of Parts 2, 3, 4, and 6 of Part 1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.")

Calibrations and routine system checks are to be performed according to the following schedule:

1. Initial and Continuing Calibration

   a) Alpha and Gamma Spectroscopy Measurements

      Energy versus channel calibration shall be established for spectroscopy systems quarterly or when the daily performance check indicates an unacceptable change in energy gain or zero offset.

      Resolution versus energy calibration shall be established for gamma spectroscopy systems quarterly or when the daily performance check indicates an unacceptable change in system resolution.

      Spectroscopy systems shall be efficiency calibrated for each applicable counting geometry annually or when the daily performance check indicates an unacceptable change in system efficiency. Efficiency versus energy curves shall be established for gamma spectroscopy systems for the energy region of interest. Single efficiency values may be used for alpha spectroscopy systems for alpha energies between 4.0 and 6.0 MeV.

      Spectroscopy system backgrounds shall be established quarterly or when the routine performance check indicates an unacceptable change in system background.

   b. Gas Flow Proportional and Other Gross Counting Measurements

      The gross counting systems must be efficiency calibrated for each alpha and beta counting geometry at least annually or when the daily performance check indicates an unacceptable change in system efficiency. Self-absorption curves must be developed at least annually, or if the absorption correction is included in an efficiency curve, a new curve must be developed when the daily performance check indicates an unacceptable change in system efficiency. A plateau curve and alpha/beta cross-talk factors must be established, and a performance check must be made after each P-10 counting gas bottle change. If an unacceptable change has occurred due to the new counting gas, then the new gas must be replaced.

If, out of necessity, counting is performed using undesirable counting gas, a special calibration must be performed for that gas.

The counter background must be established quarterly or when the routine performance check indicates an unacceptable change in instrument background. If desired, matrix or batch blanks may be used for background subtraction rather than counter background.

c. Liquid Scintillation Spectrophotometer

Efficiency quench curves must be established for the liquid scintillation spectrophotometer for each radionuclide to be counted at least annually or when the daily performance check indicates an unacceptable change in system efficiency. Instrument high voltage, gain, energy calibration, or quench indicator calibration must be adjusted using standard instrument calibration sources prior to calibration and routinely (usually daily) thereafter in order to maintain valid quench calibrations over the year. An efficiency calibration is not required when comparative measurement or internal standardization is used. However, calibration verification shall be performed.

The counter background must be established quarterly or when the routine performance check indicates an unacceptable change in instrument background. Background quench curves must be established for each radionuclide to be counted unless matrix or batch blanks are used for background subtraction.

2. Routine Calibration Verification

a) Spectroscopy Systems

The energy, resolution, and efficiency calibration shall be checked using a check source each day that the system is used. The check source shall have both low- and high-energy peaks, and the centroid energy, full width at half maximum, and net counts under each calibration peak (corrected for decay) shall be recorded and should be plotted on a control chart daily.

The counter background shall be checked 1 of every 20 counting periods or daily, whichever is less frequent. The net count rate in each background peak (gamma) or region (alpha) shall be recorded, and should be plotted on a control chart, and shall be compared to the established background spectra used for background subtraction. Acceptable tolerances shall be established for each background peak or region. When tolerance limits are exceeded, or when new background peaks are identified, a new background shall be established for the system.

Acceptable tolerances shall be established for each control chart based on system performance and analytical requirements. When tolerance limits are exceeded, recalibration shall be performed.

b. Gas Flow Proportional and Other Gross Counting Measurements

The efficiency calibration of gross counting systems must be checked using alpha and beta (if applicable) check sources each day that the system is used. The net alpha and beta counts (corrected for decay) and the alpha/beta cross-talk must be recorded and should be plotted on a QC chart daily.

The counter background must be checked each day that the system is used. The background alpha and beta counts must be recorded and should be plotted on a QC chart daily.

Acceptable tolerances must be established for each QC chart based on system performance and analytical requirements. Maximum tolerance limits of ± 10% of the value determined at time of calibration are recommended for efficiency verification control charts; otherwise, tolerance limits of ± 3 standard deviations are recommended. When tolerance limits are exceeded, recalibration is required.

c. Liquid Scintillation Spectrophotometers

The efficiency of liquid scintillation spectrophotometers must be checked using a calibration source each day that the system is used. The net counts (corrected for decay) must be recorded and should be plotted on a QC chart daily.

The counter background must be checked each day that the system is used. The background alpha and beta counts must be recorded and should be plotted on a QC chart daily.

Acceptable tolerances must be established for each QC chart based on system performance and analytical requirements. Maximum tolerance limits of ± 10% of the value determined at time of calibration are recommended for efficiency verification control charts; otherwise, tolerance limits of ± 3 standard deviations are recommended. When tolerance limits are exceeded, recalibration is required.

A.4.2.3 Blanks

(Replaces Sect. 2.3.1 of Part 1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.")

A method blank shall be prepared by the laboratory and analyzed with each batch of samples or at a frequency of 5% of the total samples in the batch, whichever is the higher frequency. The blank shall be introduced into the analytical process before any physical or chemical processing. The results of all method blanks shall be recorded and should be plotted on a control chart daily for each method. Acceptable tolerances shall be established for each control chart based on system performance and analytical requirements.

If the method blank is not used for background subtraction, it shall be used in the following manner in all analyses to ascertain whether sample concentrations reflect contamination:

- If the absolute value of the concentration of the blank is less than or equal to the associated uncertainty, no correction of sample results is performed.

- If any radionuclide activity concentration in the blank is above the associated uncertainty, the lowest concentration of that radionuclide in the associated samples must be 5 times the blank concentration. Otherwise, all samples associated with the blank that have a radionuclide activity concentration less than 5 times the blank concentration and above the associated uncertainty must be reported (on Form 2 in Attachment II or equivalent) or discussed in the Case Narrative.

A.4.2.4 Sample Specific Chemical Recovery

(Replaces Sect. 2.4 of Part 1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.")

Laboratory performance on individual samples subject to chemical processing and separation shall be established by spiking each sample with tracer quantities of other radioisotopes of the same element, or carrier quantities of the inactive isotope of the same, or a chemically similar element for all methods possible. Table 4 contains a list of acceptable tracers for use with this project. For all methods possible, samples shall be spiked before both physical and chemical processing. Sample recoveries should be within 10–100%, but regardless of the recovery the quantity of tracer material used shall be adequate to provide a maximum of 10% uncertainty at the 95% confidence level in the measured recovery. Each chemical tracer percent recovery shall be reported (on Form 3 in Attachment II or equivalent) and should be plotted on a control chart for each radionuclide and method and should fall within the prescribed limits.

The laboratory shall not correct for any recovery greater than 100%. In case of recovery greater than100%, the laboratory shall report the sample-specific chemical recovery as determined, but only correct results to 100%. An exception to this requirement may be granted when certified value alpha tracers are used and the laboratory only performs an approximately efficiency calibration (perhaps not in the exact geometry as the samples or not using a certified standard) only for purposes of calculating the tracer recovery (the tracer serves as the calibration).

Table 4: Acceptable Tracers or Carriers for Sample-Specific Chemical Recovery

Radionuclide of Interest	Acceptable Tracer or Carrier
Total Radioactive Sr	^{85}Sr or Inert Sr
^{99}Tc	^{99}Tc or ^{95m}Tc
$^{228/230/232}$Th	^{234}Th or ^{229}Th
$^{234/235/238}$U	^{232}U
^{237}Np	^{239}Np
$^{238/239/240}$Pu	^{242}Pu or ^{236}Pu
^{241}Am	^{243}Am

A.4.2.5 Laboratory Control Sample

(Replaces Sect. 2.3.2 of Part 1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.")

The laboratory control sample (LCS) serves as a monitor of the overall performance of all steps in the analysis, including the sample preparation. The LCS concentration shall be greater than 10 times the detection limit activity. At least one sample per batch, or 5% of the total number of samples, shall be an LCS, whichever is the greater frequency. All LCS results must be within the control limits of 80–120% for aqueous LCS's and 70–130% for solid LCS's recovery of the standard value. All LCS results shall be recorded and should be plotted on a control chart according to sample type and radionuclide and shall fall within the prescribed limits. The LCS may be purchased or prepared by the subcontractor in a similar matrix as the samples being analyzed.

All LCS results and LCS percent recovery (LCS %R) shall be reported (on Form 4 Attachment II or equivalent). If the results for the LCS fall outside the LCS %R control limits of 80–120% for aqueous LCS's and 70–130% for solid LCS's, the analyses must be terminated, the problem corrected, and the samples associated with that LCS reanalyzed, including redigestion if necessary.

A.4.2.6 Matrix Spike Sample Analysis

(Replaces Sect. 2.3.4 of Part 1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.")

The matrix spike sample analysis provides information about the effect of each sample matrix on the digestion and measurement methodology. Samples identified as field QC samples cannot be used for spiked sample analysis. When analyses *do not have* sample-specific chemical recovery mechanisms (Sect. A.4.2.4), at least one sample per batch, or 5% of the total number of samples, shall be a matrix spike, whichever is the greater frequency. Matrix spike sample percent recovery (MSS %R) must be within the limits of 70–130%. However, spike recovery limits do not apply when the sample concentration exceeds the spike concentration by a factor of 4 or more. The MSS %R of the matrix spike shall be recorded and plotted on a control chart and shall fall within the prescribed limits.

Under "MSS %R," the value (to one decimal place) is entered for the percent recovery for all spiked analytes, computed according to the following equation:

$$MSS\ \%R = \frac{(SSR - SR)}{SA} \times 100\%$$

where:

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added

MSS %R must be reported, whether it is negative, positive, or zero.

The values for SSR, SR, and SA must be exactly those reported (on Form 5 Attachment II or equivalent). A value of zero must be used for SSR or SR if the radionuclide value is less than zero (0).

In the instance where there is more than one spike sample per matrix and concentration per method per batch, if one spike sample recovery is not within contract criteria, all of the samples of the same matrix, level, and method in the batch must be flagged.

The units (i.e., pCi/L for aqueous and pCi/g dry-weight basis for solid) for reporting spike sample results will be identical to those used for reporting sample results (on Form 1 in Attachment II of this addendum or equivalent).

A.4.2.7 Duplicate Analysis Samples

(Replaces Sect. 2.3.3 of Part 1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.")

Duplicate analyses are indicators of laboratory precision. Samples identified as field QC samples cannot be used for duplicate sample analysis. At least one sample per batch, or 5% of the total number of samples, shall be a duplicate, whichever is the greater frequency. The duplicate samples shall be created by the laboratory after physical processing and mixing and before the chemical processing.

The duplicate error ratio (DER), which is the ratio of the difference between the duplicate results to the propagated 2 standard deviations uncertainties for the sum of the duplicate results, shall be recorded and should be plotted on control charts and shall fall within the control limit set at 1.29.

The relative percent difference (RPD), which is the ratio of the difference between the duplicate results to the average of the duplicate results multiplied by 100% shall be recorded and should be plotted on control charts and shall fall within the control limits set at ±30%.

The DER and RPD for all radionuclides detected in either the sample or the duplicate are computed according to the following equations:

$$DER = \frac{|S - D|}{\sqrt{(2\sigma_S)^2 + (2\sigma_D)^2}}$$

$$RPD = \frac{(S - D)}{\left(\frac{(S + D)}{2}\right)} \times 100\%$$

where:

S = First Sample Value

D = Second Sample Value

$2\sigma_S$ = First Sample Uncertainty

$2\sigma_D$ = Second Sample Uncertainty

The duplicate analyses results shall be in agreement when either of the DER or RPD criteria are met. The duplicate analyses results shall be reported on Form 6 or equivalent (Attachment II of this addendum).

A.4.2.8 Method of Calculating Minimum Detection Limits (MDLs)

(Replaces Sect. 2.6 of Part 1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.")

Required MDLs are given in Tables 1, 2, and 3 Attachment I. MDL is defined below. All samples shall be analyzed using aliquot sizes and counting times that will provide an MDL equal to or less than the required MDL based on *a priori* calculations. Analyses having an *a priori* calculated MDL not meeting the required MDL specifications shall be described in the case narrative.

The detection level is an *a priori* estimate of the smallest quantity that can be measured so that the probabilities for false detection and false nondetection are both 5%. The MDL assumes no interfering nuclide. The MDL is determined according to the following formula[1]:

$$\mathrm{MDL} = k_a S_o + k_b S_D$$

where:

k_a = 1.645 = the value for the upper percentile of the standardized normal variate corresponding to the 0.05 risk probability for concluding falsely that activity is present.

k_b = 1.645 = the value for the upper percentile of the standardized normal variate corresponding to the 95% confidence level for detecting the presence of activity.

S_o = the standard deviation of the net sample activity when the sample contains none of the constituent of interest at the MDL level.

S_D = the standard deviation of the net sample activity when the sample contains the constituent of interest at the MDL.

S_o and S_D may be estimated from the standard deviation of a number of determinations of blanks (S_b). When this is done, the k_a and k_b shall be replaced by the t factor appropriate for the number of determinations from the standard Student's t Table. Therefore, the MDL equation reduces to:

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[1] Currie, L. A., "Limits for Qualitative Detection and Quantitative Determination." *Analytical Chemistry* **40**, No. 3, (March 1968) p. 589.

$$MDL = \frac{2t * s_b}{KT_S} + \frac{t^2}{KT_S}$$

s_b = standard deviation of the blank population where the blank population is in net blank counts in count time T_S

T = count time in minutes

K = efficiency * $e^{-\lambda t}$ * aliquot fraction * tracer recovery* ABN
    efficiency = detector efficiency
    t = time from sample collection to mid-point of count time(or nuclide separation time, as applicable) in the same units as half-life
    λ = Analyte decay constant = ln2/(half-life)
    ABN = abundance

The square root of the background shall not be used as an estimate of the standard deviation of the blank.

A.4.2.9 Method of Determining if a Radionuclide is Detected

The following equation is to be used determine the decision level that will be used for the detection status of a radionuclide of interest:

$$DL = 1.65 \times TPU_R$$

where: DL = decision level (dpm/unit)
TPU_R = total propagated uncertainty of the result, R (dpm/unit)

If the radionuclide of interest reported result is less than the decision level (i.e., 1.65 × TPU_R) for sample flag the result as undetected (U) (on Form 1 in Attachment II or equivalent).

A.4.2.10 Target Radionuclide List Identification (Gamma Spectroscopy)

The TRL contains those radionuclides for which a quantitative analysis is required as defined in Table 3 (Attachment I). Therefore, net quantitation with uncertainties shall be provided for all TRL radionuclides whether or not the radionuclide is identified in the peak search and identification. This net quantitation is accomplished by determining the net area in the region associated with the radionuclide when the radionuclide is not detected by the peak search routine. When a peak is detected for the radionuclide, positive identification is achieved through the use of the following criteria:

- Target radionuclide energy must be within 2 keV of the observed peak.
- Gamma spectra of the sample radionuclide *must* contain 55% of total gamma abundance of the standard radionuclide library.

A.4.2.11 Tentatively Identified Radionuclides (Gamma Spectroscopy)

Gamma spectra peaks in radionuclide analyses that are not TRL isotopes are potential tentatively identified radionuclides (TIRs). TIRs must be identified by a radionuclide spectra library search. The identified TIRs shall be quantitated and reported in a peak search nuclide identification report, but not included on Form 1.

1. Identified radionuclide energy must be within 2 keV of the observed peak.
2. Gamma spectra of the sample radionuclide and the standard radionuclide library must match according to the following criteria:
   a. 55% of total abundance listed in the standard radionuclide library *must* be present in the sample spectrum.
   b. The sampling-to-count time must not be greater than 10 half-lives of the identified radionuclide.
3. Radionuclide concentrations present in the gamma spectra must be consistent with related radionuclides (e.g., when daughter radionuclides are expected to be in equilibrium with parents, detection of both provides confirmation of identification).

