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Baseline Condition Report for Building 2033 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee

This document has been approved for release to the public by:

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

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Baseline Condition Report for Building 2033 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee

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All sources of information on which SAIC has relied in making its conclusions are identified in Chap. 8 of this report. Any information, regardless of its source, not listed in Chap. 8 has not been evaluated or relied upon by SAIC in the context of this report.

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ACRONYMS

µg/L	micrograms per liter
bgs	below ground surface
BJC	Bechtel Jacobs Company LLC
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COE	U. S. Army Corps of Engineers
COPC	contaminant of potential concern
CROET	Community Reuse Organization of East Tennessee
DOE	U. S. Department of Energy
dpm	disintegrations per minute
EPA	U. S. Environmental Protection Agency
FFA	Federal Facility Agreement
IROD	Interim Record of Decision
MCL	maximum contaminant level
OREIS	Oak Ridge Environmental Information System
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
pCi/L	picocuries per liter
PRG	preliminary remediation goal
QA	quality assurance
QC	quality control
RL	remediation level
ROD	Record of Decision
SU	survey unit
SVOC	semivolatile organic compound
TDEC	Tennessee Department of Environment and Conservation
TRU	transuranic
TVA	Tennessee Valley Authority
UT-B	University of Tennessee-Battelle
VOC	volatile organic compound

EXECUTIVE SUMMARY

This report documents the baseline environmental condition of the U. S. Department of Energy's (DOE's) Building 2033 at the Oak Ridge National Laboratory (ORNL). DOE is proposing to lease this building to the Community Reuse Organization of East Tennessee (its sublessees, agents, or representatives). This report provides supporting information for the use, by a potential lessee, of a government-owned building at ORNL.

The lease footprint includes the building, the adjacent parking lot on the east side of the building, and a segment of the sidewalk connecting the east parking lot to the building. The building was built in 1994 and is located among other office, laboratory, and operational support buildings in the northwest quadrant of the ORNL campus. The building sits off of Hilltop Circle immediately south of Building 2000. From the early 1940s to the early 1990s, this site was a wooded and grassy area of ORNL.

Building 2033 is a three-story office and laboratory building consisting of approximately 32,000 ft^2 of floor area. The building is situated on a sloping site such that grade-level access is afforded at both the upper and basement levels. The main entrance is on the upper level off of Hilltop Circle. Each floor has an approximate area of 11,000 ft^2. The basement has a crawl space accounting for approximately 25% of the footprint on the north side. The remaining area consists of corridors and stairs, mechanical, and other space.

The exterior of the building consists of composite metal insulating and finish panels and bronze-tinted insulating glass in bronze, anodized aluminum frames. The building structural system consists of steel framing. Above-grade floors consist of concrete slab on metal form-deck supported by steel joists. The building mechanical systems consist of a central heating and air-conditioning system, an automatic sprinkler fire-suppression system, and standard restroom plumbing. Sanitary sewer service is connected to the ORNL system. Domestic water is provided by the municipal utility. There is one card-reader access control system for the building.

Based on the date of construction, the presence of asbestos-containing material and polychlorinated biphenyls (PCBs) is unlikely in the building.

The east side parking lot is paved and consists of approximately 11,000 ft^2 and the portion of the sidewalk included consists of approximately 150 linear ft.

A review of the property and government records was performed to identify any areas on the property proposed for lease where hazardous substances and/or petroleum products or their derivatives were stored for 1 year or more, or were known to have been released, or disposed of. The review and inspection were modeled after the requirements of Section 120(h) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Based on information and records available at this time, there is no indication that hazardous materials or chemicals exceeding 1000 kg have been stored and/or used at Building 2033 or that there were releases or disposal of hazardous substances.

There are no environmental waste management areas associated with the lease space. However, the lease space is part of an area listed in the CERCLA Federal Facility Agreement (FFA). Based on historic data, the Interim Record of Decision (IROD) for this FFA area (Bethel Valley) (DOE 2002) assumes no soil remediation in the study area and defers groundwater investigations to the final Bethel Valley Record of Decision (ROD). Final RODs for all media are scheduled for fiscal year 2009 or beyond.

Historical radiological surveys from Building 2033 were reviewed and new radiological surveys were conducted in the building. The historical building surveys indicate that contamination levels do not exceed contamination release limits for ORNL. Recent radiological surveys of the building interior

revealed anomalous readings that were determined to be related to track-in of radon and thoron progeny except for one small spot at the entrance. This spot was remediated by removal of the carpet. Therefore, results of the surveys performed in the study area indicate that the surfaces are now below the DOE surface contamination limits and within the acceptable dose-equivalent rate range for interior surfaces.

Soil samples were collected near the building to determine the potential for exposures to workers as they enter and exit the building. The samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), PCBs, metals, pesticides/herbicides, baseline radionuclides, and transuranic radionuclides.

No VOCs were detected in the samples and low levels of SVOCs and PCBs [below preliminary remediation goals (PRGs)] were detected in a few samples. All sample locations were found to have detected metals results, which is to be expected because native soils generally have a measurable content of metals. Only the metal arsenic exceeded the PRG in one sampling location. The average remediation level established in the IROD is an order of magnitude above the maximum concentration detected in that sample.

Although some individual soil sample results for all radionuclide analytes exceeded either their background reference values or their PRGs, no radionuclides exceeded both their background reference value and their PRG.

Historical groundwater data are also available for monitoring wells located in the adjacent space. These samples have been analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and radiological constituents. Monitoring well #813 is located at the southeast corner of Building 2033 and was sampled in the late 1980s through the early 1990s for VOCs. Low concentrations (µg/L scale) of a few VOCs were detected. However, the underlying fee and groundwater are not part of the lease space and access to both is restricted.

The risk evaluation considered exposure to building interiors as well as potential soil exposure while entering or exiting Building 2033. The soil evaluation found that only a single arsenic detection was above the industrial worker PRG. Because only a single detection of arsenic exceeded the PRG, and the average detected arsenic concentration was below the PRG, arsenic is not considered to be a contaminant of potential concern (COPC). Because no soil COPCs were identified, potential exposures to soils were not evaluated further in this risk assessment and a hazard index (HI), which represents the potential for toxic effects to an exposed individual, was not calculated. The risk calculation for the building interior based on the data obtained from the radiological surveys indicated that risks were approximately 2E-08, which does not exceed the U. S. Environmental Protection Agency target risk range of E-06 to E-04. The results indicate a low likelihood of adverse health effects associated with Building 2033 industrial/office worker exposure to the building interior surfaces or area soils. Based on the results of the evaluations presented in this report, Building 2033 is suitable for lease.

1. PROPERTY IDENTIFICATION

Building 2033 discussed in this baseline environmental condition report is located among other office, laboratory, and operational support facilities in the northwest quadrant of the Oak Ridge National Laboratory (ORNL) on the Oak Ridge Reservation (ORR) in Roane County, Tennessee. Figure 1.1 delineates the footprint of the study area showing the location of the building in relation to the rest of the ORNL main campus. The building sits off of Hilltop Circle immediately south of Building 2000. The building is situated on a sloping site such that grade-level access is afforded at the upper, east side, and basement levels. The main entrance is on the upper level off of Hilltop Circle, and a service drive connects to Second Street from the south and east sides of the building.

The lease footprint includes the building, the adjacent parking lot on the east side of the building, and the segment of sidewalk connecting the east parking lot to the building (Fig 1.2). Figures 1.3 through 1.11 are aerial photographs of the area showing the facility and surrounding areas from pre-construction of ORNL (1942) to 1998 and a satellite image taken in 2004. From the early 1940s to the 1990s, the site was a wooded and grassy area of ORNL.

Building 2033 is a three-story office and laboratory building consisting of approximately 32,000 ft^2 of floor area and was built in 1994. Each floor has an approximate footprint of 11,000 ft^2. The basement has a crawl space accounting for approximately 25% of the footprint on the north side. The remaining area consists of corridors and stairs, mechanical, and other space.

The east side parking lot is paved and consists of approximately 11,000 ft^2 and the portion of the connecting sidewalk consists of approximately 150 linear ft.