4. All peaks greater than 3 standard deviations of the background identified radionuclides spectrum should be considered and identified if possible.

5. Guidelines for tentative identification are as follows:

   a. Peaks present in the sample spectrum but not in the reference spectrum shall be reviewed for possible background contamination or interference.

   b. When the above criteria are not met, but the gamma spectral interpretation specialist judges the identification to be correct, the identification may be reported.

   c. If the gamma spectral interpretation specialist judges the identification to be uncertain or there are extenuating factors affecting radionuclide identifications, the TIR result may be reported as "unknown."

A.4.3 REPORTING REQUIREMENTS

A.4.3.1 Radionuclide Quantitation

(Replaces Sect. 2.5 of Part 1 of Attachment J to "Basic Ordering Agreement Attachment 1 Statement of Work Minimum Requirements for Radiochemistry.")

Analytical uncertainties shall be reported with all results to qualify the data. For all radionuclide analyses, the result shall be reported as the actual measurement result, whether positive or negative, with its associated 2σ uncertainty. Reporting results as "less than" or as "not detected" is not acceptable. The reported uncertainty shall include all uncertainties associated with the analysis (i.e., total propagated or combined standard uncertainty). So that the number of significant figures reported for results reflect the precision of the analytical technique, the laboratory shall report two significant figures for the uncertainty and the result shall be reported to the same decimal place as the uncertainty.

A.4.3.2 Reporting Times

Routine analytical service turnaround, including QA documentation, *shall be 21 calendar days*, beginning the day of sample receipt at the laboratory and ending the day of data package receipt at the SMO. Dates of receipt and shipment shall be documented by the laboratory.

A.4.3.3 Data Package

(In addition to Sect. 2.3.4 of Part 1 of Attachment I to "Basic Ordering Agreement Attachment 1 Statement of Work Data Package Components.")

The laboratory will deliver a complete data package consistent with QC requirements specified in this addendum. All results will be reported on a dry-weight basis for soils and floor sweepings. The percent moisture will be reported for all solid samples. For all requested analyses, the subcontractor laboratory shall provide completed reporting forms (Attachment II of this addendum) and other deliverables as specified in the data package checklist (Attachment III of this addendum). *Although the data forms attached are just example forms, their content shall be required to be in the data package for review.*

All paper copy reports shall be certified by the Laboratory QAO and must be signed and dated stating that verification was performed. The paper copy shall be transmitted to BJC SMO using document control procedures (e.g., transmittal and receipt forms). Before receiving the first samples, a standard operating procedure shall be developed by the laboratory (and approved by the SMO) that will ensure that the paper copy is correct and that describes document revision procedures once the deliverables are sent to the SMO. The following statement, signed by the Laboratory QAO, shall be included with the report narrative:

> "The laboratory certifies that all methods and performance criteria used were those described in the applicable SOW developed by BJCRP specifically for this project. Furthermore, that all data outside the project performance criteria has been approved by the Project QAO for this project and that he or she has received a satisfactory (as determined by the Project QAO) explanation."

Supporting QC data for these analyses shall be reported for QC analyses required by the addendum and reported on forms supplied by Project Management (Attachment II in this addendum). These QC data shall include all data required by the addendum.

Documentation shall be included with all results to associate the project sample identification number and the laboratory sample identification number to the specific analyses performed for each of these sample identification number combinations. For each reported value, the subcontractor laboratory shall include in the data package all raw data used to obtain that value. The data packages, including the forms in Attachment II of this addendum, and a copy of all raw data shall be provided to the SMO no later than 21 calendar days following sample receipt. The raw data (Attachment III) shall include standard, QC, and sample instrument output; lab logbooks sheets; preparation log sheets; sample logging data; external and internal COC sheets; standard preparation logs; run logs; calibration data; calibration verification data, and/or control charts. Instrument output shall include spectral channel counts or spectral peak search and nuclide identification reports. Calibration verification data and/or control charts for background, resolution, energy, and efficiency shall be provided and can be delivered on a project basis. All laboratory QC sample analyses (blanks, spikes, etc.) will be cross-referenced to the applicable environmental and field sample analyses.

Initial calibration and calibration verification on day of initial calibration information shall be provided prior to the shipment of the first samples. Whenever a new initial calibration is performed, a copy of the new initial calibration and calibration verification information shall be delivered to the project in the same manner as a data package (see Sect. A.3 of this addendum).

The laboratory shall provide a summary status report to the SMO at 11 calendar days after sample receipt. The report will include the number of samples received, the number of analyses and samples completed, the number of analyses in progress and remaining, and any nonconformances or problem areas noted.

A.4.3.4 Chain of Custody

All COC forms will be compared with the sample labels on the containers received at the laboratory. An SRR shall be prepared and sent to Project QAO that describes any differences in the COC forms and the sample labels or tags. Other deviations, such as broken or otherwise damaged containers, must be noted on the receiving report. The signed copy of the COC form shall be returned to the Project Data Coordinator within 5 working days, along with a laboratory-generated report which includes the project sample number, laboratory sample number, and analyses to be performed (Sect. A.4.1, paragraph 5 of this addendum).

4.4 CORRECTIVE ACTIONS

The subcontractor laboratory shall be responsive to corrective actions recommended by BJCRP through the SMO. The laboratory must present a final report to the SMO detailing all corrective actions taken to resolve the deficiencies identified under the performance evaluation. Corrective actions shall be performed within 30 days from receipt of a corrective action report at the subcontractor laboratory. Failure to correct deficiencies may result in, but not be limited to, the following actions:

- reduction in the number of samples sent under the addendum;
- suspension of sample shipment;
- additional audits or evaluations; or
- subcontract and/or addendum termination.

Nonconformance Reports (NCR) may be issued to the laboratory and must be either closed or a written response prepared within the negotiated period identified in the NCR. Nonconformances or deficiencies in data deliverables must be resolved before work is accepted. Corrected and resubmitted data shall be clearly identified as such by acceptable procedure, which will include, at a minimum, "AMENDED," the NCR number, laboratory manager signature, and date.

NCRs will be cited on all nonconformances, including those identified on SRRs, COCs, and other deliverables. The laboratory shall have a specified period in which to resolve each NCR.

4.5 RECORDS RETENTION

The subcontract laboratory shall have a records management program for all record material and data generated by the processes necessary to perform the radiochemical analyses. The records management program shall have, at a minimum, the following:

- written procedures for handling laboratory records and data throughout their life cycle;
- a system for rapid retrieval of requests for records;
- written records retention and disposition schedules that reflect Federal, State, and local legislative and regulatory requirements;
- criteria for identifying QA/QC records and encapsulating QA/QC records procedures within the overall records management program.

The subcontract laboratory shall stipulate which record series shall be created and then manage in accordance with the records' life cycles. These records shall, at a minimum, include the following:

- program and policy manuals;
- implementing procedures;
- equipment calibration and maintenance;
- results of all QC performance checks;

- audit case files, including records management and QA audits; and
- data used in the determination of sample results.

Documentation and records generated by the Subcontract Laboratory for this contract shall be retained on-site by the Subcontract Laboratory for a period not to exceed five calendar years. Records may be sent to BJC SMO at mutually agreed upon intervals. Request for copies of records over and above a reasonable number may be made and will be considered as added scope. No record shall be disposed of by the Subcontract Laboratory at any time during the contract performance without the concurrence of BJC SMO.

Attachment I

Target Radionuclide List with Minimum Detection Limits

Table 1

Potential Alpha Emitting Target Radionuclides and Reporting Requirements for 21 Calendar Days Turn Around Times[a]

Analysis	Method	MDL Water (pCi/L)	MDL[a] Soil, Sludge, Floor Sweepings (pCi/g)
^{228}Th	Radiochemical Separation/Alpha Spectrometry	0.021	0.1
^{230}Th	Radiochemical Separation/Alpha Spectrometry	0.13	0.1
^{232}Th	Radiochemical Separation/Alpha Spectrometry	0.25	0.1
^{234}U	Radiochemical Separation/Alpha Spectrometry or TI/MS	0.11	0.1
^{235}U	Radiochemical Separation/Alpha Spectrometry or TI/MS	0.1	0.1
^{238}U	Radiochemical Separation/Alpha Spectrometry or TI/MS	0.077	0.1
^{237}Np	Radiochemical Separation/Alpha Spectrometry	0.016	0.091
^{238}Pu	Radiochemical Separation/Alpha Spectrometry	0.016	0.27
^{239}Pu	Radiochemical Separation/Alpha Spectrometry	0.015	0.25
^{241}Am	Radiochemical Separation/Alpha Spectrometry	0.015	0.22

[a] MDLs for air filters, Vegetation, and animal tissue will be provided on a case-by-case basis.

[b] MDLs are based on the availability of 200g sample size for soil.

Table 2

Potential Beta Emitting Target Radionuclides and Reporting Requirements for 21 Calendar Days Turn Around Times[a]

Analysis	Method	MDL Water (pCi/L)	MDL[b] Soil, Sludge, Floor Sweepings (pCi/g)
^{3}H	Radiochemical Separation/Liquid Scintillation Counting	580	1100
Total Radioactive Sr	Radiochemical Separation/Beta Count	0.085	1.4
^{99}Tc	Radiochemical Separation/Beta Count	3.4	57

[a] MDLs for air filters, Vegetation, and animal tissue will be provided on a case-by-case basis.

[b] MDLs are based on the availability of 200g sample size for soil.

Table 3

Potential Gamma Emitting Target Radionuclides, Gross Analyses, and Reporting Requirements for 21 Calendar Days Turn Around Times[a]

Analysis	**Method**	**MDL Water (pCi/L)**	**MDL[b] Soil, Sludge, Floor Sweepings (pCi/g)**
Gamma Emitters[c]			
^{137}Cs	Gamma Spectrometry	0.15	0.1
^{228}Ac	Gamma Spectrometry	1	1
^{234}Th	Gamma Spectrometry	1	1
^{234m}Pa	Gamma Spectrometry	1	1
Gross Analyses			
Total Activity	Liquid Scintillation ^{99}Tc Calibration	10	10

[a] MDLs for air filters, Vegetation, and animal tissue will be provided on a case-by-case basis.

[b] MDLs are based on the availability of 200g sample size for soil.

[c] The subcontract laboratory shall resolve and quantify unknown mixtures of gamma-emitting radionuclides. The nuclides and MDLs listed shall be interpreted as minimum capability; the subcontract laboratory shall detect and quantify unspecified gamma-emitting radionuclides with a detection limit commensurate with its photon yield and energy, related to the Cs-137 MDL. Project Management may relax the MDLs for individual nuclides in mixtures if requested and justified by the subcontract laboratory.

Attachment II

Radiochemical Analysis Data Reporting Forms

ENVIRONMENTAL SURVEY
COVER PAGE
RADIOMETRIC DATA ANALYSIS PACKAGE

Lab Name: ____________________________ Case No.: _______________

Method Type: ____________________________ SDG No.: _______________

Matrix: _______________

Sample Numbers

Client ID	Lab ID No.

Comments: ____

____

____

Release of the data contained in this data package has been authorized by the laboratory manager or the manager's designee, as verified by the following signature:

____

Manager, Radiological Laboratory

Date: ________________________

RADIOMETRIC ANALYSIS RESULTS

FORM 1

Date: ____________________

Lab Name: ____

Case No.: ____________________

Method Type: ____

SDG No.: ____________________

Client Sample No.	Lab ID No.	Sample Type	Radio-nuclide	Result	Lab Q	2σ TPU Uncertainty	Units	Analysis Date	Method No.	Instrument ID	Val Q

Legend shall be attached.

Comments: ____

____

____

BLANK SUMMARY
FORM 2

Lab Name: ______________________________ Contract: ______________

Lab Sample: ______________________________ SDG No.: ______________

Blank Matrix (soil/water): ___________________ Case No.: ______________

Concentration Units (pCi/L or pCi/g): ____________________

Radiochemical Determination	Method Blank Result	Method Blank 2σ Uncertainty	Field Blank Result	Field Blank 2σ Uncertainty	Trip Blank Result	Trip Blank 2σ Uncertainty

Comments: ____

____

____

CHEMICAL RECOVERY
FORM 3

Lab Name: ______________________ Contract: ______________

Radiochemical Determination: ______________ SDG No.: ______________

Sample Matrix (soil/water): ______________ Case No.: ______________

$$CT\%R = \frac{CT_{Found}}{CT_{True}} \times 100$$

Spike Units (pCi or mg) ______________

Sample Identification	Chemical Tracer	Chemical Tracer/Carrier Result (CT_{Found})	Gross Counts/ Gross Mass	Chemical Tracer/Carrier Added (CT_{True})	Net Counts/ Net Mass	CT%R	Val Q

Comments:

LABORATORY CONTROL SAMPLE
FORM 4

Lab Name: ______________________________ Contract: ______________

Lab Sample ID: ___________________________ Case No.: ______________

Solid LCS Source: ________________________ SDG No.: ______________

Aqueous LCS Source: ______________________

$$LCS\%R = \frac{LCS_{Found}}{LCS_{True}} \times 100$$

Radiochemical Determination	Aqueous (pCi/L)			Solid (pCi/g)		
	True	Found	LCS %R	True	Found	LCS %R

Comments:____

____

____

MATRIX SPIKE SAMPLE RECOVERY
FORM 5

SAMPLE NO.

Lab Name: ______________________________

Lab Sample ID: ______________________________

Matrix (soil/water): ______________________________

% Solids for Sample: ______________________________

Contract: _______________

Case No.: _______________

SDG No.: _______________

$$MSS\%R = \frac{(SSR - SR)}{SA} \times 100$$

Concentration Units (pCi/L or pCi/g):__________________

Radiochemical Determination	Spiked Sample Result (SSR)	Sample Result (SR)	Spike Added (SA)	MSS %R	Val Q

Comments:____

DUPLICATES
FORM 6

SAMPLE NO.