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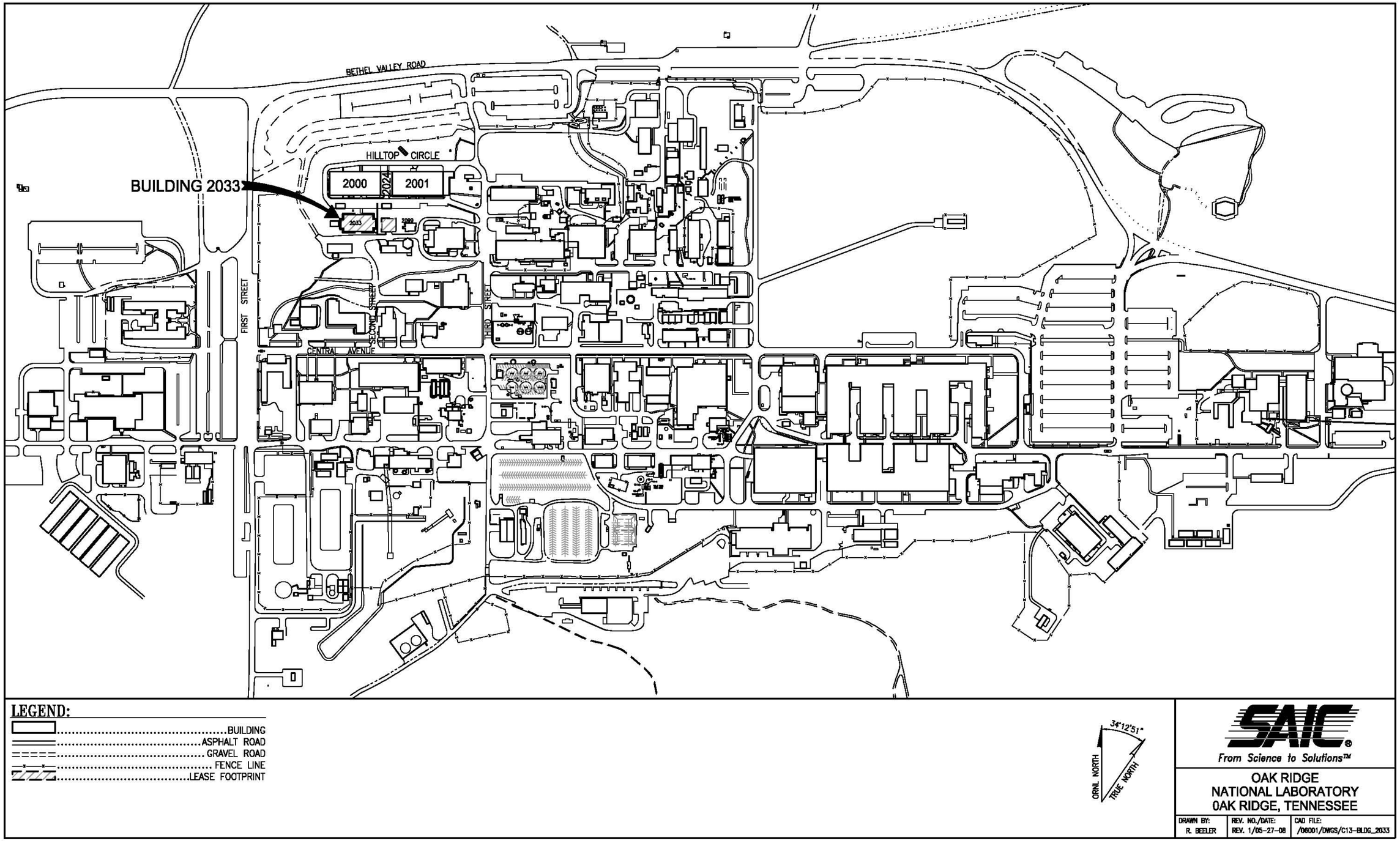

Fig. 1.1. Location of Building 2033 within ORNL.

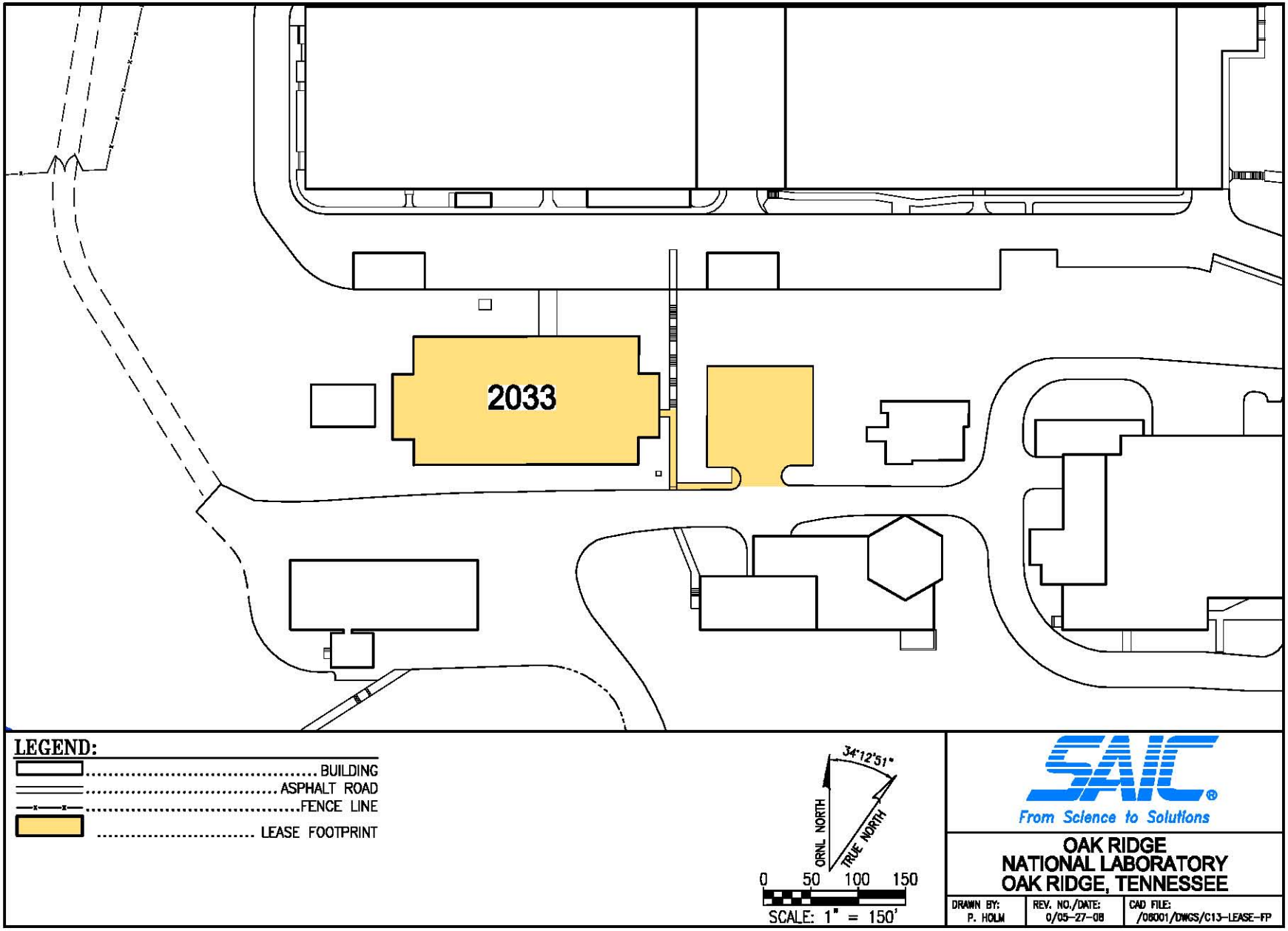

Fig. 1.2. Lease footprint for Building 2033.