☐

Lab Name: ______________________________ Contract: ______________

Lab Sample ID: ______________________________ Case No.: ______________

Matrix (soil/water): ______________________________ SDG No.: ______________

% Solids for Sample: ______________________________ % Solids for Duplicate: ______________

$$\mathrm{DER} = \frac{|S - D|}{\sqrt{(2\sigma_S)^2 + (2\sigma_D)^2}} \qquad \mathrm{RPD} = \frac{|S - D|}{\left(\frac{S + D}{2}\right)} \times 100\%$$

Radiochemical Determination	Sample Result (S)	Sample Uncertainty ($2\sigma_S$)	Duplicate Result (D)	Duplicate Uncertainty ($2\sigma_D$)	DER	RPD	Val Q

Comments:____

____

____

PREPARATION LOG
FORM 7

Lab Name: ______________________________ Contract: ______________

Case No: ___________________________ SDG No.: ______________

Method: ________________________

Sample No.	Preparation Date	Weight (gram) or Volume (ml) of Sample Homogenized	Weight (gram) or Volume (ml) Aliquot of Homogenized Sample Processed	Dilution Factor (Fraction of aliquot counted)

Comments:____

____

____

Attachment III

Radiochemical Analysis Data Package Checklist

GENERAL INFORMATION ANALYSES

DATA PACKAGE CHECKLIST

Reportable Item Description	Level C	Level D	CK
Case Narrative: The case narrative shall discuss what samples were analyzed along with customer and laboratory identification numbers. It also should contain information on sample matrix, sample preparation method description, sample chemical method description, any analysis problems, and any other unusual characteristics or notations during analysis.	X	X	
Lab logbooks sheets, Preparation log sheets, Run logs, and Sample logging data;		X	
Chain of Custody (Internal and External)	X	X	
FORMS (Not all of the forms listed below are applicable for all analyses. Use only the appropriate forms for the analyses that were performed.)			
1. Form 1's: The Analytical Results Form contains the customer identification, laboratory identification, sample matrix, SDG number, case number, sample mass or volume used in the analysis, sample type, sample receipt date, sample analysis date, batch identification, analyte, analytical method, net result, total propagated uncertainty, MDA, units, laboratory data qualifier, and instrument identification.	X	X	
2. Form 2's: The Blank Summary Form contains blank identification, blank matrix, SDG number, case number, the net result, and the associated total propagated uncertainty for each analysis type for each blank and blank type in the package, and units.	X	X	
3. Form 3's: Sample Specific Chemical Recovery Summary Form contains the customer identification, laboratory identification, sample matrix, SDG number, case number, chemical tracer used, amount of chemical tracer added, chemical tracer result and associated total propagated uncertainty, chemical tracer percent recovery, units, and laboratory qualifier. For isotopic tracers: gross counts of tracer and net counts of tracer. For gravimetric carriers: tare weight for carrier, gross weight for carrier, and net weight for carrier.	X	X	
4. Form 4's: The Laboratory Control Sample Summary Form contains laboratory control sample identification, SDG number, case number, laboratory control sample is true value (not process average value), laboratory control sample is true value associated error, the laboratory control sample result and associated total propagated uncertainty, laboratory control sample matrix, and laboratory control sample percent recovery.	X	X	

Reportable Item Description	**TSCA**	**ENVIRO CARE**	**CK**
5. Form 5's (if applicable): The Matrix Spike Sample Summary Form contains matrix spike sample identification, SDG number, case number, radionuclide of interest, matrix spike added, original sample result and its associated total propagated uncertainty, matrix spike sample result and its associated total propagated uncertainty, matrix spike sample percent recovery, units, and laboratory qualifier. **(If there is sample specific chemical recovery used in the analysis, a MSS is not required for that analysis.)**	X	X	
6. Form 6's: The Duplicate Summary Form contains duplicate sample identification, SDG number, case number, radionuclide of interest, original sample result and associated total propagated uncertainty, duplicate sample result and associated total propagated uncertainty, sample matrix, and laboratory qualifier. Calculate DER and RPD.	X	X	
7. Form 7's: The Preparation Log Form contains sample identification, preparation date, preparation method, sample mass or volume homogenized, Aliquot mass or volume of homogenized sample processed, dilution factor of aliquot analyzed.	X	X	
STANDARDS AND TRACERS			
1. Standard, LCS, MS, and Tracer Certifications showing NIST traceability.		X	
2. Laboratory Standard, LCS, MS, and Tracer Solutions dilution information showing NIST traceability.		X	
3. Standard, LCS, MS, and Tracer Solutions Calculation Sheets.		X	
CALIBRATION			
1. Initial Calibration results: original calibration counting results, calibration curve plots and data points, and calibration uncertainty.		X	
2. Initial count of the continuing calibration check standard and continuing calibration data and/or continuing calibration control charts.		X	

ALPHA SPECTROMETRY ANALYSES

DATA PACKAGE CHECKLIST

Reportable Item Description	Level C	Level D	CK
CALIBRATION			
1. Initial (annual) Efficiency, Resolution, and Energy Calibration including all data points, calibration calculations, efficiency curves, and standard used for each geometry used in data package. Plus the initial count of the continuing calibration standard.		X	
2. Initial (annual) background calibration		X	
3. Efficiency, Resolution, Energy, and Background Continuing calibration count with control charts.	X	X	
4. Background checks with control charts		X	
RAW DATA (for all samples and QC)			
1. Alpha Spectroscopy Report	X	X	
2. Nuclide Activity Summary	X	X	
3. Spectrum Plot	X	X	
4. Channel by Channel Report	X	X	
5. Gross Sample Counts Within Peak Regions Report	X	X	
6. Nuclide Identification Report	X	X	
CALCULATIONS			
1. Example Computations [Analytical Result and Associated Total Propagated Uncertainty (multiplier specified)]	X	X	
2. Background Subtractions Identified	X	X	

GAMMA SPECTROMETRY ANALYSES

DATA PACKAGE CHECKLIST

Reportable Item Description	Level C	Level D	CK
CALIBRATION			
1. Initial (annual) Efficiency, Resolution, and Energy Calibration including all data points, calibration calculations, efficiency curves, and standard used for each geometry used in data package. Plus the initial count of the continuing calibration standard.		X	
2. Initial (annual) background calibration		X	
3. Efficiency, Resolution, Energy, and Background Continuing calibration count with control charts.	X	X	
4. Background checks with control charts		X	
RAW DATA (for all samples and QC)			
1. Peak Search Report	X	X	
2. Background Corrected Peak Search Report	X	X	
3. Unidentified Energy Line Report	X	X	
4. Summary of Nuclide Activity Report	X	X	
5. Nuclide Line Activity Report	X	X	
6. Summary of Nuclide Activity Report	X	X	
7. Rejected Report	X	X	
8. Full Combined Activity-MDA Report	X	X	
9. Spectrum Plot	X	X	
10. Channel by Channel Report: Note: If the energy range of the spectra is provided and the discriminator settings are set below the energy range, the channel by channel report is not needed.	X	X	
CALCULATIONS			
1. Example Computations [Analytical Result and Associated Total Propagated Uncertainty (multiplier specified)]	X	X	
2. Background Subtractions Identified	X	X	

GAS FLOW PROPORTIONAL COUNTING ANALYSES

DATA PACKAGE CHECKLIST

Reportable Item Description	Level C	Level D	CK
CALIBRATION			
1. Current Instrument Plateaus and cross talk factors.		X	
2. Current Self-absorption curves.		X	
3. Current Initial Efficiency Calibration		X	
4. Current Initial (annual) Background Calibration		X	
5. Continuing calibration counts with control charts.	X	X	
6. Background checks with control charts		X	
RAW DATA			
1. Instrument Printouts for all samples and QC.	X	X	
CALCULATIONS			
1. Example Computations [Analytical Result and Associated Total Propagated Uncertainty (multiplier specified)]	X	X	
2. Background Subtractions Identified	X	X	

LIQUID SCINTILLATION COUNTING ANALYSES

DATA PACKAGE CHECKLIST

Reportable Item Description	Level C	Level D	CK
CALIBRATION			
1. Efficiency and Background Quench Curves complete with acceptance limits.		X	
2. Continuing calibration counts with control charts.	X	X	
3. Background checks with control charts		X	
RAW DATA			
1. Instrument Printouts	X	X	
2. Spectrum Plot	X	X	
CALCULATIONS			
1. Example Computations [Analytical Result and Associated Total Propagated Uncertainty (multiplier specified)]	X	X	
2. Background Subtractions Identified. If background quench curves are used they must be provided complete with acceptance limits.	X	X	

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APPENDIX C

RADIOLOGICAL SURVEY PLAN FOR THE K-1251 BARGE FACILITY

C.1. AREA TO BE SURVEYED

The land parcel to be surveyed consists of approximately 2 acres of land comprising the former K-1251 barge unloading facility at the East Tennessee Technology Park (ETTP). This tract is bounded to the west by the Clinch River. A gravel drive extends on the east side to Bear Creek Road. The tract is enclosed by a fence except for the access road that leads form Bear Creek Road. Refer to Fig. C.1 for the complete footprint of the survey area.

C.2. HISTORY OF THE AREA

The land parcel consists of the former K-1251 barge-unloading facility. Historically, the site was used for the storage of uranium hexafluoride (UF_6) cylinders. Barges carrying loads of UF_6 cylinders on the Clinch River would be unloaded and the cylinders stored in an area adjacent to the riverbank. The site is currently inactive and all equipment, including a large crane, has been removed. Existing documentation indicates that the tract had minimal involvement with site operations but may have become contaminated via material transfer from the site.

C.3. EXISTING SURVEY AND SAMPLING DATA SUMMARY

A search of the Bechtel Jacobs Company LLC (BJC) Radiation Control (RADCON) electronic survey data collected between 1996 and 2006 showed one characterization survey, performed during this time frame, associated with the K-1251 facility. The survey, performed in 2000 (20000216KA36147001), consisted of an area survey with a sodium iodide (NaI) detector. The survey results revealed all areas to be less than twice background. Only two locations were time counted. The highest count rate was obtained in the ditch on the north and east sides of the fenced area where a count rate of 10,000 counts per minute (cpm) was obtained (background was 5400 cpm). No other radiological survey data were found.

A search of the Oak Ridge Environmental Information System (OREIS) database showed data are available from only one historical soil sample within the K-1251 footprint. The sample from station RAD436 was collected in 1994 and quantified for radionuclides. The results are shown in Table C.1. All detected radionuclide results were below their respective background values.

C.4. DATA QUALITY OBJECTIVES PURPOSE

The purpose of this survey plan is to obtain radiological survey data to determine the presence of residual contamination in the area through the use of a scoping survey. The data gathered, combined with the process knowledge, will be used to support the lease of the K-1251 facility. The data quality objectives (DQOs) are detailed in the Design of Radiological Surveys (DRS) document[1] found in Appendix A.

---

[1] *Design of Radiological Survey and Sampling to Support Title Transfer or Lease of Property on the Department of Energy Oak Ridge Reservation*, BJC/OR-554-R1, August 2006.

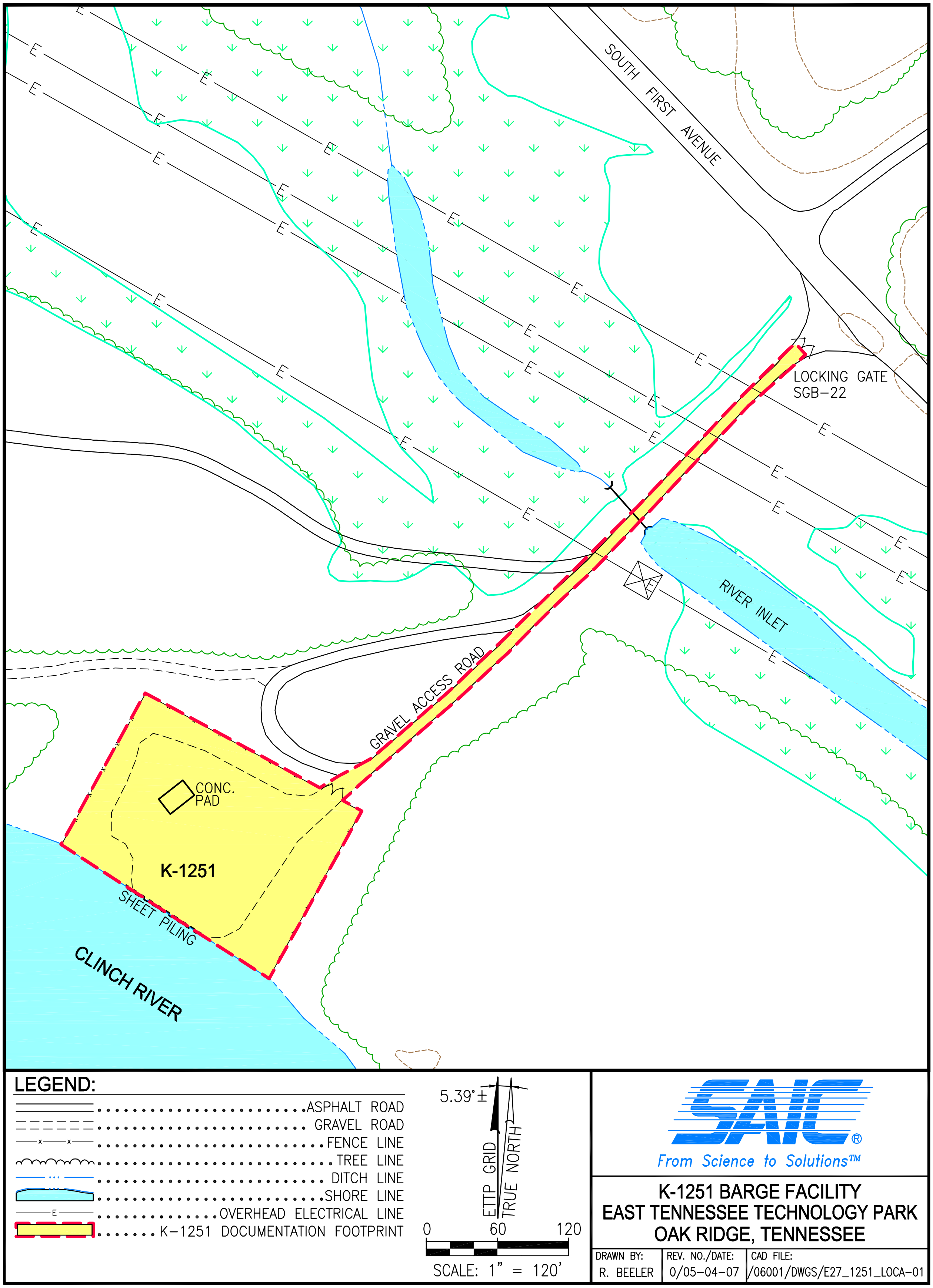

Fig. C.1. K-1251 parcel footprint.

Table C.1. Historical radiological soil sample data from K-1251

Sample ID	Sample depth (ft)	^{241}Am (pCi/g)	^{60}Co (pCi/g)	^{137}Cs (pCi/g)	^{237}Np (pCi/g)	^{238}Pu (pCi/g)	$^{239/240}$Pu (pCi/g)	^{228}Ra (pCi/g)	^{99}Tc (pCi/g)	^{228}Th (pCi/g)	^{230}Th (pCi/g)	^{232}Th (pCi/g)	^{234}Th (pCi/g)	^{234}U (pCi/g)	^{235}U (pCi/g)	^{238}U (pCi/g)
RAD436	0–0.5	NA	0.004 U	0.397	0.02 U	0.00 U	0.009 U	0.21	0.00 U	0.268	0.95	0.309	0.44 U	0.303	0.091	0.32

NA = data not available.

Bold = detected value exceeds radionuclide background data set. Background concentration as defined by Bechtel Jacobs Company LLC in DOE 2003. The background data set that the Environmental Management Program is using has values for only ^{40}K, ^{226}Ra, ^{228}Th, ^{230}Th, ^{232}Th, ^{234}U, and ^{238}U. However, the U. S. Environmental Protection Agency (EPA) report on the September 2001 sampling of the Scarboro community (SESD Project No. 01-1222, April 2003) denotes that, in some cases, the preliminary remediation guide (PRG) values are far below the background values. As an example, the EPA report mentions that the ^{137}Cs background is approximately 1 picocurie per gram (pCi/g), but the PRG is far lower. For this report, a background of 1.0 pCi/g is used for ^{137}Cs. Evaluation of the ^{228}Ra result assumes equilibrium with ^{232}Th background levels.

Validation qualifier definitions:

J denotes the analyte was positively identified; the associated result is the approximate concentration of the analyte in the sample.

U denotes the analyte was analyzed for, but was not detected above the reported sample quantitation limit.

UJ denotes the analyte was not detected above the reported detection limit, which is approximated due to quality deficiency.

C.5. MEASUREMENT TECHNIQUES/SURVEY APPROACH

C.5.1 RADIONUCLIDES OF CONCERN

Process history of the ETTP site indicates that uranium (natural, depleted, and/or enriched) would be the most prominent radiological contaminant potentially present in the K-1251 land parcel due to contamination from the UF_6 cylinders. Uranium-235 enrichment levels expected from operations since the early 1960s would be anticipated to be between 0.2 to 5.0%. Most cylinders would have potentially contained enrichments of less than 3%.[1]

Other radionuclides (^{60}Co, ^{137}Cs, $^{89/90}$Sr, ^{237}Np, ^{99}Tc, and $^{238/239/240}$Pu) have also been detected on-site at ETTP. These other radionuclides originated from the introduction of contaminated materials from Oak Ridge National Laboratory and/or from the Hanford and Savannah River reactor returns uranium reprocessing program. These radionuclides are normally expected to be found in much lower quantities than uranium in process areas. However, transuranics may concentrate in the heal of UF_6 cylinders due to their lower volatility and, therefore, contamination at the K-1251 site may have lower uranium to transuranics ratios (U:TRU) than is typical for process buildings. The process building weighted average[2] ratios are 1140:1 for U:TRU and 350:1 for uranium to technetium-99 (U:^{99}Tc).

C.5.2 DETERMINATION OF THE RESIDUAL RADIOACTIVITY LIMITS

The overall goal of this survey is to show that residual contamination exceeding the release criteria is not present in each of the survey units. As shown by modeling, the dose and risk obtained from exposure to radioactivity at the U. S. Department of Energy (DOE) surface contamination limits, as set forth in Title 10 *Code of Federal Regulations* 835[3] and also in DOE Order 5400.5,[4] is less than that from the dose and risk criteria, as explained in the design documents. As a result of this modeling, the derived concentration guideline levels (DCGLs) for this survey will be set at the DOE contamination limits for uranium (see Table C.2), which is the dominant contaminant present on-site. For volumetric or mass measurements such as those commonly seen in water and soil matrices, the DOE Order 5400.5 mandates that the generic guidelines for thorium and radium will be used. Guidelines for other radionuclides are to be based on specific survey unit modeling at the 10^{-5} risk level while using an industrial worker scenario assuming the unity rule for all radioisotopes based on an established isotopic ratio. A separate limit for the maximum allowable contamination that is concentrated in a smaller area, the derived concentration guideline level$_{\text{elevated measurement comparison}}$ (DCGL$_{\text{EMC}}$), is normally calculated based upon modeling the dose obtained from an area determined by the number of samples taken in the survey unit and the spacing between them. However for surface contamination measurements, the DCGL$_{\text{EMC}}$ will be set to three times the appropriate contamination limit, which equates to the contamination averaging criteria as set forth by DOE in 5400.5 for an elevated reading within a 1 square meter (m^2) maximum size area. For volume contamination, the DCGL$_{\text{EMC}}$ will be established based on the size of the contaminated area (A) and area factors equal to $(100\ \text{m}^2/\text{A})^{.05}$.

---

[1] Contracted Health Physics Technician Training handouts, K-25 Site, 1993.

[2] *Isotopic Distribution of Contamination Found at the U. S. Department of Energy Gaseous Diffusion Plants*, Science Applications International Corporation, BJC/OR-257, October 1999.

[3] (*CFR* 1999). 10 *Code of Federal Regulations*, entitled *Occupational Radiation Protection*; the values are taken from Appendix D, "Surface Radioactivity Values."

[4] DOE Order 5400.5 is entitled *Radiation Protection of the Public and the Environment*; the values are taken from Fig. IV-1, "Surface Contamination Guidelines."

Table C.2. Contamination limits (DCGLs) for all survey units

	DCGL (dpm/100 cm^2)	$DCGL_{EMC}$ (dpm/area)
Total alpha	5,000	15,000
Removable alpha	1,000	N/A
Total beta-gamma	5,000	15,000
Removable beta-gamma	1,000	N/A

DCGL = derived concentration guideline level.
$DCGL_{EMC}$ = derived concentration guideline $level_{\text{elevated measurement comparison}}$.
N/A = not applicable.

C.5.3 IDENTIFICATION OF SURVEY UNITS AND CLASSIFICATIONS

Under the DRS protocols that are based on *Multi-Agency Radiation Survey and Site Investigation Manual* (*MARSSIM*) guidance, areas are classified as either Class 3, 2, or 1 based upon historical data and process knowledge. Survey units must be of the same or similar material type—for example, a survey unit cannot contain both asphalt and soil. It would be divided into a survey unit of asphalt and another survey unit of soil. Refer to the design documents for complete descriptions of the different classifications of survey units. An area will be considered to be a Class 3 survey unit if it is not expected to have residual radioactivity levels above 25% of the DCGL [1250 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) total activity or 250 dpm/100 cm^2 removable activity]. A Class 2 survey unit is expected to have, or has had, residual radioactivity levels less than the DCGL. A Class 1 survey unit is expected to have, or has had, residual radioactivity levels above the DCGL.

The K-1251 parcel will consist of one land survey unit (LSU) and one exterior survey unit (ESU), as shown in Table C.3. The LSU will be a Class 2 survey unit and consist of the area enclosed by the fence adjacent to the Clinch River and the access road. Historical documentation indicates this area was once utilized as a UF_6 cylinder storage area. There are no data indicating that spills or accidental releases occurred in this area; thus, contamination levels are not expected to exceed the DCGL. The ESU will be Class 2 survey unit and consist of the concrete pad. Historical knowledge indicates that this area may have once been posted as a radiological contamination area. However, since it has been downposted, no residual contamination in excess of the DCGL is expected.

Table C.3. Survey units

Survey Unit	Class
LSU 1	Class 2
ESU 1	Class 2

ESU = Exterior survey unit.
LSU = Land survey unit.

C.5.4 INSTRUMENTATION SELECTION AND SURVEY TECHNIQUES

Refer to the DRS in Appendix A for details on instrumentation selection. NaI meters and Bicron MicroRem® meters will be used for land surveys, as specified in this survey plan. For exterior surface surveys, alpha scintillation and beta-gamma Geiger-Müeller (GM) detectors, or equivalent, will be attached to scalar rate meters and will have minimum detectable activities less than 25% of the DCGL. Removable contamination surveys (i.e., smear surveys) will be conducted at all locations where exterior surface fixed/total measurements are taken. All removable contamination survey smears will be counted on a gas-proportional counter calibrated to detect both alpha and beta-gamma radiations.

The Walkover team should be equipped with the following:

- Field notebook and writing instruments.
- Maps showing the LSU and assessment locations.
- Global Positioning System (GPS) instrument for in-field locating of the assessment locations and for documenting locations of notable field observations.
- Survey pin-flags.
- Alpha scintillation and beta-gamma GM detectors, or equivalent, attached to scalar rate meters for exterior surface surveys.
- A Bicron MicroRem® meter.
- A 2-in.-diameter by 2-mm-thick NaI detector for surveying assessment locations and possible anthropogenic features, and sediment collection area. If a 2-in.-diameter by 2-mm-thick NaI detector is not available, a 2-in. by 2-in. NaI detector may be substituted.

If necessary, the visual inspections and location of assessment points using a GPS unit may be performed by a separate team prior to the survey measurements. If so, the assessment points and any other locations to be measured (anthropogenic, groundwater runoff, and sediment collection areas) will need to be marked in such a way that the locations can be found by the survey team.

For the Class 2 LSU, systematic NaI walkover survey scans will be performed and will provide 30% coverage of the area. Any anthropogenic, groundwater runoff, and sediment collection areas recognized during the NaI walkover, and any scan areas determined to have elevated readings, will be marked and timed, fixed-NaI and dose-rate measurements taken at the specifically identified locations of highest scan reading. A fixed NaI and dose-rate measurements will also be taken at systematic points with a random start location based on a supplied grid.

For the Class 2 ESU, systematic alpha and beta/gamma survey scans will be performed and will provide 50% coverage of the area. NaI and dose-rate measurements will also be taken. Any areas recognized during the scan to have elevated readings will be marked and additional fixed, timed measurements are to be taken at these specifically identified locations. Timed measurements will also be performed at predetermined, randomly generated points based upon a supplied grid. A dose rate measurement will be performed at the center of the area and at any point where other measurements exceed twice background.

All surveys will be performed in accordance with established BJC RADCON procedures (e.g., scan rate, probe distance, and source checks).

C.5.5 AREA PREPARATION

All areas will be surveyed in an "as-found" condition. Materials may be rearranged or moved to allow for survey access to areas covered by material and/or equipment.

C.5.6 REFERENCE COORDINATE SYSTEM FOR SURVEY

Class 2 survey units require a sample grid with systematic measurements taken based upon a random starting point. These survey grids are based upon the survey unit's area and number of systematic sample measurements required in each.

C.6. SURVEY DESIGN

C.6.1 QUANTIFY DATA QUALITY OBJECTIVES

The null hypothesis (H_o) for each survey unit is that the residual contamination exceeds the DCGL. The alternative hypothesis (H_a) is that the survey unit meets the DCGL. Decision error levels, as set forth in the design document, are 0.05 for Type I (α) errors and 0.10 for Type II (β) errors in all survey units. The Lower Bound of the Gray Region (LBGR) is initially set to one-half of the DCGL. These parameters apply to all survey units, regardless of their classification (see Table C.4). The design documents discuss the DQO process in greater detail.

Table C.4. Parameters for computing number of samples

Parameter	Survey design document
Type I error rate (α)	0.05
Type II error rate (β)	0.10
Non-parametrical statistical test	Sign[5]
LBGR	2500 dpm/100 cm^2
Number of data points per survey unit	11

dpm = disintegrations per minute.
LBGR = Lower Bound of the Gray Region.
SEC = Safety and Ecology Corporation.

C.6.2 DETERMINATION OF THE NUMBER OF DATA POINTS

There are no historical survey results available to use to determine a standard deviation for this property. However the number of data points for timed NaI and dose measurements will be based on the number of data points required for soil sampling. Because the detection limits expected to be achieved by the laboratory measurements are low relative to the DCGL, it is estimated that an LBGR equal to one-half of the DCGL can be achieved for survey measurements for this project and that a Δ/σ value (also known as the "relative shift") of 3 can be obtained, where Δ is the DCGL – LBGR, the LBGR is 50% of the DCGL, and σ is the standard deviation of the data."[6] (Note: This is true for survey data but does not apply to sample results from soil.) The Sign test was utilized, as the residual contamination present within the survey units should be at a very small fraction of the DCGL. The *MARSSIM*[7]

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[5] The WRS statistical test is for usage when the primary contaminants are found in background. The Sign test is to be used when the contaminant is not found in background or when the contaminants are in background, but at a small fraction of the DCGL. The Sign test will be used for this survey.

[6] (NRC 1997a). Nuclear Regulatory Commission, Nuclear Regulatory Guide (NUREG)-1505, *A Proposed Nonparametrical Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys, Final Edition*, December 1997.

[7] (NRC 1997b). Nuclear Regulatory Commission, NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Final Edition*, December 1997.

recommends that the relative shift be between 1 and 3. Due to the lack of sampling data associated with the K-1251 facility, a relative shift of 3 was assumed. Therefore, the number of data points per survey unit will be based upon the upper-bound relative shift of 3.0, and a minimum of eleven locations (see Table C.4) will be required to characterize each survey unit in the K-1251 area.

C.6.3 SURVEY PROCEDURES

All surveys are to be performed in accordance with this survey plan, the design documents, and BJC RADCON procedures.[8] Note: Survey technique is covered in the design documents and will not be repeated in this plan. However, variations or clarifications of the design documents will be included.

In any area in which the survey indicates activity exceeding 5000 dpm/100 cm^2, direct alpha and beta-gamma measurements will be made following the establishment of a 1-m^2 grid to obtain data applicable to the DOE Order 5400.5 release criteria. BJC RADCON procedures will be followed for posting of the immediate area. In addition, any contamination survey location found in excess of two times the DCGL will also have a dose-rate measurement taken at a distance of 3 ft.

Any activity in excess of the DCGL (when averaged over 1 m^2) will require that a Class 2 SU, or sections thereof, be reclassified as Class 1 and surveyed appropriately.

Many of the radionuclides found on the Oak Ridge Reservation have natural background concentrations. Therefore, background subtraction will be required for all direct field measurements. Some comparison to background levels will also be required for the scanning because only a gross signal will be measured. Material-specific backgrounds might be necessary for materials such as tile, brick, and cinderblock because these materials contain elevated levels of naturally occurring radionuclides. For example, the background is 1716 dpm/100 cm^2 total beta-gamma above ambient background for a glazed clay-tile floor, 1103 dpm/100 cm^2 total beta-gamma above ambient background for a red-clay brick, and 142 dpm/100 cm^2 total beta-gamma above ambient background for a concrete block using a GM detector.[9] This level of radioactivity is within that of the naturally occurring radioactive material contained in the glazed clay-tile/brick/concrete block matrix and will be subtracted from the net ambient readings for these materials before determining if the result is greater than 25% of the DCGL or the DCGL.

A summary of the survey requirements for each type of survey unit is found in Table C.5.

C.6.3.1 Exterior Survey Units

C.6.3.1.1 Class 2 exterior survey units

The concrete pad is classified as a Class 2 ESU. The Class 2 survey protocols are as follows: The concrete pad will be scan-surveyed using hand-held alpha scintillation meters and gas-proportional meters and with a NaI meter with 50% scan coverage. The survey measurement locations for fixed, timed measurements will be systematically chosen per survey grid (see Fig. C.2). In addition, smears and direct readings will be obtained from locations of the highest contamination with results greater than 25% of the

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[8] Primarily EH-4516, "Radioactive Contamination Control and Monitoring," found in BJC-EH-4000, *Radiation Protection Program Description for Bechtel Jacobs Company LLC, Oak Ridge, Tennessee.*

[9] Values computed based upon the beta-gamma background levels for brick, ceramic tile, and ambient found in Table 5.1 of NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, December 1997 (NRC 1997b), and an average beta-gamma Geiger-Müeller correction factor of 34 (dpm/100 cm^2)/cpm for a planar radiation source.

Table C.5. Summary of survey unit requirements

Survey unit type	Class 3	Class 2	Class 1
Exterior		• Fifty percent scan of surfaces. • Minimum of eleven total and removable readings, at a minimum, per survey unit. • Reading locations based upon a grid. • Dose-rate at center. • One dose-rate reading at any location exceeding twice background. • NaI scan of areas that have a potential for holding activity that would be difficult to detect by alpha and beta-gamma scans. • Upgrading to Class 1 if activity > DCGL.	• One hundred percent scan of all surfaces. • Minimum of eleven total and removable readings, at a minimum, per survey unit. • Reading locations based upon a grid. • One dose-rate reading at any location exceeding twice background. • NaI scan of areas that have a potential for holding activity that would be difficult to detect by alpha and beta-gamma scans.
Land		• Minimum of eleven total timed NaI counts, at a minimum, per survey unit at systematic points. • Reading locations based upon a grid. • NaI walkover survey in/on each survey unit with coverage equal to 30% general areas and 100% of suspect areas. • Pin flag and make additional timed, fixed NaI and dose-rate measurements at any point found to be greater than 3 times the background (or other trigger point) during the NaI walkover survey. • One dose-rate reading per every grid point. • Upgrade to Class 1 if activity > DCGL.	• Minimum of eleven total timed NaI counts, at a minimum, per survey unit at systematic points. • Reading locations based upon a grid to be determined, as needed. • NaI walkover survey in/on each survey unit with 100% coverage. • Pin flag and make additional timed, fixed NaI and dose-rate measurements at any point found to be greater than 3 times the background during the NaI walkover survey. • One dose-rate reading per every grid point.

DCGL = derived concentration guideline level.

DCGL, as indicated by the scanning surveys for each horizontal and vertical surface. Any two areas that exceed the DCGL will be reclassified as Class 1 areas and surveyed accordingly. All reclassified areas will be discussed in an addendum to this survey plan that will be issued and included in the survey report and in the facility's baseline environmental condition documentation.