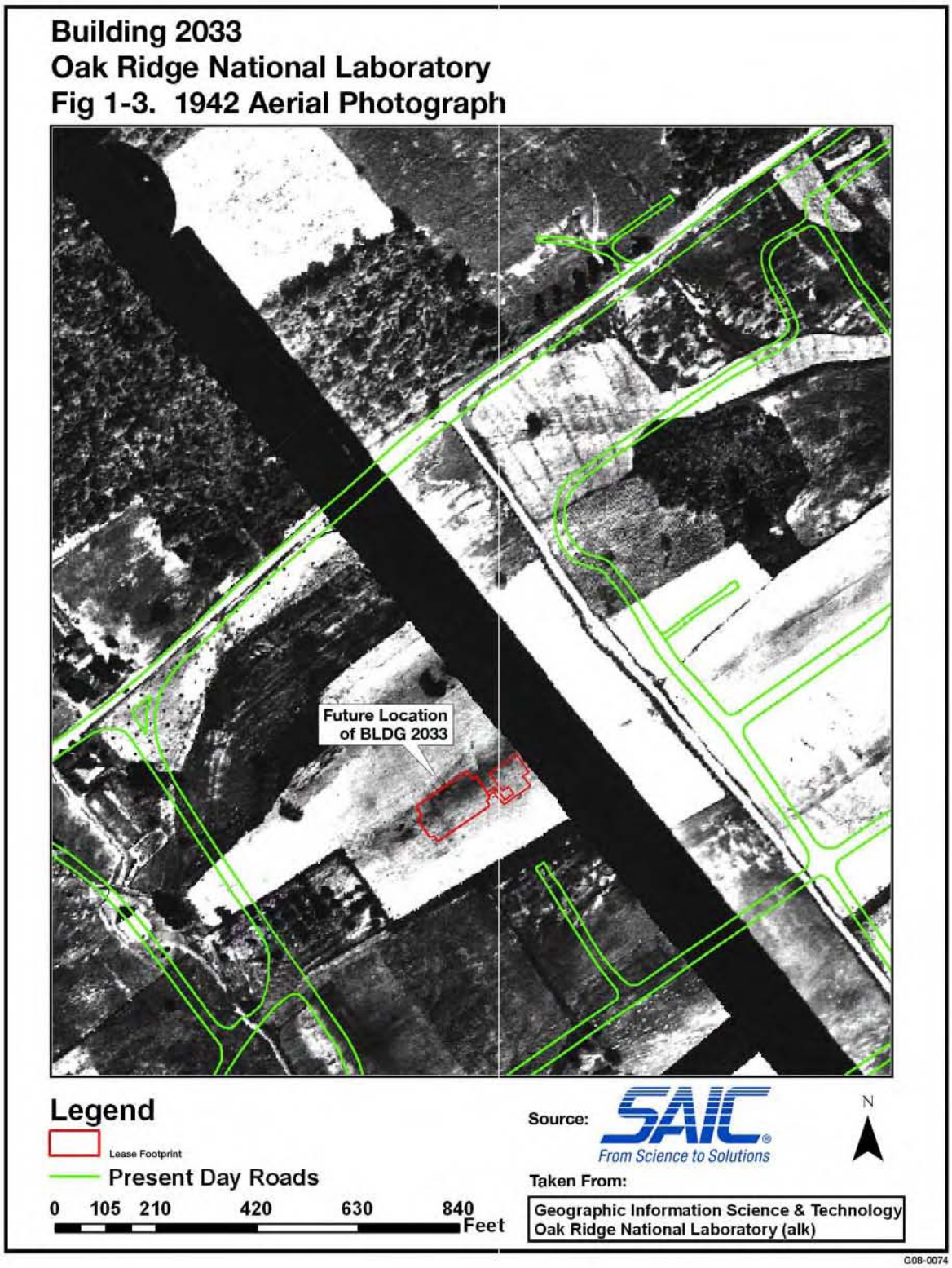

Fig. 1.3. Aerial photograph of the Building 2033 study area (1942).

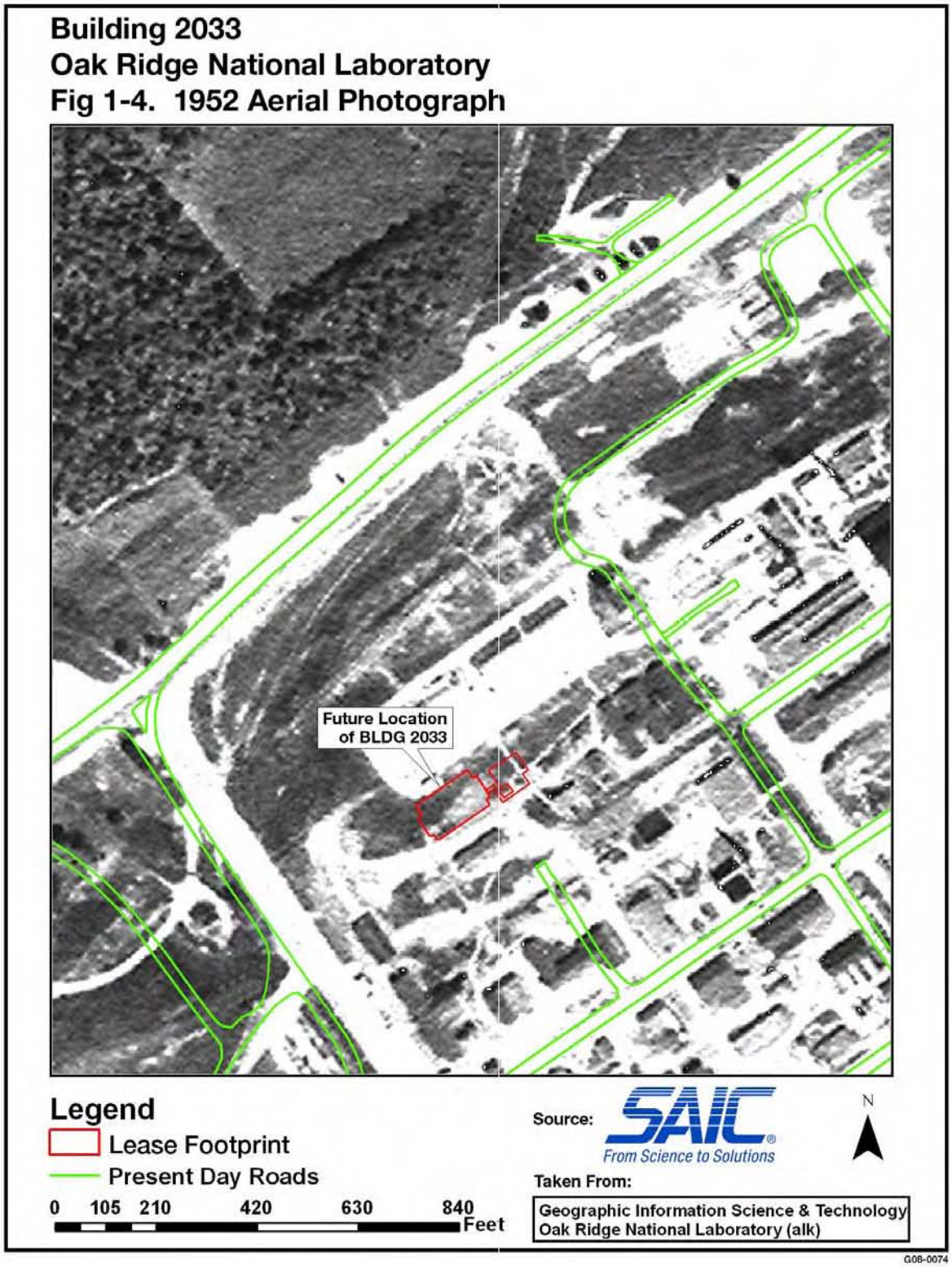

Fig. 1.4. Aerial photograph of the Building 2033 study area (1952).

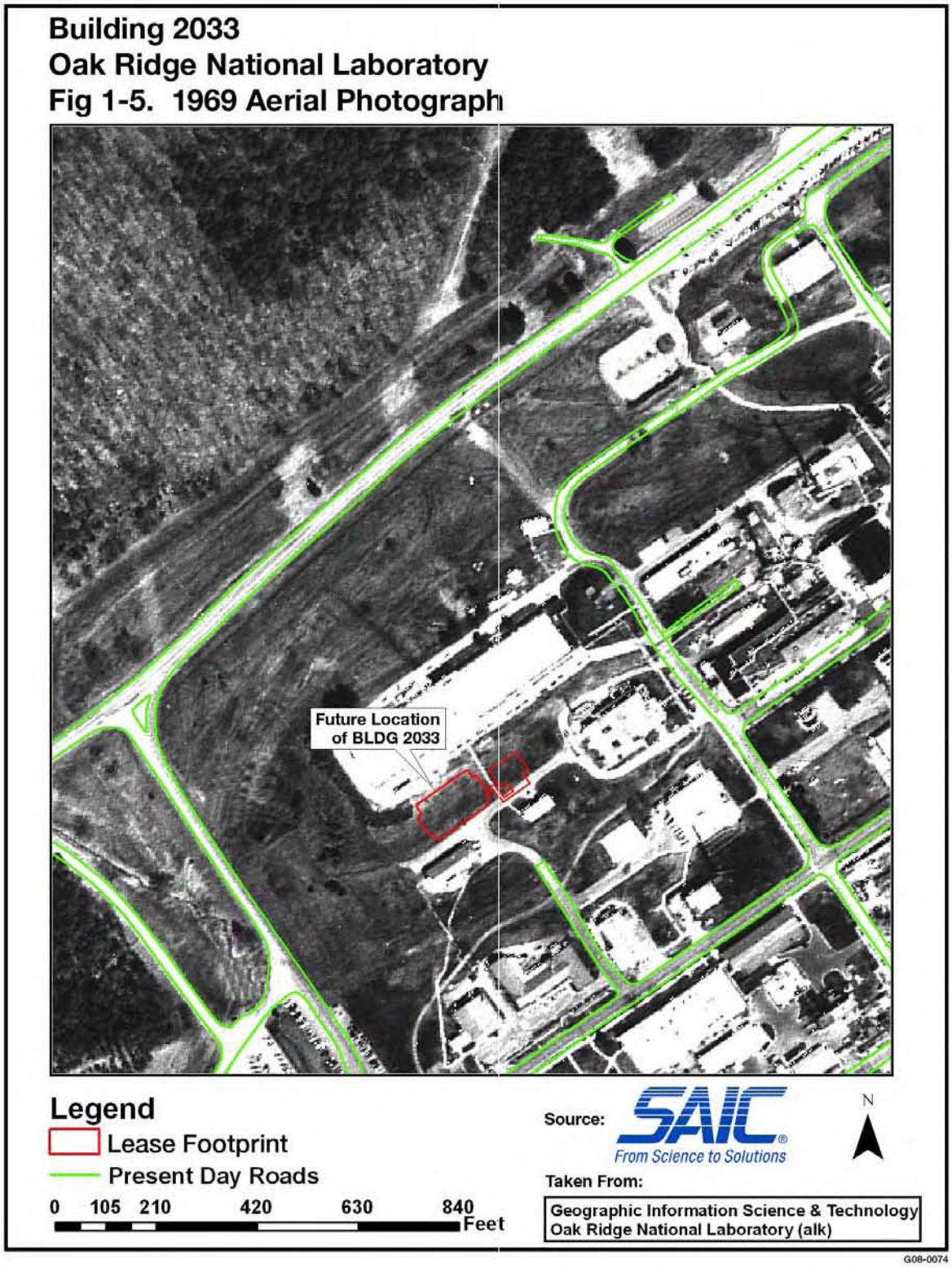

Fig. 1.5. Aerial photograph of the Building 2033 study area (1969).

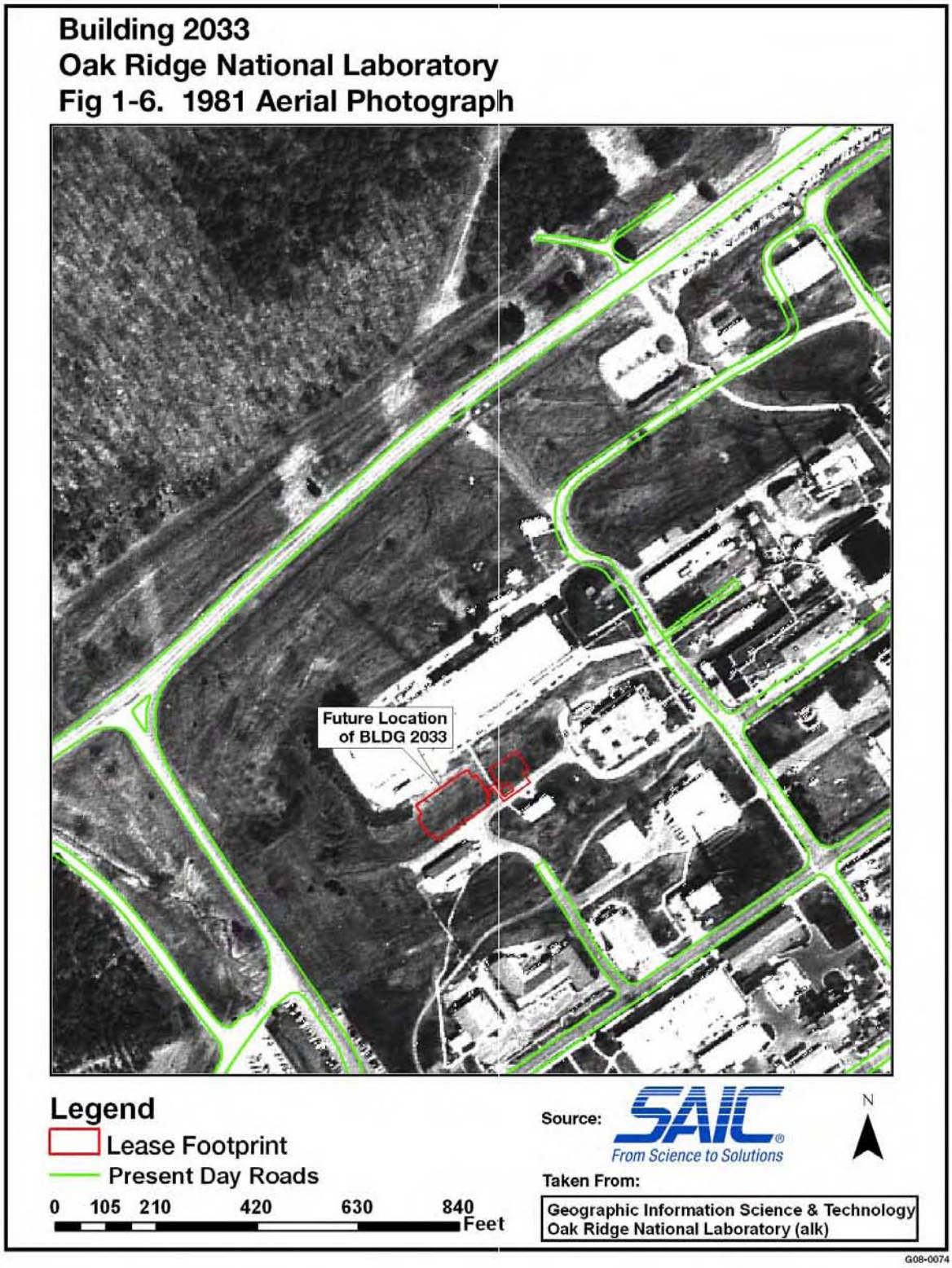

Fig. 1.6. Aerial photograph of the Building 2033 study area (1981).