C.6.3.1.2 Class 1 exterior survey units

Although there are currently no Class 1 exterior areas, the potential exists for having a Class 2 area upgraded to a Class 1. Class 1 SUs follow the Class 2 survey protocols, with the exception that 100% of the surfaces will be scanned.

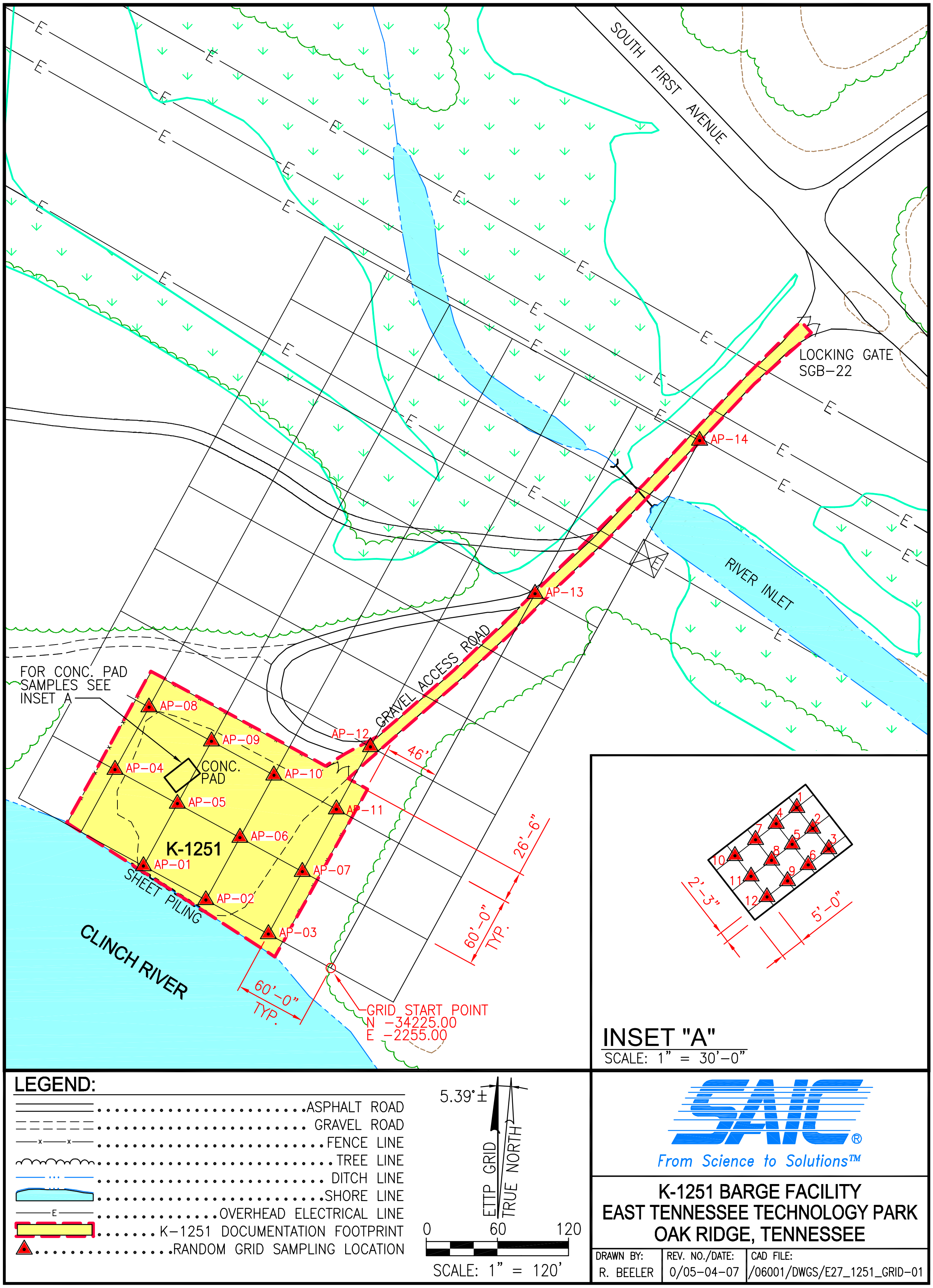

Fig. C.2. K-1251 assessment point locations.

C.6.3.2 Land Survey Units

A separate sampling plan is being prepared to evaluate soil contamination. Locations of biased sampling for laboratory analysis will be identified and pin flagged by the NaI walkover survey as described below.

C.6.3.2.1 Class 2 land survey units

Class 2 survey unit survey protocols are as follows. NaI walkover survey judgment scans will be performed with 30% coverage of the general land areas. Scan with 100% coverage suspect areas and areas that are deemed to have the potential for elevated contamination levels based on professional judgment. Emphasis will be placed on road bed areas, suspect areas of soil or vegetation discoloration, and other areas based on professional judgment. NaI survey measurements will be performed at the fixed grid assessment points, any anthropogenic, groundwater runoff, and sediment collection areas recognized during the NaI walkover, and any scan areas determined to have elevated readings. (Sediment accumulation areas are those areas where overland flow and surface drainage gradients decrease and sediment may accumulate. These accumulation areas will generally be flat or low-lying areas that would tend to accumulate run-off and any sediments.) The static survey measurement locations will be systematically chosen per survey grid. A 10-ft-diameter surface area will be scanned at each of these points with the NaI detector, and the location of the highest reading will be counted for 1 minute and the results recorded. Locations for collection of biased samples for laboratory analysis will be pin flagged for any location that has a timed NaI survey reading greater than three times the established background. The basis for the "three times rule" stems from the fact that natural backgrounds vary by up to a factor of three, depending on geology, topography, and other geometric factors. However, the data for each LSU will be reviewed to determine if other areas exist where there is a clear elevation in count rate as compared to surrounding areas but less than three times the established background. Professional judgment will be used to evaluate if the specific geology, topography, and matrix (e.g., rock outcroppings, pavement, severe slopes, and brick buildings) could have caused the elevated readings. If a background specific to the geology and topography for the area can be obtained, a lower trigger level (e.g., two times the background or the 99% decision level for the NaI meter) may be used based on professional judgment.

The measurements at each point will include fixed, timed NaI and dose-rate measurements. Any Class 2 areas that exceed the DCGL will be reclassified as Class 1 areas and surveyed accordingly. All reclassified areas will be discussed in the survey report and the Baseline Environmental Analysis Report (BEAR) Chap. 6, "Survey Results."

C.6.3.2.2 Class 1 land survey units

Although there are currently no Class 1 land areas, the potential exists for having a Class 2 area upgraded to a Class 1. The Class 1 survey units follow the Class 2 survey protocols, with the exception that 100% of the accessible surface will be scanned with the NaI meter.

C.6.4 SPECIFICATION OF SAMPLING LOCATIONS

Systematic assessment points will be based on the survey grid as shown on Fig. C.2. The ESU assessment points are at a distance relative to the corner of the concrete pad. For LSU assessment points, the state plane system coordinates and longitude/latitude for each assessment point for LSU 1 are shown in Table C.6. In addition, the walkover inspection team will identify anthropogenic, groundwater runoff, and sediment accumulation areas, and any other areas scanned above background in the LSUs, as biased assessment points.

Table C.6. Assessment point locations for LSU 2

Assessment point number	Oak Ridge administrative grid easting	Oak Ridge administrative grid northing	Tennessee State grid easting	Tennessee State grid northing	Latitude	Longitude
AP-01	-2413.0467	-34138.8534	2443365.164	578002.8507	84.396362	35.910541
AP-02	-2360.3645	-34167.5690	2443420.685	577980.1209	84.396176	35.910476
AP-03	-2307.6822	-34196.2845	2443476.207	577957.3913	84.395990	35.910412
AP-04	-2437.0135	-34057.4557	2443332.372	578081.1019	84.396469	35.910758
AP-05	-2384.3312	-34086.1712	2443387.894	578058.3723	84.396283	35.910693
AP-06	-2331.6490	-34114.8867	2443443.415	578035.6426	84.396096	35.910628
AP-07	-2278.9667	-34143.6022	2443498.937	578012.9129	84.395910	35.910563
AP-08	-2408.2979	-34004.7734	2443355.102	578136.6236	84.396389	35.910909
AP-09	-2355.6157	-34033.4890	2443410.623	578113.8938	84.396203	35.910844
AP-10	-2302.9335	-34062.2045	2443466.145	578091.1641	84.396017	35.910779
AP-11	-2250.2512	-34090.9200	2443521.666	578068.4345	84.395830	35.910714
AP-12	-2221.5357	-34038.2377	2443544.396	578123.9561	84.395750	35.910866
AP-13	-2082.7069	-33908.9065	2443668.107	578267.7912	84.395325	35.911255
AP-14	-1943.8781	-33779.5753	2443791.817	578411.6264	84.394899	35.911645

LSU = land survey unit.

C.7. DOCUMENTATION

Survey data will be documented in accordance with the procedures and reviews required by the DOE Contractor. A report will be prepared, describing the survey methods, results, and evaluation. The report will include the findings of the assessment, describe the materials surveyed and their condition, and justify the contamination potential classification assigned. The data evaluation will be included, along with the assessment of the quality assurance/quality control (QA/QC) documentation. This report, or a summary of the report, will also be included and referenced in the facility's baseline environmental conditions documentation.

C.8. QUALITY ASSURANCE

All appropriate QA/QC reviews to ensure the quality of the data gathered will be performed and documented.

Survey instruments and methods specified in applicable RADCON operating and technical procedures have been documented as to their ability to provide a 95% confidence level in detection of surface contamination at levels that meet the requirements of this protocol. Supporting data are provided on each survey form.

Radiological Control Technicians not involved in the execution of this protocol will repeat approximately 5% of the direct and removable activity measurements on items destined for unrestricted release for verification. The results must confirm the initial findings for acceptance as satisfying release criteria.

A DOE Contractor RADCON-Certified Health Physicist, or another designated health physicist, will review, evaluate, and validate the survey results, including assessment of the QA/QC information and data, prior to generation of the radiological survey report. The final radiological survey report will include the details of this assessment. It will be provided to the DOE Contractor project QA manager, project manager, and site project health physicist for approval prior to its inclusion into the BEAR.

APPENDIX D

WALKOVER INSPECTION PROTOCOL

CLASS 3 AND CLASS 4 SOIL UNIT
WALKOVER INSPECTION PROTOCOL

Purpose

The DVS defines a Class 3 SU as an area of land at ETTP that:

- is, or was, impacted;
- has no or very low potential for COC concentrations to exceed remediation levels (RLs), risk-based levels, or be a source of groundwater contamination; and
- there is insufficient evidence to support a no-action decision.

The DVS defines a Class 4 SU as an area of land at ETTP that has no evident anthropogenic impacts.

The purpose of the Class 3 and Class 4 SU walkover inspections will be to visually inspect Class 3 and Class 4 SUs to collect observations and screening data to support the no-action decision. The inspections will focus on identifying any anthropogenic features delineating the boundaries of the features and determining if sampling of the feature is warranted. Surface water run-off and sediment accumulation areas will also be identified for sampling by the inspection teams.

Personnel

Walkover Inspection Personnel. A minimum of two people will conduct each geophysical investigation. One or both of these people will, at a minimum:

- have knowledge of ETTP site activities;
- be trained in the use of a field notebook for recording observations;
- have the background and experience necessary to identify anthropogenic features such as soil or rubble deposits;
- be trained in the use of global positioning system (GPS) instruments; and
- be trained in the use of the FIDLER radiation detector.

Sample Collection Personnel. A minimum of two people will collect soil samples from selected areas identified during the walkover inspection. One or both of these people will, at a minimum:

- be trained in collection of soil samples;
- be trained in the use of a field notebook for recording observations; and
- be trained in the use of GPS instruments.

Equipment. The walkover team will be equipped with the following:

- field notebook and writing instruments;
- maps and/or aerial photographs showing the SU to be inspected and the assessment locations;
- GPS instrument for in-field locating of the walkover inspection team, assessment locations, and for documenting locations of notable field observations;
- survey pin-flags;
- compass or other directional device; and
- FIDLER radiation detector for surveying assessment locations and possible anthropogenic features; and

- appropriate personal protection equipment (PPE) as specified in a prepared safety and health plan (SHP) and its activity hazards analysis (AHA).

The sampling team will be equipped with all of the necessary equipment for collecting soil samples from the depth interval of 0 to 12 inches below ground surface (bgs) as specified in project-approved soil sample collection procedures and as described in project-specific work plans.

Special Considerations.

1. All work will be conducted in a safe manner consistent with a prepared SHP and its AHA.
2. Walkover investigations and sample collection should be conducted between mid-fall and early spring when vegetation is at a minimum. This will enhance safety and maximize the ability to make observations and use GPS.

Procedure.

1. A technical team, that includes one or more members of the field teams, will examine maps and aerial photographs of the Class 3 and Class 4 SUs to be inspected. A systematic grid, with random start location, will be calculated with an average assessment location density of one location per acre. The grid will be overlain on field-ready maps of the SUs to be inspected.
2. Walkover maps should be annotated with state plane coordinates of the anticipated transects. Coordinates should be reported in the same coordinate system used by the field GPS instrument.
3. An action level for the FIDLER detector will be determined prior to performing an assessment. A description of the action level and how it was determined will be presented in the project-specific work plans.
4. The walkover inspection team will assemble all of its equipment and make sure the equipment is in proper working order prior to taking it to the field.
5. Each day while in the field, but prior to beginning the walkover, the walkover team will:
    - review the AHA for their work;
    - calibrate their equipment;
    - take three readings of the ambient radiation with the FIDLER detector and record the average value of the three readings in the field notebook as the radiation background reading;
    - record in the field notebook time, weather, and personnel present; and
    - record in the field notebook any observations that could influence the interpretation of the walkover survey.
6. The walkover inspection team will walk to each randomly selected assessment location. Upon reaching the location, the walkover inspection team will describe the area in the field notebook, making note of any unusual or anthropogenic features. The walkover inspection team will also survey a 10-foot diameter surface area at the location with the FIDLER detector and record the range of readings in the field notebook.
7. While traversing routes to assessment locations and at the assessment locations themselves, the walkover inspection team will take note of any unusual or anthropogenic features, plant flags at locations selected for subsequent soil sampling associated with each feature, and survey each feature with the FIDLER detector. The following information will be recorded in the field notebook for each such feature:
    - description of the anthropogenic feature;
    - coordinates of the feature boundary from the GPS instrument;
    - range of survey readings taken from the FIDLER detector;
    - a clear description of any parts of the feature whose FIDLER survey reading exceeds the pre-determined action level; and
    - any observations that may influence the interpretation of the visual and radiation surveys.

8. The walkover inspection team will use professional judgment to select soil sampling locations and will take into account results from the FIDLER survey, visible anthropogenic materials, soil staining or discoloration, and stressed vegetation.
9. During the walkover inspection, the walkover inspection team will identify sediment accumulation areas in the Class 3 and Class 4 SUs. Sediment accumulation areas are those areas where overland flow and surface drainage gradients decrease and sediment may accumulate. These accumulation areas will generally be flat or low lying areas that would tend to accumulate run-off and any associated sediments.
10. The walkover inspection team will select sample locations within the accumulation areas that will provide representative materials for the areas, plant a flag at each selected sediment accumulation area sample location, record the approximate boundary of the area on the map, determine and record in the field notebook the coordinates of the selected sediment sample locations based on the GPS instrument, assign a sample location ID number according to the project protocol, and record that number on the sample location flag and in the field logbook.
11. Following the walkover inspection, a sampling team will return to each soil sampling location, including sediment accumulation areas, and collect sufficient sample mass at each location for analysis. Sampling and analysis will follow project-specific work plans.
12. Soil samples will be transported to the appropriate laboratory as described in the project-specific work plan.
13. Following completion of field activities and return of analytical results, the BJC technical team will prepare documentation describing the findings of the walkover inspection. The report will include the recorded information on each feature noted by the field team and the laboratory analytical results. Based on the findings of the technical team, a recommendation will be made as to whether the SUs, or any part of them, need to be reclassified.