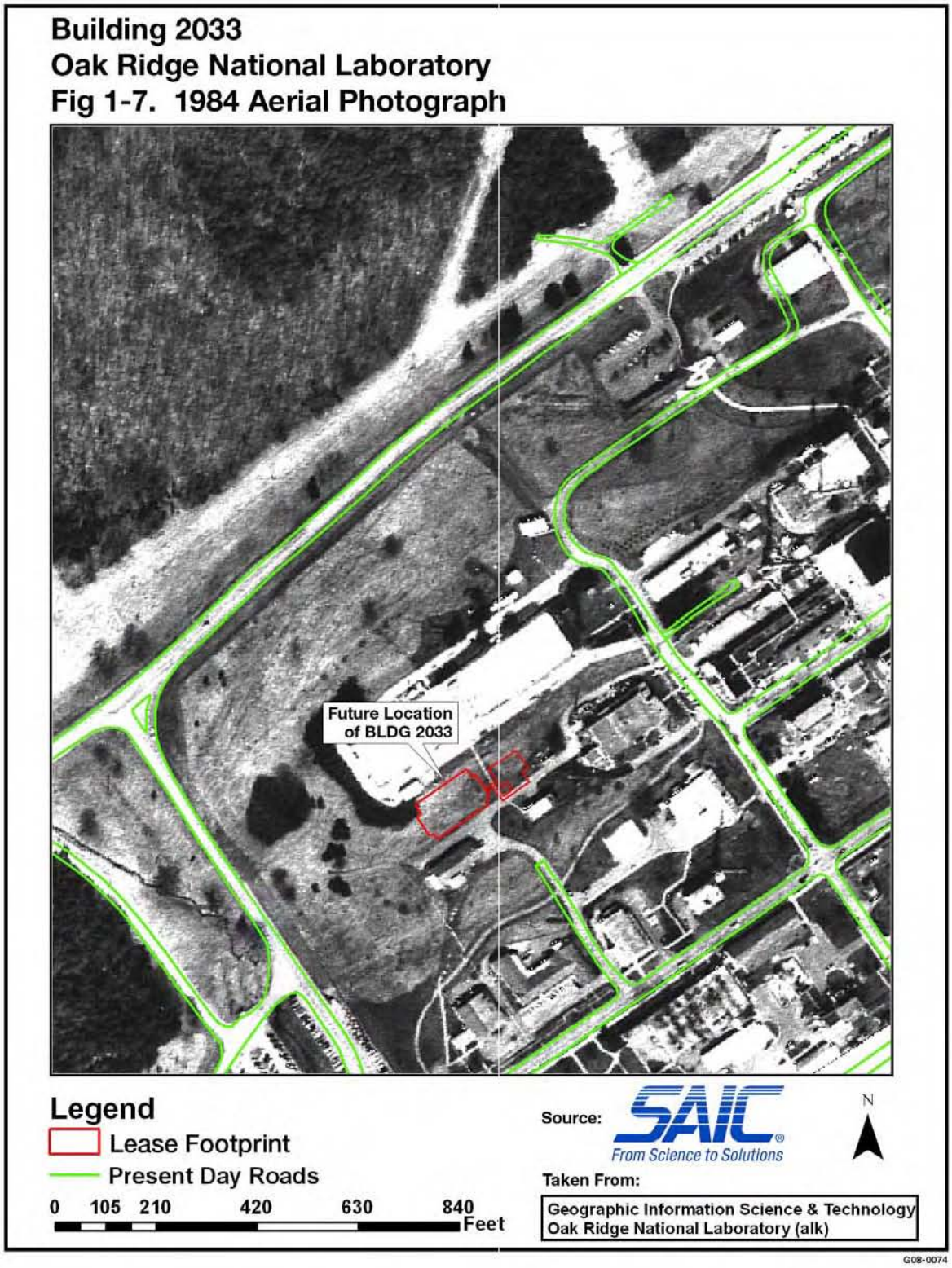

Fig. 1.7. Aerial photograph of the Building 2033 study area (1984).

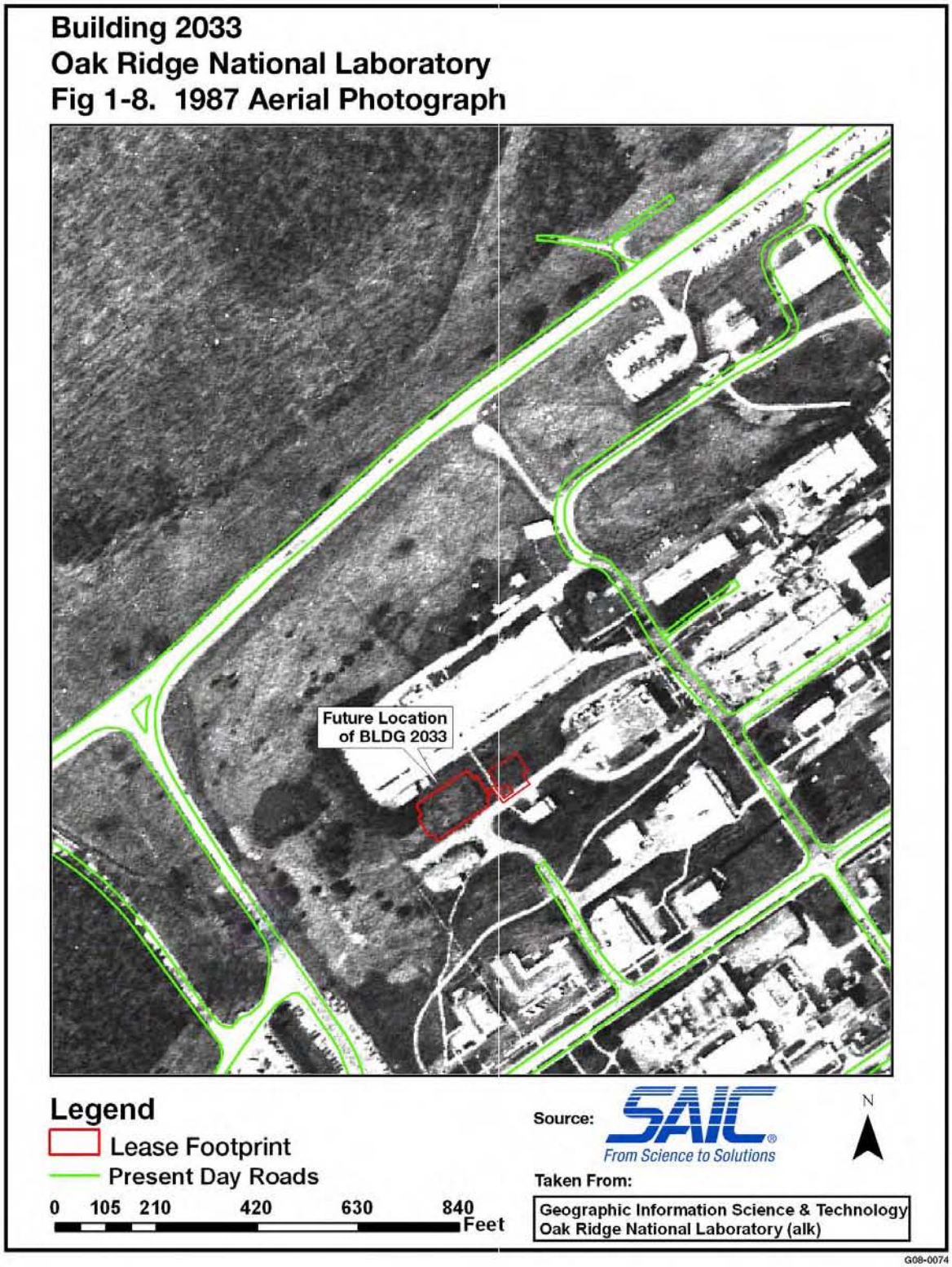

Fig. 1.8. Aerial photograph of the Building 2033 study area (1987).

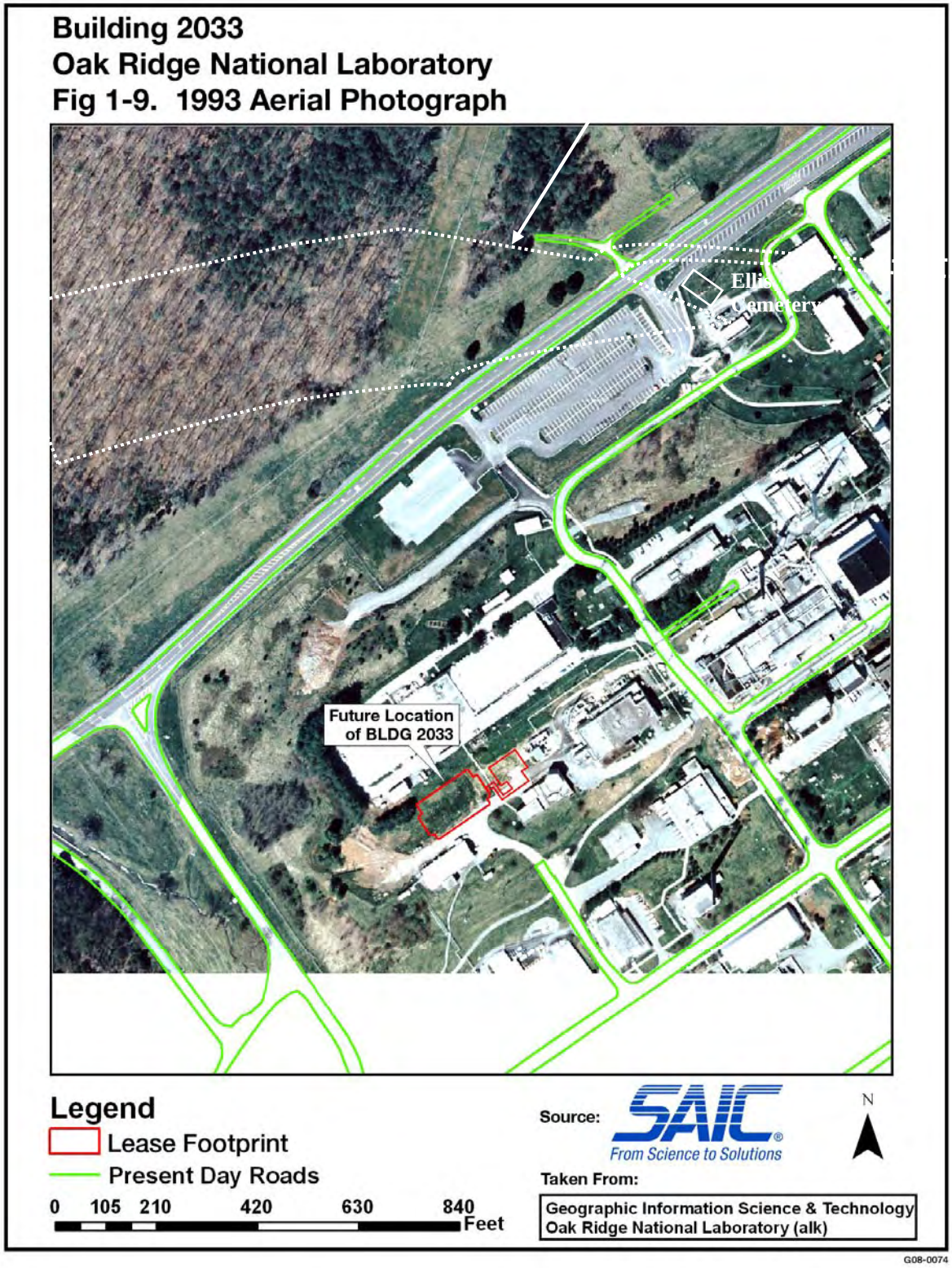

Fig. 1.9. Aerial photograph of the Building 2033 study area (1993).

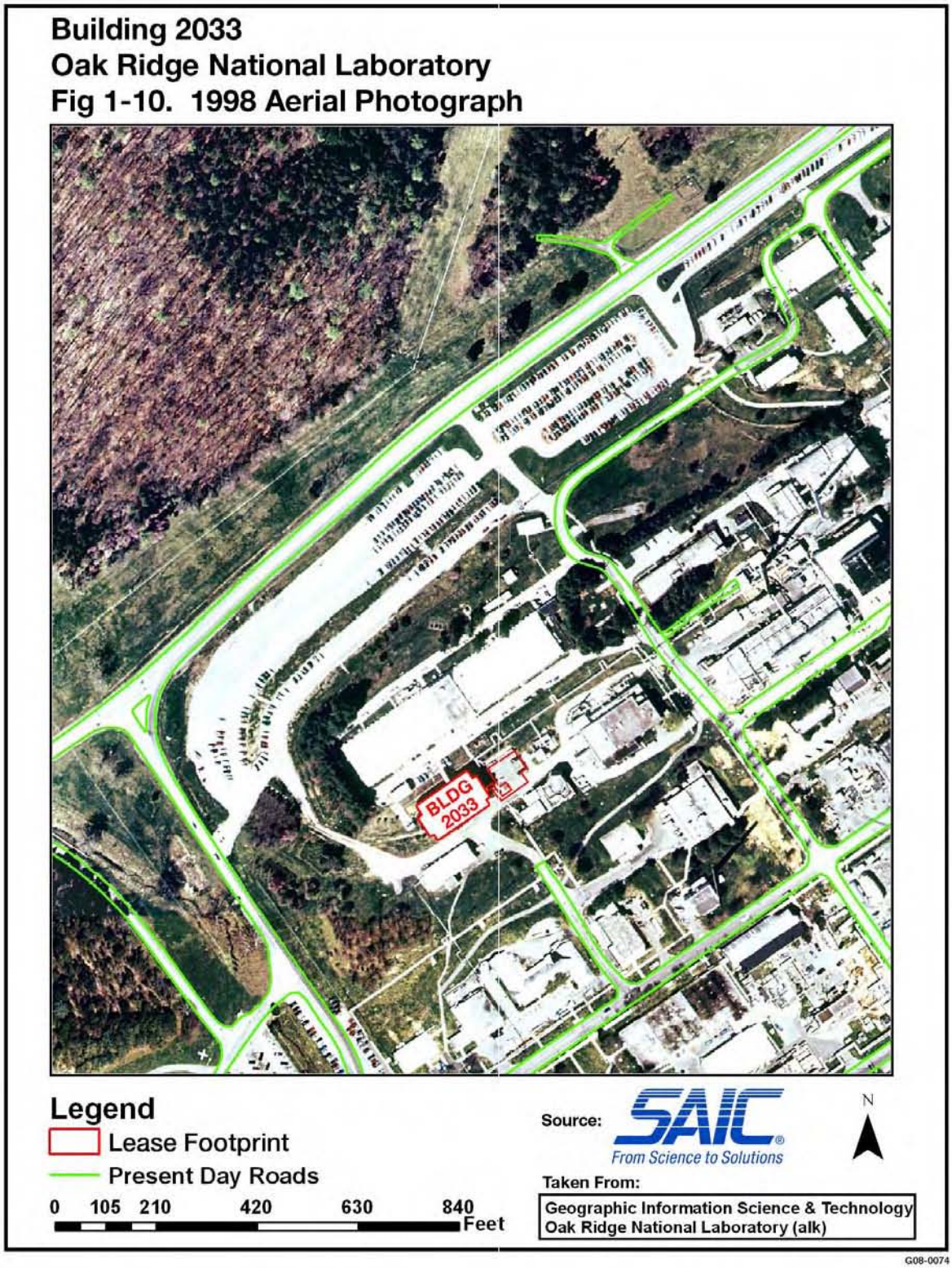

Fig. 1.10. Aerial photograph of the Building 2033 study area (1998).