APPENDIX E

RISK EVALUATION FOR THE K-1251 BARGE FACILITY

CONTENTS

FIGURES

TABLES

ACRONYMS

bgs	below ground surface
COPC	contaminant of potential concern
CPD	Clean Parcel Determination
DOE	U. S. Department of Energy
EBS	Environmental Baseline Survey
EPA	U. S. Environmental Protection Agency
EPC	exposure point concentration
ETTP	East Tennessee Technology Park
HI	hazard index
HQ	hazard quotient
PRG	preliminary remediation goal
RAGS	*Risk Assessment Guidance for Superfund*
RL	remedial level
ROD	Record of Decision
TDEC	Tennessee Department of Environment and Conservation

EXECUTIVE SUMMARY

The goal of this risk evaluation is to determine the potential for adverse health effects associated with the K-1251 Barge Facility. The U. S. Department of Energy (DOE) is proposing to lease this facility to the Community Reuse Organization of East Tennessee. Because the intended use of this area is as an industrial site, the risk evaluation seeks to determine if the land parcel is suitable for lease as an industrial facility.

The methodology followed in performing this risk evaluation included screening the site data against nationally available preliminary remediation goals (PRGs) to provide screening-level risk estimates and determine the need for a full risk calculation. The full risk calculation is conducted only when the screening-level risk estimates of constituents exceeding PRGs indicate the potential for elevated risks [cumulative screening-level risks exceeding E-04 or a hazard index (HI) above 1], or where no nationally recognized PRGs are available for the exposure scenario being considered. Additionally, although K-1251 is not within Zone 1 or Zone 2, sampling results were also compared with remediation levels (RLs) developed for the East Tennessee Technology Park (ETTP) Record of Decision (ROD) for either Zone 1 or Zone 2 soils, for informational purposes.

The U. S. Environmental Protection Agency has established a generally acceptable target risk range of E-04 to E-06 (also expressed as 10^{-4} to 10^{-6}) and a generally acceptable HI of 1. The risk estimate is a value that represents the excess cancer incidence that might be expected due to the exposure scenario evaluated. The HI is a value that represents the potential for toxic effects to an exposed individual.

The screening-level risk estimate for the K-1251 Barge Facility indicated the cumulative risks were below 1E-04 and the HI associated with site-related constituents did not exceed 1; therefore, a full risk calculation was not necessary. As stated above, because the risks did not exceed the generally acceptable upper risk level of E-04 or exceed an HI of 1, the risk evaluation was considered indicative of the low likelihood of adverse health effects associated with industrial exposure to the K-1251 Barge Facility soils. The facility, therefore, is considered suitable for lease.

E.1. INTRODUCTION

The goal of this risk evaluation is to determine the potential for adverse health effects associated with K-1251 Barge Facility, which is proposed for lease by the U. S. Department of Energy (DOE). Specifically, the objectives of this evaluation are: (1) to determine exposure to constituents based on available data for site media, and (2) to use these data to provide an estimate of the potential for adverse effects to human health. The risk calculations utilized in this evaluation are based on the document *Risk Assessment Guidance for Superfund* (RAGS) [EPA 1989]. The following sections describe the process used to provide a quantitative analysis of the risks to human health from exposure to the K-1251 Barge Facility.

E.1.1 RISK EVALUATION METHODOLOGY

The risk evaluation methodology utilizes a step-wise process in order to more efficiently determine if the property under consideration is suitable (from a health perspective) for lease. As detailed below, the site data are screened against trigger levels first to determine if further examination of the data is necessary. By virtue of the decision needed to be made when examining the data (i.e., health protection), the screening process is conservative.

The risk evaluation method to support the lease of the K-1251 Barge Facility includes analysis of soil exposures. A process agreed to by both DOE and the regulators [i.e., U. S. Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC)] is utilized in order to be consistent with other programs (e.g., Environmental Management). Soil sampling results are compared with Preliminary Remediation Goals (PRGs) or site-specific remediation levels (RLs). PRGs are health-protective concentrations that have been developed by EPA Region 9 as a set of national standards. RLs are health-protective concentrations that have been established in the site Records of Decision (RODs).

PRGs are developed based on a specific exposure scenario (i.e. industrial) and exposure pathways (soil ingestion, inhalation, and/or dermal contact) for a given level of risk and hazard [i.e., risk of 1E-05 and hazard quotient (HQ) of 1]. The risk represents the estimated number of increased cancer incidences for the exposed population (i.e., risk of 1E-05 means a 1-in-100,000 increased incidence). The HQ is a measure of the potential for toxic effects from an individual contaminant, and the sum of HQs for multiple constituents is referred to as the hazard index (HI). An HI that exceeds 1 indicates the possibility that toxic effects may occur in the exposed population. The RLs use site-specific data to develop health-protective concentrations for contaminants that are site-related and considered widespread. Because site-specific data are used to develop RLs, they are higher in concentration than the PRGs.

As indicated above, the evaluation of risk and hazards is based on comparing soil sample results with PRGs and/or RLs. If there are constituents with concentrations in excess of the PRGs or RLs, further evaluation is conducted. To ensure that cumulative risks are below 1E-04 and the overall HI is below 1 for the facility, as a back-check, the media concentrations are divided by the PRG to calculate a risk and HI estimate. If the estimate indicates the potential for elevated risks and/or hazards, a full risk calculation is conducted. The full risk calculation is based on an exposure assessment and identified exposure parameters (e.g., soil ingestion rate, exposure frequency, body weight, etc.) for the anticipated receptors. The results of the full risk calculation are then compared to the acceptable risk and hazard levels to determine the potential for adverse health effects associated with soils in order to determine if the property is suitable for lease.

The following sections describe the process used to provide a quantitative analysis of the risks to human health while occupying the K-1251 Barge Facility.

E.2. DESCRIPTION AND HISTORY

A full description and history of K-1251 Barge Facility, as well as site maps, are presented in Chaps. 1 through 4 of the draft Baseline Environmental Analysis Report (BEAR) for the K-1251 Barge Facility study area (DOE 2007, in progress).

E.3. AVAILABLE DATA

The data available for the K-1251 Barge Facility study area consist of results from four soil sampling locations and two concrete sampling locations. Chapter 6 of the EBS provides a detailed evaluation of all available data, which are summarized in the following section.

E.4. DATA DISCUSSION

The available data for the K-1251 Barge Facility are discussed in detail in Chap. 6 of the EBS and are summarized below. Duplicate analyses were conducted at some locations for quality assurance. For the risk assessment, duplicate analyses were reduced to a single result (for each location, sample depth, and sampling date) in order to avoid biasing the dataset toward locations with duplicate analyses available. Where the original sample and duplicate were both detections, the larger detection was selected as the representative result. Where both the original and duplicate were non-detections, the sample with the lower detection limit was selected as the representative result. Non-detected results in the dataset were evaluated at half the detection limit when calculating mean and exposure point concentrations (EPCs) for the risk evaluation.

E.4.1 K-1251 BARGE FACILITY SOIL DATA

Soil data were collected in August 2007 and generated soil analytical results from three locations. Samples were collected from five sample intervals from 0 to 10 ft below ground surface (bgs) and analyzed for metals, organics, and radionuclides. Additionally, data collected in 1994 from one historical sample location (RAD436) were included in the evaluation.

E.4.2 K-1251 BARGE FACILITY CONCRETE DATA

Two samples of the concrete pad were collected in August 2007 at the K-1251 Barge Facility. These samples, collected from the top 3 in. of the concrete surface, were analyzed for PCBs and indicated that Aroclor-1254 and Aroclor-1260 were detected at concentrations ranging from 0.002 to 0.0067 mg/kg. These concentrations are well below the established RL of 10 mg/kg for PCBs in Zone 1 of the ETTP and the industrial worker PRG. As previously mentioned, PCBs were commonly used for their heat-resistant properties in oils, paints, and other materials. The industrial nature of the activities conducted at the barge facility likely accounts for the presence of PCBs on the concrete pad.

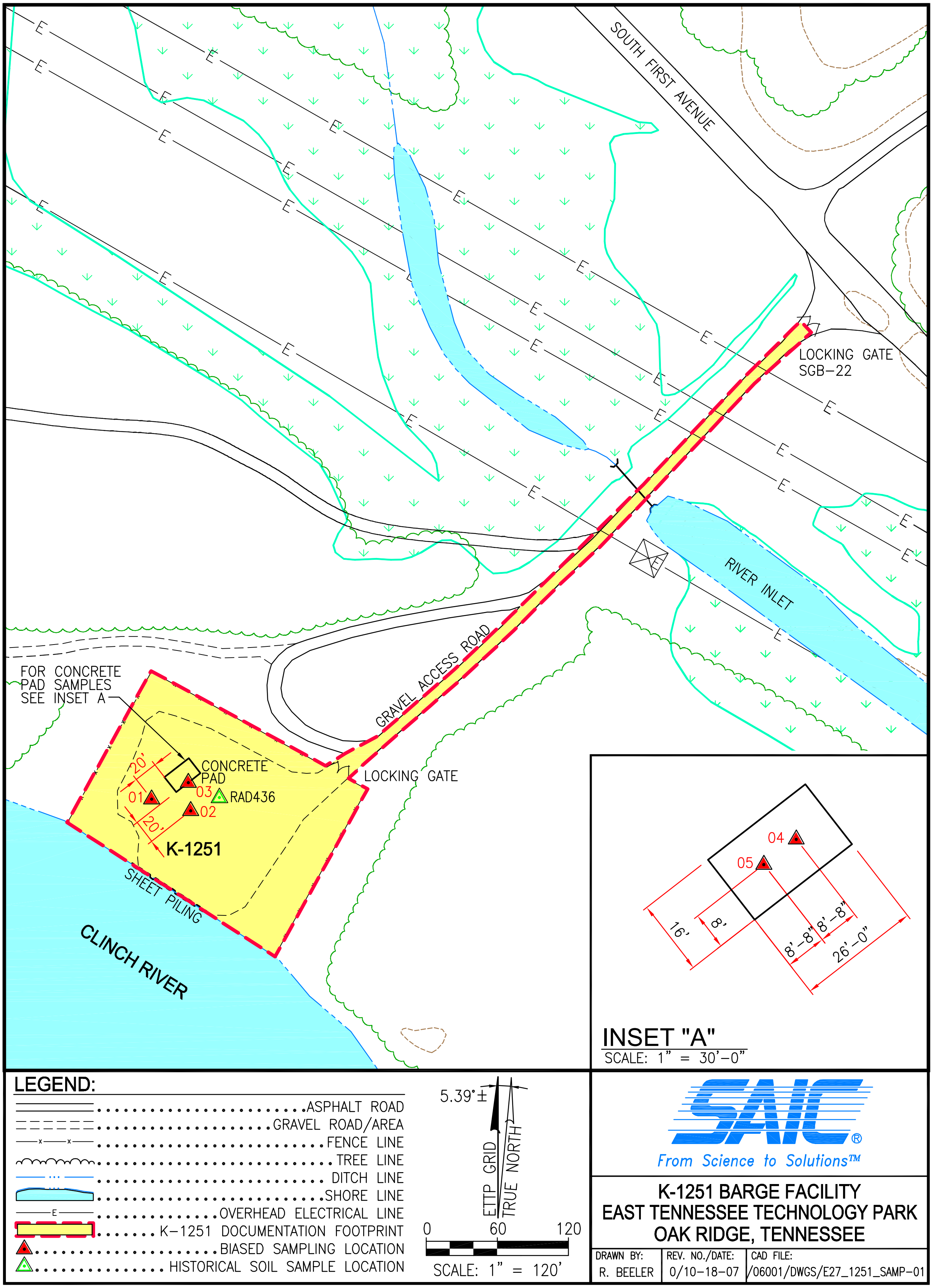

Fig. E.4.1. K-1251 Barge Facility soil sampling locations.

E.5. EXPOSURE ASSESSMENT

An exposure assessment combines information about site characteristics and site-related data with exposure assumptions in order to quantify the intake of contaminants by a hypothetically exposed individual. The estimated exposure is based on the following:

- characterizing the exposure scenario based on site surveys,

- identifying complete exposure pathways based on assumed receptor activities and site-specific information, and

- quantifying receptor exposure based on exposure assumptions and chemical-specific data.

The steps in the exposure assessment are discussed in detail in the following sections.

E.5.1 EXPOSURE SCENARIO EVALUATION

Exposure scenarios are selected based on site surveys and anticipated uses of the K-1251 Barge Facility. The East Tennessee Technology Park (ETTP) area is being leased and transferred for industrial uses ranging from light to heavy industrial applications. Therefore, an industrial worker scenario was considered representative of current and future land use.

Exposures to the industrial worker, while spending time outside and within the lease area, were evaluated using soil sampling results. Exposure to concrete was not considered a likely exposure pathway since access to contaminants in the concrete matrix would require significant disturbance of the concrete pad, not included in the expected industrial activities. Uncertainties associated with the exposure scenario evaluation are presented in Chap. E.7.

E.5.1.1 Industrial Scenario

The hypothetical industrial scenario assumes that an industrial worker may be present on the K-1251 Barge Facility currently and in the future. It is assumed that the industrial worker is exposed to soils from 0 to 10 ft bgs, while working in the area. Details associated with this theoretical industrial scenario are presented in the following section.

E.5.2 EXPOSURE PATHWAY IDENTIFICATION

Evaluating the exposure pathways requires describing the mechanism by which an individual may become exposed to contaminants associated with K-1251 Barge Facility lease area soils. A complete exposure pathway requires the following:

- a source of contamination,
- a pathway of migration from the source of contamination to the exposure point,
- a receptor present at the exposure point, and
- an exposure mechanism at the exposure point.

If any one component of a complete exposure pathway is missing, then the pathway is considered incomplete. Only complete exposure pathways were evaluated in the risk screen.

Complete exposure pathways associated with K-1251 Barge Facility soils include ingestion, inhalation, dermal contact, and external exposure to ionizing radiation. The ingestion pathway is complete because contaminated media may be present, a receptor may be present on the parcel, and a receptor may contact and ingest contaminants from the media. The inhalation pathway is complete because contaminated media may be present, contaminants may become airborne, a receptor may be present on the parcel, and an individual may inhale contaminants in the air. The dermal pathway is complete because contaminated media may be present, a receptor may be present on the parcel, and a receptor may contact and dermally absorb contaminants from the media. External exposure to ionizing radiation is a complete exposure pathway because radionuclides may be present in media, ionizing radiation may be emitted, and a receptor may be present to absorb the radiation. The following section describes how each of these exposure pathways was quantified in the risk screen.

E.5.3 QUANTIFICATION OF EXPOSURE

Quantifying the exposure to the receptor requires the following:

- statistical evaluation of the representative dataset;
- selection of contaminants of potential concern (COPCs), based on comparison to PRGs;
- identification of the COPCs that have available toxicity data and can be quantitatively evaluated;
- estimation of the exposure parameters appropriate to the exposure scenarios;
- selection of toxicity data appropriate for the receptor and exposure pathways; and
- calculation of the intake, risks, and hazards to the receptors based on the calculated exposure concentrations (Chap. E.6).