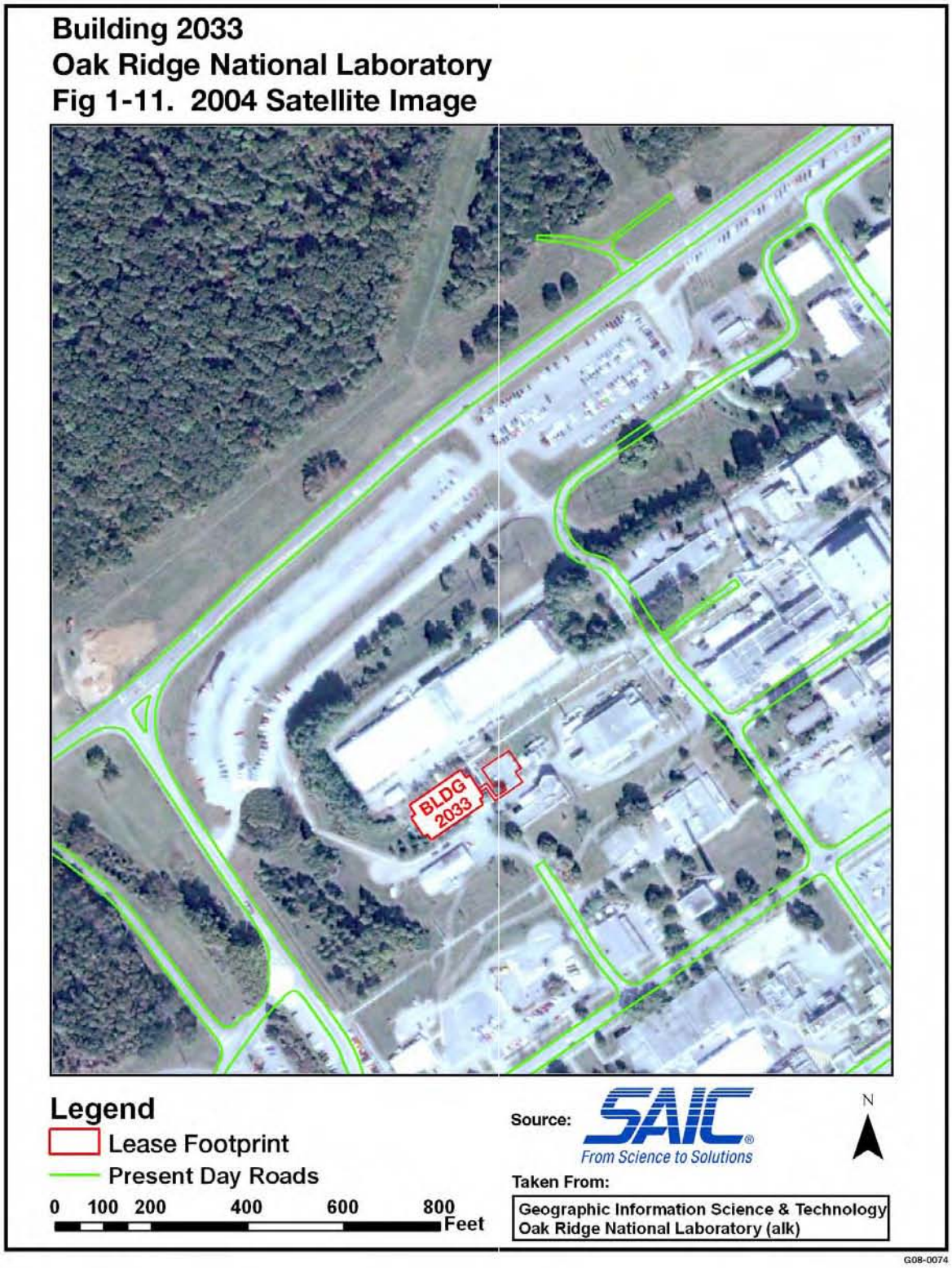

Fig. 1.11. Satellite image of the Building 2033 study area (2004).

2. TITLE SEARCH

On February 15, 2006, the State of Tennessee Roane County Recorder's Office was visited, and a review was conducted of the recorded deeds documenting previous ownership of the land tract where Building 2033 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 (BJC 2006a).

3. FEDERAL RECORDS SEARCH

As part of the federal records search, government records, title documents, and historical aerial photographs and satellite images (ORNL 2005a) were searched; inspections of the property and adjacent properties were performed; and interviews with current and former employees were conducted. Based on the reviews, inspections, and interviews documented herein, DOE has determined that there is no evidence to indicate that hazardous substances or petroleum products, or their derivatives and acutely hazardous wastes were stored for one year or more, known to have been released, or disposed of on the property during the time the property was owned by the United States. The property proposed for lease has been under the ownership of DOE or its predecessor agencies since 1943.

The lease property was originally part of Tract No. A-6, which was included as part of a Judgment on the Declaration of Taking No. 1, Civil Action No. 429, Friday, November 20, 1942, in the United States District Court for the Eastern District of Tennessee, "United States of America, Petitioner, vs. 56,200 Acres of Land, More or Less Situated in Roane and Anderson Counties, Tennessee, and Ed C. Browder, et ux., Defendants." Tract A-6 was acquired from J. H. Anderson, et ux. The deed is filed in book X-5, p. 277, in the Roane County Recorder's Office. Deeds of landowners prior to federal acquisition of the property did not indicate any evidence of past hazardous substance or petroleum product activity (BJC 2006a). Appendix A contains the DOE Realty Office documentation.

4. PAST AND PRESENT ACTIVITIES

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

The main campus area of ORNL was farmland prior to the construction of the Laboratory in the early 1940s. Figure 1.3 reveals the land as it appeared in 1942 prior to construction of ORNL. The land in the future footprint of Building 2033 and the immediate surrounding area, at that time, sloped to the south and appears to be pastureland or cropland. No structures such as farmhouses, barns, or other farm buildings are visible.

The aerial photograph taken in 1952 (Fig. 1.4) shows ORNL buildings constructed to the north and south of the study area, but again the study area itself appears to be partially wooded and grassed with no structures visible. The same is true for the aerial photographs taken in 1969, 1981, 1984, 1987, and 1993 (Figs. 1.5 through 1.9).

The 1998 aerial photograph (Fig. 1.10) and the 2004 satellite image (Fig. 1.11) show the study area much as it appears in present day (ORNL 2005a).

There are no solid waste management units under the Hazardous and Solid Waste Amendments of 1984 to the Resource Conservation and Recovery Act of 1976 within the area where Building 2033 is located (SAIC 2006a).

The ORR was placed on the National Priorities List on November 21, 1989, and investigations and environmental cleanup activities are continuing in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), the National Oil and Hazardous Substances Pollution Contingency Plan, and the Federal Facility Agreement (FFA) [DOE 1992]. The FFA, a tri-party agreement entered into by DOE, U. S. Environmental Protection Agency (EPA) Region 4, and the Tennessee Department of Environment and Conservation (TDEC) in 1992, establishes the schedules and milestones for environmental remediation of the ORR. The general area where Building 2033 is located is listed in Appendix C of the FFA and was included in the Bethel Valley Interim Record of Decision (IROD). Based on historic data, this IROD currently assumes no soil remedial actions in the study area and defers groundwater investigations to the final Bethel Valley Record of Decision (ROD). Final remediation decisions are scheduled for no earlier than fiscal year 2009 (BJC 2006b).

4.2 PAST AND PRESENT ACTIVITIES FOR THE ADJACENT PROPERTY

The areas adjacent to the study area are also located within the bounds of ORNL. The nearest non-DOE property is State Highway 95, located approximately 1 mile west of the study area. There is no indication that activities from this non-DOE area would have contributed any contamination to the area proposed for lease.

Buildings 2000 and 2001 are the closest primary structures to Building 2033 and were some of the first buildings constructed at ORNL, as evidenced by their presence in the 1952 aerial photograph. These buildings have been in use as offices and laboratories from the mid-1940s until 2004 when the last researcher was relocated to a different facility. The buildings are currently slated for demolition.

Buildings and parking lots located to the east and south of Building 2033 are of relatively recent construction (approximately the same age as Building 2033) and there is no indication that activities from these areas would have contributed any contamination to the area proposed for lease.

As with the proposed lease space, the soils in the adjacent areas of the lease space are listed in Appendix C of the FFA and were included in the Bethel Valley IROD.

5. RESULTS OF VISUAL AND PHYSICAL INSPECTIONS

5.1 VISUAL AND PHYSICAL INSPECTIONS OF THE PROPERTY PROPOSED FOR LEASE

A walkdown of Building 2033 was conducted by SAIC and ORNL personnel on November 2, 2007, to determine the environmental conditions of the facility. The building consists of three floors and is concrete on steel support with metal siding. The main entry is located on the upper or third floor, which is at grade with the hilltop. The upper or third floor consists entirely of offices, conference rooms, and restrooms/change rooms. Floors within this area are either carpeted or tiled.

The second floor consists primarily of office space, calibration labs, and restrooms/change rooms. Sealed sources are in use within the laboratory areas. Floors on this level are either tiled or carpeted.

The first floor, or basement, consists of storage areas, laboratories, and mechanical rooms. A chemical supply cabinet was located within one of the storage areas. Cabinets and laboratories were locked so it was not possible to determine if additional chemical supply cabinets exist. Compressed gas cylinders are stored on the loading dock located to the rear of the building on the first floor. All cylinders were in racks with locked or secured caps. No evidence of release of chemicals was noted during the walkdown.

Based upon the information provided in the Hazardous Material Incident System and the facility walkdown, there are no chemicals noted that are stored in excess of a reportable quantity. Chemicals stored at the building include cleaning supplies (e.g., bleach, etc.), compressed gases (e.g., methane, hydrogen in air mix < 3%, etc.), and laboratory supplies (e.g., buffer solutions, etc.).

Due to the age of the structure and the fact that it was built under a construction subcontract, no metal-based paints or asbestos are thought to be within the structure. Asbestos surveys have not identified asbestos within the building to date, per facility personnel. Based upon the date of construction, it is unlikely that polychlorinated biphenyls (PCBs) will be found within light ballasts in the building. Although it is possible that ballasts were replaced with older fixtures, it is thought unlikely. Based upon available information, floor drains are still operational and are connected to the ORNL sanitary sewer system.