The ingestion, inhalation, dermal contact, and external exposure pathways were quantified using available data. The purpose of the quantification of exposures is to provide a conservative estimate of exposures related to the exposure scenarios evaluated. At each step in the quantification process, assumptions are made in order to provide an upper-bound estimate of risk that is protective of human health.

The evaluation of the K-1251 Barge Facility was based on the following industrial worker exposure scenario:

- the industrial worker is exposed to K-1251 Barge Facility soils for 2 hours each week;
- the industrial worker ingests 100 mg/d of contaminated soil; and
- the industrial worker inhales 20 m^3/d.

As described in the risk evaluation methodology in Sect. E.1.1, for the K-1251 Barge Facility study area soils, detected concentrations were compared with EPA Region 9 industrial PRGs at a risk level of 1E-05 and an HQ of 1, as well as site-specific RLs. Results of the risk evaluation are presented in Chap. E.6.

E.6. RISK RESULTS

The risk estimate is a value that represents the excess cancer incidence that might be expected due to the exposure scenario evaluated. The EPA has established a generally acceptable target risk range of E-04 to E-06 (also expressed as 10^{-4} to 10^{-6}) and a target HI of 1. The following sections present the risk results for the K-1251 Barge Facility study area.

E.6.1 INDUSTRIAL SCENARIO

Hypothetical industrial exposures associated with K-1251 Barge Facility soils may occur via ingestion, inhalation, dermal contact, and external exposure. As discussed in the previous section, EPA Region 9 industrial PRGs and ETTP RLs were used to screen the soils as follows:

- each detected result was compared with EPA Region 9 PRGs for the industrial scenario at risk level 1E-05 and an HQ of 1;

- detected results were compared with the RLs developed for the ETTP ROD; and

- detected results were compared with background levels provided by Bechtel Jacobs Company LLC.

Table E.6.1 presents the results of the K-1251 Barge Facility risk evaluation based on industrial exposures. None of the chemical constituents exceed their respective PRGs. Of the site-related radiological constituents, only ^{137}Cs exceeded the PRGs calculated at the 1E-05 ELCR level (Note that ^{226}Ra, ^{228}Th, and ^{232}Th have background levels that exceed their respective PRGs, and ^{228}Ra is considered to be in equilibrium with ^{232}Th. These constituents are considered site-wide COPCs and are exempted from consideration for individual facilities per DOE2002a). The data also indicate that no detected concentrations exceeded maximum RLs, and all average detected concentrations were below average RLs.

As discussed in Sect. E.1.2, as a back-check, the results of the screen were evaluated to determine if the generally acceptable upper risk level of E-04 (also expressed as 10^{-4}) and HI of 1 were exceeded as follows:

- constituents with detected concentrations above the PRGs were evaluated to determine if the average detected concentration would result in a risk exceeding E-04 or an HI exceeding 1. These screening-level risk estimates are based on dividing average detected concentrations for each constituent by their respective PRGs where appropriate, and

- in the case of multiple constituents with detected concentrations above PRGs, an evaluation was conducted to determine if the screening-level risk estimates based on average detected concentrations might exceed a risk of E-04 or an HI of 1.

The screening-level risk estimate indicated the cumulative risks from K-1251 Barge Facility soils were below 1E-04 and the HI was below 1. Because the risks did not exceed the generally acceptable upper risk level of E-04 or HI of 1, no further evaluation was needed, and a full risk calculation was not conducted. The screening was considered indicative of the low likelihood of adverse health effects associated with industrial exposure to K-1251 Barge Facility soils. K-1251 Barge Facility is, therefore, considered suitable for lease.

Table E.6.1. Results of industrial risk screen for K-1251 Barge Facility soils

Analyte	Frequency of detect	Minimum detect	Maximum detect	Average detected result	Background concentration[a]	Frequency of detects exceeding background	Maximum RL	Frequency of detects exceeding maximum RL	Average RL	Frequency of detects exceeding average RL	Industrial PRG (ILCR = 1E-5, HQ = 0.1)	Frequency of detects exceeding PRG limit	Location(s) of maximum detected result
Aluminum	8/8	3450 J	12400 J	6572.5	40300	0/8		NA		NA	9.2E+05	0/8	K1251-NS-02
Antimony	4/8	3.74	12.6	6.68	1.52	4/8		NA		NA	4.1E+02	0/8	K1251-NS-01
Arsenic	8/8	2.32	5.41	3.92	14.95	0/8	900	0/8	300	0/8	1.6E+01	0/8	K1251-NS-01
Barium	8/8	24.5 J	151 J	61.54	124.93	1/8		NA		NA	6.7E+04	0/8	K1251-NS-02
Beryllium	8/8	0.279 J	1.23	0.59	2.2	0/8	6000	0/8	2000	0/8	1.9E+03	0/8	K1251-NS-02
Boron	8/8	2.18 J	25.4	9.59		NA		NA		NA	2.0E+05	0/8	K1251-NS-02
Cadmium	4/8	0.151 J	1.53 J	0.68	0.22 U	3/8		NA		NA	4.5E+02	0/8	K1251-NS-02
Cobalt	8/8	3.08 J	10.1 J	6.55	42	0/8		NA		NA	1.3E+04	0/8	K1251-NS-01
Copper	8/8	7.95 J	16.7 J	10.64	22.48	0/8		NA		NA	4.1E+04	0/8	K1251-NS-02
Iron	8/8	9480 J	21900 J	14760	58600	0/8		NA		NA	3.1E+05	0/8	K1251-NS-02
Lead	8/8	24.1 J	2260 J	735.91	37.91	7/8		NA		NA		NA	K1251-NS-02
Manganese	8/8	153 J	561 J	286.25	2200	0/8		NA		NA	1.9E+04	0/8	K1251-NS-01
Mercury	8/8	0.0129	0.0326	0.02	0.17	0/8	1800	0/8	600	0/8	3.1E+02	0/8	K1251-NS-01
Nickel	8/8	7.9 J	20.3 J	11.76	26.07	0/8		NA		NA	2.0E+04	0/8	K1251-NS-02
Selenium	1/8	0.944 J	0.944 J	0.94	1.47	0/8		NA		NA	5.1E+03	0/8	K1251-NS-01
Silver	0/8	ND	ND	ND	0.6 U	0/8		NA		NA	5.1E+03	0/8	
Thallium	0/8	ND	ND	ND	0.4 U	0/8		NA		NA	6.7E+01	0/8	
Vanadium	8/8	4.8	18.2	11.01	65.47	0/8		NA		NA	1.0E+03	0/8	K1251-NS-02
Zinc	8/8	28.5 J	581 J	222.31	89.7	4/8		NA		NA	3.1E+05	0/8	K1251-NS-02
PCB-1016	0/8	ND	ND	ND		NA	100	0/8	10	0/8	3.7E+01	0/8	
PCB-1221	0/8	ND	ND	ND		NA	100	0/8	10	0/8	7.4E+00	0/8	
PCB-1232	0/8	ND	ND	ND		NA	100	0/8	10	0/8	7.4E+00	0/8	
PCB-1242	0/8	ND	ND	ND		NA	100	0/8	10	0/8	7.4E+00	0/8	
PCB-1248	0/8	ND	ND	ND		NA	100	0/8	10	0/8	7.4E+00	0/8	
PCB-1254	0/8	ND	ND	ND		NA	100	0/8	10	0/8	7.4E+00	0/8	
PCB-1260	3/8	0.0024 J	0.0073	0.0061		NA	100	0/8	10	0/8	7.4E+00	0/8	K1251-NS-02
PCB-1262	0/8	ND	ND	ND		NA	100	0/8	10	0/8	7.4E+00	0/8	
PCB-1268	0/8	ND	ND	ND		NA	100	0/8	10	0/8	7.4E+00	0/8	

Table E.6.1. Results of industrial risk screen for K-1251 Barge Facility soils (continued)

Analyte	Frequency of detect	Minimum detect	Maximum detect	Average detected result	Background concentration[a]	Frequency of detects exceeding background	Maximum RL	Frequency of detects exceeding maximum RL	Average RL	Frequency of detects exceeding average RL	Industrial PRG (ILCR = 1E-5, HQ = 0.1)	Frequency of detects exceeding PRG limit	Location(s) of maximum detected result
Americium-241	0/8	ND	ND	ND		NA		NA		NA	5.7E+01	0/8	
Bismuth-212	7/7	0.283	0.592	0.48		NA		NA		NA	3.7E+05	0/7	K1251-NS-01
Cesium-137	7/8	0.016	3.14	1.16	1	3/8	20	0/8	2	1/8	1.1E+00	2/8	K1251-NS-02
Cobalt-60	1/8	0.0159	0.0159	0.02		NA		NA		NA	6.0E-01	0/8	K1251-NS-02
Lead-212	8/8	0.385	1.21	0.72		NA		NA		NA	6.1E+04	0/8	K1251-NS-02
Lead-214	8/8	0.335	1.59	0.74		NA		NA		NA	7.5E+05	0/8	K1251-NS-02
Neptunium-237	0/8	ND	ND	ND		NA	50	0/8	5	0/8	2.7E+00	0/8	
Plutonium-238	0/8	ND	ND	ND		NA		NA		NA	1.7E+02	0/8	
Plutonium-239	1/8	0.17 J	0.17 J	0.17		NA		NA		NA	1.5E+02	0/8	K1251-NS-02
Radium-226[c]	8/8	0.362	1.46	0.65	1.25	1/8	15	0/8	5	0/8	2.6E-01	8/8	K1251-NS-02
Radium-228[d]	8/8	0.406	1.28	0.73		NA		NA		NA	1.6E-02	8/8**[b]	K1251-NS-02
Strontium-90	0/8	ND	ND	ND		NA		NA		NA	1.1E+02	0/8	
Technetium-99	0/8	ND	ND	ND		NA		NA		NA	8.9E+03	0/8	
Thallium-208	8/8	0.116	0.382	0.22		NA		NA		NA	3.7E+05	0/8	K1251-NS-02
Thorium-228	8/8	0.43 J	1.37 J	0.78	1.86	0/8		NA		NA	1.6E-02	8/8**[b]	K1251-NS-02
Thorium-230	8/8	0.496 J	2.14 J	0.97	1.2	1/8		NA		NA	2.1E+02	0/8	K1251-NS-02
Thorium-232	8/8	0.381	1.5 J	0.78	1.95	0/8	15	0/8	5	0/8	1.6E-02	8/8**[b]	K1251-NS-02
Thorium-234	8/8	0.18	1.48	0.84		NA		NA		NA	3.3E+04	0/8	K1251-NS-02
Uranium-234	8/8	0.431 J	1.7 J	0.97	1.47	2/8	7000	0/8	700	0/8	3.3E+02	0/8	K1251-NS-02
Uranium-235	3/8	0.0885 J	0.265 J	0.15		NA	80	0/8	8	0/8	3.9E+00	0/8	K1251-NS-02
Uranium-238	8/8	0.565 J	1.56 J	0.91	1.47	1/8	500	0/8	50	0/8	1.8E+01	0/8	K1251-NS-02
1,1-biphenyl	0/8	ND	ND	ND		NA		NA		NA	2.3E+04	0/8	
1,2,4,5-Tetrachlorobenzene	0/8	ND	ND	ND		NA		NA		NA	1.8E+02	0/8	
1,2,4-Trichlorobenzene	0/8	ND	ND	ND		NA		NA		NA	2.2E+02	0/8	
1,2-Dichlorobenzene	0/8	ND	ND	ND		NA		NA		NA	4.1E+03	0/8	
1,3-Dichlorobenzene	0/8	ND	ND	ND		NA		NA		NA	2.1E+03	0/8	
1,4-Dichlorobenzene	8/8	0.00026 J	0.000859 J	0.00057		NA		NA		NA	7.9E+01	0/8	K1251-NS-02
2,3,4,6-Tetrachlorophenol	0/8	ND	ND	ND		NA		NA		NA	1.8E+04	0/8	
2,4,5-Trichlorophenol	0/8	ND	ND	ND		NA		NA		NA	6.2E+04	0/8	
2,4,6-Trichlorophenol	0/8	ND	ND	ND		NA		NA		NA	6.2E+01	0/8	

Table E.6.1. Results of industrial risk screen for K-1251 Barge Facility soils (continued)

Analyte	Frequency of detect	Minimum detect	Maximum detect	Average detected result	Background concentration[a]	Frequency of detects exceeding background	Maximum RL	Frequency of detects exceeding maximum RL	Average RL	Frequency of detects exceeding average RL	Industrial PRG (ILCR = 1E-5, HQ = 0.1)	Frequency of detects exceeding PRG limit	Location(s) of maximum detected result
2,4-Dichlorophenol	0/8	ND	ND	ND		NA		NA		NA	1.8E+03	0/8	
2,4-Dimethylphenol	0/8	ND	ND	ND		NA		NA		NA	1.2E+04	0/8	
2,4-Dinitrophenol	0/8	ND	ND	ND		NA		NA		NA	1.2E+03	0/8	
2,4-Dinitrotoluene	0/8	ND	ND	ND		NA		NA		NA	2.5E+01	0/8	
2,6-Dinitrotoluene	0/8	ND	ND	ND		NA		NA		NA	2.5E+01	0/8	
2-Chloronaphthalene	0/8	ND	ND	ND		NA		NA		NA	2.3E+04	0/8	
2-Chlorophenol	0/8	ND	ND	ND		NA		NA		NA	2.4E+02	0/8	
2-Methyl-4,6-dinitrophenol	0/8	ND	ND	ND		NA		NA		NA	6.2E+01	0/8	
2-Methylphenol	0/8	ND	ND	ND		NA		NA		NA	3.1E+04	0/8	
2-Nitrobenzenamine	0/8	ND	ND	ND		NA		NA		NA	1.8E+03	0/8	
3,3'-Dichlorobenzidine	0/8	ND	ND	ND		NA		NA		NA	3.8E+01	0/8	
3-Nitrobenzenamine	0/8	ND	ND	ND		NA		NA		NA	1.8E+02	0/8	
4-Chlorobenzenamine	0/8	ND	ND	ND		NA		NA		NA	2.5E+03	0/8	
4-Nitrobenzenamine	0/8	ND	ND	ND		NA		NA		NA	8.2E+02	0/8	
Acenaphthene	2/8	0.0113 J	0.0242 J	0.02		NA		NA		NA	2.9E+04	0/8	K1251-NS-03
Anthracene	3/8	0.0187 J	0.0655 J	0.04		NA		NA		NA	2.4E+05	0/8	K1251-NS-03
Benz(*a*)anthracene	3/8	0.0592 J	0.129 J	0.09		NA		NA		NA	2.1E+01	0/8	K1251-NS-03
Benzaldehyde	0/8	ND	ND	ND		NA		NA		NA	6.2E+04	0/8	
Benzo(*a*)pyrene	4/8	0.0663 J	0.139 J	0.1		NA		NA		NA	2.1E+00	0/8	K1251-NS-03
Benzo(*b*)fluoranthene	3/8	0.0705 J	0.213 J	0.12		NA		NA		NA	2.1E+01	0/8	K1251-NS-02
Benzo(*k*)fluoranthene	1/8	0.0268 J	0.0268 J	0.03		NA		NA		NA	2.1E+02	0/8	K1251-NS-01
Bis(2-chloroethyl) ether	0/8	ND	ND	ND		NA		NA		NA	5.8E+00	0/8	
Bis(2-chloroisopropyl) ether	0/8	ND	ND	ND		NA		NA		NA	7.4E+01	0/8	
Bis(2-ethylhexyl)phthalate	0/8	ND	ND	ND		NA		NA		NA	1.2E+03	0/8	
Butyl benzyl phthalate	0/8	ND	ND	ND		NA		NA		NA	1.2E+05	0/8	
Caprolactam	0/8	ND	ND	ND		NA		NA		NA	3.1E+05	0/8	
Carbazole	1/8	0.0553 J	0.0553 J	0.06		NA		NA		NA	8.6E+02	0/8	K1251-NS-03
Chrysene	3/8	0.0524 J	0.119 J	0.1		NA		NA		NA	2.1E+03	0/8	K1251-NS-03
Di-n-butyl phthalate	0/8	ND	ND	ND		NA		NA		NA	6.2E+04	0/8	
Di-n-octylphthalate	0/8	ND	ND	ND		NA		NA		NA	2.5E+04	0/8	

Table E.6.1. Results of industrial risk screen for K-1251 Barge Facility soils (continued)

Analyte	Frequency of detect	Minimum detect	Maximum detect	Average detected result	Background concentration[a]	Frequency of detects exceeding background	Maximum RL	Frequency of detects exceeding maximum RL	Average RL	Frequency of detects exceeding average RL	Industrial PRG (ILCR = 1E-5, HQ = 0.1)	Frequency of detects exceeding PRG limit	Location(s) of maximum detected result
Dibenz(*a,h*)anthracene	0/8	ND	ND	ND		NA		NA		NA	2.1E+00	0/8	
Dibenzofuran	0/8	ND	ND	ND		NA		NA		NA	1.6E+03	0/8	
Diethyl phthalate	0/8	ND	ND	ND		NA		NA		NA	4.9E+05	0/8	
Dimethyl phthalate	0/8	ND	ND	ND		NA		NA		NA	6.2E+06	0/8	
Diphenylamine	0/8	ND	ND	ND		NA		NA		NA	1.5E+04	0/8	
Fluoranthene	7/8	0.014 J	0.283 J	0.08		NA		NA		NA	2.2E+04	0/8	K1251-NS-03
Fluorene	2/8	0.0133 J	0.0301 J	0.02		NA		NA		NA	2.6E+04	0/8	K1251-NS-03
Hexachlorobenzene	0/8	ND	ND	ND		NA		NA		NA	1.1E+01	0/8	
Hexachlorobutadiene	0/8	ND	ND	ND		NA		NA		NA	1.8E+02	0/8	
Hexachlorocyclopentadiene	0/8	ND	ND	ND		NA		NA		NA	3.7E+03	0/8	
Hexachloroethane	0/8	ND	ND	ND		NA		NA		NA	6.2E+02	0/8	
Indeno(*1,2,3-cd*)pyrene	5/8	0.128 J	0.163 J	0.14		NA		NA		NA	2.1E+01	0/8	K1251-NS-02
Isophorone	0/8	ND	ND	ND		NA		NA		NA	5.1E+03	0/8	
N-Nitroso-di-n-propylamine	0/8	ND	ND	ND		NA		NA		NA	2.5E+00	0/8	
Naphthalene	1/8	0.0135 J	0.0135 J	0.01		NA		NA		NA	1.9E+02	0/8	K1251-NS-03
Nitrobenzene	0/8	ND	ND	ND		NA		NA		NA	1.0E+02	0/8	
Pentachlorophenol	0/8	ND	ND	ND		NA		NA		NA	9.0E+01	0/8	
Phenol	0/8	ND	ND	ND		NA		NA		NA	1.8E+05	0/8	
Pyrene	6/8	0.0215 J	0.221 J	0.09		NA		NA		NA	2.9E+04	0/8	K1251-NS-03
1,1,1-Trichloroethane	0/8	ND	ND	ND		NA		NA		NA	6.9E+03	0/8	
1,1,2,2-Tetrachloroethane	0/8	ND	ND	ND		NA		NA		NA	9.3E+00	0/8	
1,1,2-Trichloro-1,2,2-trifluoroethane	0/8	ND	ND	ND		NA		NA		NA	6.9E+04	0/8	
1,1,2-Trichloroethane	0/8	ND	ND	ND		NA		NA		NA	1.6E+01	0/8	
1,1-Dichloroethane	0/8	ND	ND	ND		NA		NA		NA	1.7E+03	0/8	
1,1-Dichloroethene	3/8	0.000595 J	0.000955	0.00072		NA		NA		NA	4.1E+02	0/8	K1251-NS-01
1,2-Dibromo-3-chloropropane	0/8	ND	ND	ND		NA		NA		NA	1.1E+01	0/8	
1,2-Dibromoethane	0/8	ND	ND	ND		NA		NA		NA	6.3E-01	0/8	
1,2-Dichloroethane	0/8	ND	ND	ND		NA		NA		NA	6.0E+00	0/8	
1,2-Dichloropropane	0/8	ND	ND	ND		NA		NA		NA	7.4E+00	0/8	

Table E.6.1. Results of industrial risk screen for K-1251 Barge Facility soils (continued)

Analyte	Frequency of detect	Minimum detect	Maximum detect	Average detected result	Background concentration[a]	Frequency of detects exceeding background	Maximum RL	Frequency of detects exceeding maximum RL	Average RL	Frequency of detects exceeding average RL	Industrial PRG (ILCR = 1E-5, HQ = 0.1)	Frequency of detects exceeding PRG limit	Location(s) of maximum detected result
1,4-Dioxane	0/8	ND	ND	ND		NA		NA		NA	1.6E+03	0/8	
2-Butanone	0/8	ND	ND	ND		NA		NA		NA	1.1E+05	0/8	
2-Methoxy-2-methylpropane	0/8	ND	ND	ND		NA		NA		NA	3.6E+02	0/8	
4-Methyl-2-pentanone	0/8	ND	ND	ND		NA		NA		NA	4.7E+04	0/8	
Acetone	5/8	0.00228 J	0.00859 J	0.01		NA		NA		NA	5.4E+04	0/8	K1251-NS-01
Benzene	0/8	ND	ND	ND		NA		NA		NA	1.4E+01	0/8	
Bromodichloromethane	0/8	ND	ND	ND		NA		NA		NA	1.8E+01	0/8	
Bromoform	0/8	ND	ND	ND		NA		NA		NA	2.2E+03	0/8	
Bromomethane	0/8	ND	ND	ND		NA		NA		NA	1.3E+01	0/8	
Carbon disulfide	0/8	ND	ND	ND		NA		NA		NA	1.2E+03	0/8	
Carbon tetrachloride	0/8	ND	ND	ND		NA		NA		NA	5.5E+00	0/8	
Chlorobenzene	0/8	ND	ND	ND		NA		NA		NA	5.3E+02	0/8	
Chloroethane	0/8	ND	ND	ND		NA		NA		NA	6.5E+01	0/8	
Chloroform	0/8	ND	ND	ND		NA		NA		NA	4.7E+00	0/8	
Chloromethane	0/8	ND	ND	ND		NA		NA		NA	1.6E+02	0/8	
Cumene	0/8	ND	ND	ND		NA		NA		NA	5.2E+02	0/8	
Cyclohexane	0/8	ND	ND	ND		NA		NA		NA	9.4E+03	0/8	
Dibromochloromethane	0/8	ND	ND	ND		NA		NA		NA	2.6E+01	0/8	
Dichlorodifluoromethane	0/8	ND	ND	ND		NA		NA		NA	3.1E+02	0/8	
Ethylbenzene	0/8	ND	ND	ND		NA		NA		NA	7.4E+03	0/8	
Methyl acetate	0/8	ND	ND	ND		NA		NA		NA	9.2E+04	0/8	
Methylcyclohexane	0/8	ND	ND	ND		NA		NA		NA	8.7E+03	0/8	
Methylene chloride	2/8	0.00235 J	0.00413	0.00387		NA		NA		NA	2.1E+02	0/8	K1251-NS-02
Styrene	0/8	ND	ND	ND		NA		NA		NA	1.8E+04	0/8	
Tetrachloroethene	0/8	ND	ND	ND		NA		NA		NA	1.3E+01	0/8	
Toluene	1/8	0.000297 J	0.000297 J	0.000297		NA		NA		NA	2.2E+03	0/8	K1251-NS-01
Trichloroethene	0/8	ND	ND	ND		NA		NA		NA	6.5E+01	0/8	
Trichlorofluoromethane	0/8	ND	ND	ND		NA		NA		NA	1.3E+03	0/8	
Vinyl chloride	0/8	ND	ND	ND		NA		NA		NA	7.5E+00	0/8	
cis-1,2-Dichloroethene	0/8	ND	ND	ND		NA		NA		NA	1.5E+02	0/8	

Table E.6.1. Results of industrial risk screen for K-1251 Barge Facility soils (continued)

Analyte	Frequency of detect	Minimum detect	Maximum detect	Average detected result	Background concentration[a]	Frequency of detects exceeding background	Maximum RL	Frequency of detects exceeding maximum RL	Average RL	Frequency of detects exceeding average RL	Industrial PRG (ILCR = 1E-5, HQ = 0.1)	Frequency of detects exceeding PRG limit	Location(s) of maximum detected result
trans-1,2-Dichloroethene	0/8	ND	ND	ND		NA		NA		NA	2.3E+02	0/8	

Units are in picocuries per gram (pCi/g) or milligrams per kilogram (mg/kg).

[a] The background data set that is being used has values for only ^{40}K, ^{226}Ra, ^{228}Th, ^{230}Th, ^{232}Th, and ^{238}U. However, the U. S. Environmental Protection Agency (EPA) report on the September 2001 sampling of the Scarboro community (SESD Project No. 01-1222, April 2003) denotes that, in some cases, the PRG values are far below the background values. As an example, the EPA report mentions that the ^{137}Cs background is approximately 1 pCi/g, but the PRG is far lower. For this report, a background of 1.0 pCi/g is used for ^{137}Cs. In addition, a background for ^{288}Ra has been assumed based on equilibrium with ^{228}Th and for ^{234}U based on equilibrium with ^{238}U. Background values for other radionuclides for which data is not available are assumed to be zero.

[b] PRG not applicable for this radionuclide, due to an exception in the Zone 1 Record of Decision (DOE 2002a). The exception takes background levels for these radionuclides into consideration.

[c] Assumed to be in equilibrium with measured radon progeny, ^{214}Bi.

[d] Assumed to be in equilibrium with measured progeny, ^{228}Ac.

NA = Not applicable, not available, or insufficient data to calculate the statistic.

ND = Not detected

PCB = polychlorinated biphenyl.

RL = remediation level.

E.7. EVALUATION OF UNCERTAINTIES

The estimation of uncertainty, whether quantitative or qualitative, is fundamental to scientific activities that involve measured or assessed quantities. Estimates of risk are conditional based on a number of assumptions concerning exposure. Generation of a point estimate of risk, as has been done in this screening-level assessment, has the potential to yield under- or overestimates of the actual value and can lead to improper decisions. Therefore, it is necessary to specify the assumptions and uncertainties inherent in the screening-level evaluation process to place the risk estimates in perspective and ensure that anyone making risk-management decisions is well informed.

Uncertainty about environmental risk estimates is known to be at least an order of magnitude or greater (EPA 1989). The evaluation of uncertainties for the assessment is qualitative, since the resource requirements necessary to provide a quantitative statistical uncertainty analysis for this study area would generally outweigh the benefits. The focus of the discussion in this section will be on the important variables and assumptions that contribute most to the overall uncertainty.

E.7.1 UNCERTAINTY IN THE SOURCE TERM

Several uncertainties are associated with the data set and the data evaluation process. These uncertainties include the selection of COPCs and the determination of the EPC.

Although the data evaluation process used to select COPCs adheres to established procedures and guidance, it also requires making decisions and developing assumptions on the basis of historical information, process knowledge, and best professional judgment about the data. Uncertainties are associated with all such assumptions. The background concentrations and PRGs used to screen analytes are also subject to uncertainty. The toxicity values used in the derivation of PRGs are subject to change; as additional information (from scientific research) becomes available, these periodic changes in toxicity values may cause the PRG values to change as well, causing increased uncertainty in the data screening process.

Representative concentrations and other statistics are calculated in this risk screen based on the assumption that the samples collected are truly random samples. Some of the data may not have been taken randomly, but rather may have come from biased sampling, aimed at identifying high contaminant concentration locations.

This evaluation has been performed using only the COPCs with available toxicity data. It should be noted that the qualitative COPCs determined for this study area could potentially increase the risks/hazards to a receptor. Radionuclides that are short-lived isotopes were eliminated from the dataset, along with daughter products of isotopes that include the contribution of the daughter in the PRG calculation to overestimating their contribution to the overall risks.

Additional uncertainty is associated with the inclusion of constituents, which are present at concentrations similar to concentrations found in background samples. The effect of including these constituents in the risk evaluation is to overestimate the site-related risks and toxic effects associated with the K-1251 Barge Facility (see Chap. E.6).

E.7.2 UNCERTAINTY IN THE EXPOSURE ASSESSMENT

For each exposure pathway, assumptions are made concerning the parameters, the routes of exposure, the amount of contaminated media an individual can be exposed to, and intake rates for different routes of exposure. In the absence of site-specific data, the assumptions used in this assessment are consistent with EPA-approved parameters and default values. When several of these upper-bound values are combined in estimating exposure for any one pathway, the resulting risks can be in excess of the 99th percentile and, therefore, outside the range that may be reasonably expected.

The guidance values for intake rates and exposure parameters are assumed to be representative of the hypothetical populations evaluated. All contaminant exposures and intakes are assumed to be from the site-related exposure media (i.e., no other sources contribute to the receptor's risk). Even if these assumptions are true, other areas of uncertainty may apply. Selected intake rates and population characteristics (i.e., weight, life span, and activities) are assumed to be representative of the exposed population. The consistent conservatism used in the estimation of these parameters generally leads to overestimation of the potential risk to the postulated receptors.

E.7.3 UNCERTAINTY IN TOXICITY VALUES AND RISK PREDICTIONS

Uncertainty in the values used to represent the dose-response relationship will highly impact the risk estimates. These uncertainties are contaminant-specific and are embedded in the toxicity value. The factors that are incorporated to represent sources of uncertainty include the source of the data, duration of the study, extrapolations from short- to long-term exposures, intrahuman or interspecies variability, and other special considerations. In addition, toxicity varies with the chemical form.

Uncertainties related to the summation of carcinogenic risk and non-carcinogenic hazard estimates across contaminants and pathways are a primary uncertainty in the risk characterization process. In the absence of information on the toxicity of specific chemical mixtures, additive (cumulative) risks are assumed (EPA 1989).

Limitations of the additive risk approach for exposure to multiple chemicals include the following:

1. The slope factors may represent the mean but often represent the upper 95th percentile estimate of potency (the central estimate on the mean for radionuclides), so the summation can result in an excessively conservative estimate of lifetime risk.

2. The reference doses do not have equal accuracy or precision and are not based on the same severity of effects.

3. The effects of a mixture of carcinogens are unknown, and possible interactions could be synergistic or antagonistic.

Despite these limitations and the general unavailability of data on these interactions, summations were performed for the carcinogenic risks and chemical hazards presented in the risk screen. This approach is consistent with RAGS (EPA 1989).

In order to avoid double-counting the short-lived daughters of specific isotopes, the daughters were excluded from the COPC list if analytical results for the parent were available; only daughters as defined by EPA (2001) were excluded. As a special case, the ^{232}Th decay chain was evaluated as "^{232}Th+D" (which combines the slope factors for ^{232}Th, ^{228}Ra+D, and ^{228}Th+D) when calculating risks. When evaluating data for "^{232}Th+D," a conservative approach was used, whereby the largest concentration among ^{232}Th, ^{228}Ra, and ^{228}Th was used to determine the maximum detected concentration and to estimate all summary statistics. Another special consideration for radioisotopes was to eliminate ^{40}K from the COPC list, as it was considered to be naturally occurring and, therefore, was not considered to be a COPC.

E.8. REFERENCES

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