5.2 VISUAL AND PHYSICAL INSPECTION OF THE ADJACENT PROPERTY

The adjacent areas are owned by DOE and are part of the ORNL main campus. The closest primary structures to the lease space are Buildings 2000 and 2001. These are primarily rounded, metal structures (Quonset Huts) that have been painted. Because they contain no workers and are slated for demolition, maintenance of these buildings has been reduced to a minimum. Therefore, weathering has caused paint chips to flake off the buildings, and the paint chips are visible on the ground near the buildings. Because of concern about PCBs and lead in old paints, the paint chips have been sampled and analyzed by ORNL. The analyses indicated PCB levels above regulatory concern, and the outside surface of the buildings has been labeled according to Toxic Substances Control Act of 1976 regulations by the ORNL Environmental Compliance organization. To ascertain if the paint chips have contaminated the surrounding soils, historical sampling has been conducted in the immediate vicinity of Buildings 2000 and 2001. These data are evaluated in Chap. 6 of this report along with soil samples collected recently around Building 2033.

To prevent the paint chips mentioned above from entering into surface water, the storm drains in the vicinity of Buildings 2000 and 2001 have been lined with a water-permeable barrier to allow water to pass through but to capture any debris. These barriers are cleaned on a periodic basis and the paint chips disposed of through the ORNL Laboratory Waste Services Division.

6. SAMPLING RESULTS

Although primarily only the Building 2033 footprint is proposed for lease, access to the building will require workers to pass near soils in the vicinity of the building. Historically soil sampling had been conducted to the north of Building 2033; however, these data were deemed to be insufficient to fully characterize soils in the immediate vicinity of the building. Therefore, surface soil samples were collected from the areas adjacent to Building 2033 to identify any potential contamination in soils at the surface surrounding the building. Samples were not collected from the parking lot because it is a paved surface and access to the soils beneath the pavement is restricted. Sections 6.1 and 6.2 present the results of both historical and recent chemical and radiological soil sampling that was performed in the vicinity of Building 2033.

In addition, radiological surveys were conducted in the building interior and of the adjoining east parking lot to support the proposed lease. Radiological survey results are discussed in Sect. 6.2.

Although the proposed lease does not include the underlying fee and access to the groundwater is restricted, a general discussion of data from nearby groundwater monitoring wells is also included in Sect. 6.3.

6.1 CHEMICAL SAMPLING

This section presents and discusses the results of the historical and recent chemical soil sampling that was performed in the vicinity of Building 2033. For comparison purposes, nationally available industrial preliminary remediation goals (PRGs) have been used for screening the analytical results for the recently collected soil samples near Building 2033 to determine constituents of potential concern (COPCs).

6.1.1 Historical Soil Samples

A search of the Oak Ridge Environmental Information System (OREIS) database showed that no soil data were available from the immediate vicinity of Building 2033 (i.e., within 50 ft of the building). However, limited data were available from the area to the north of the building. The results for these historical samples are discussed below.

Soil samples were collected as part of the ongoing monitoring program for Buildings 2000/2001, which began in 1999. These samples were only analyzed for polychlorinated biphenyls (PCBs). Under the monitoring program, a threshold of 40 mg/kg has been established as the acceptable concentration for PCBs in soil. EPA must be notified if results exceed this concentration. Since the initiation of the sampling program, total PCB concentrations in soil samples continue to be lower than the threshold concentration. The soil sampling locations nearest to Building 2033 (see Fig. 6.1) have indicated that PCBs were not detected at the 99S5 and 00S6 locations directly north of 2033. At the 05S3 location, northeast of 2033, an estimated concentration of 0.012 mg/kg of total PCBs was reported for the sample collected in 2005.

6.1.2 2007 Soil Sampling

In December 2007, four surface soil samples were collected from the areas adjacent to Building 2033. The sampling locations were chosen based on best professional judgment. The four samples represent a composite of soil material collected from three separate locations on each side of the building (see Fig. 6.2). Samples were collected in accordance with the Sampling and Analysis Plan for Building 2033 (Appendix B). Soil samples were collected from a depth of 0.0 to 0.5 ft below ground

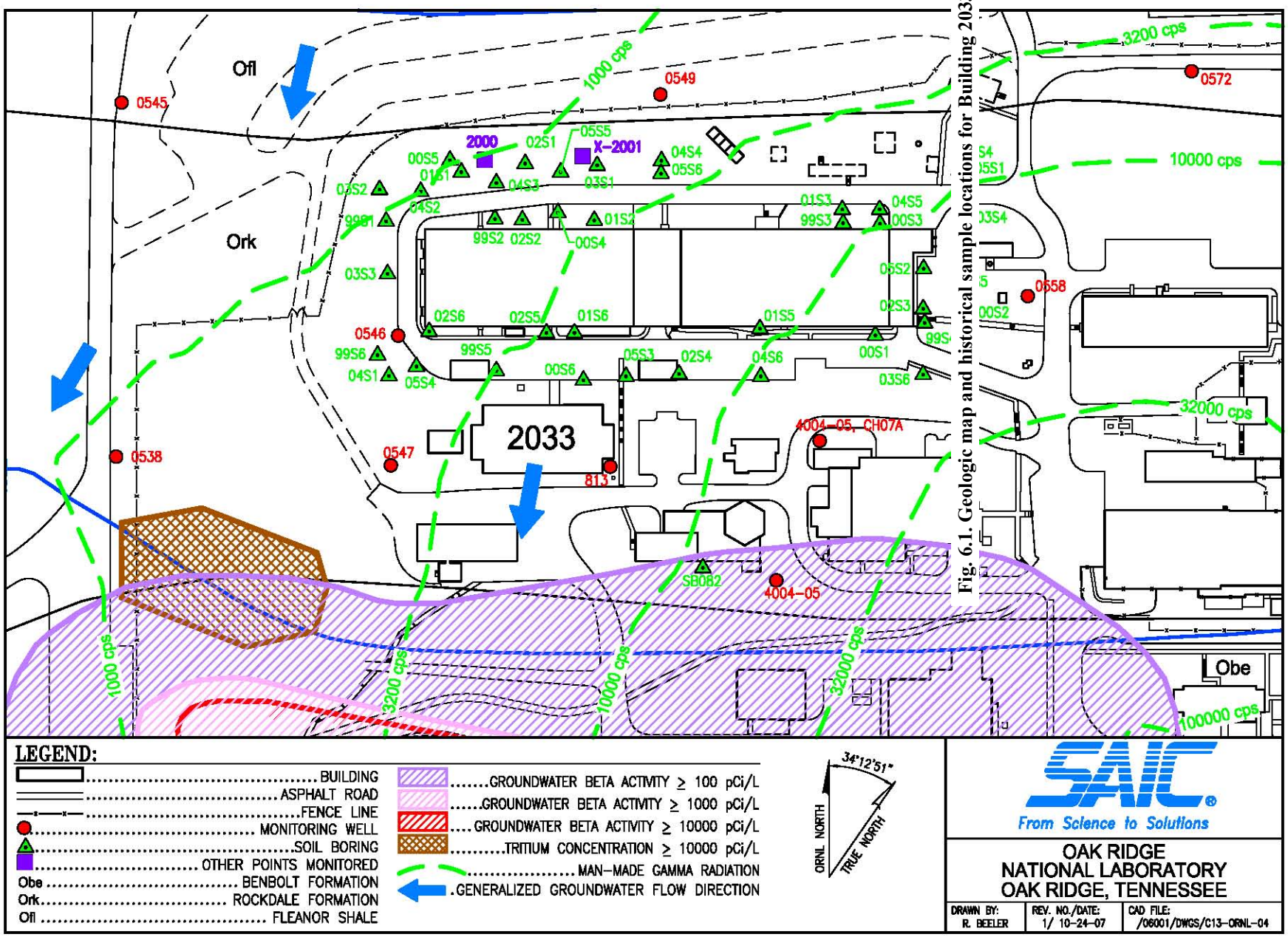

Fig. 6.1. Geologic map and historical sample locations for Building 2033.

Fig. 3.1. Geologic map and historical sample locations for Building 2033

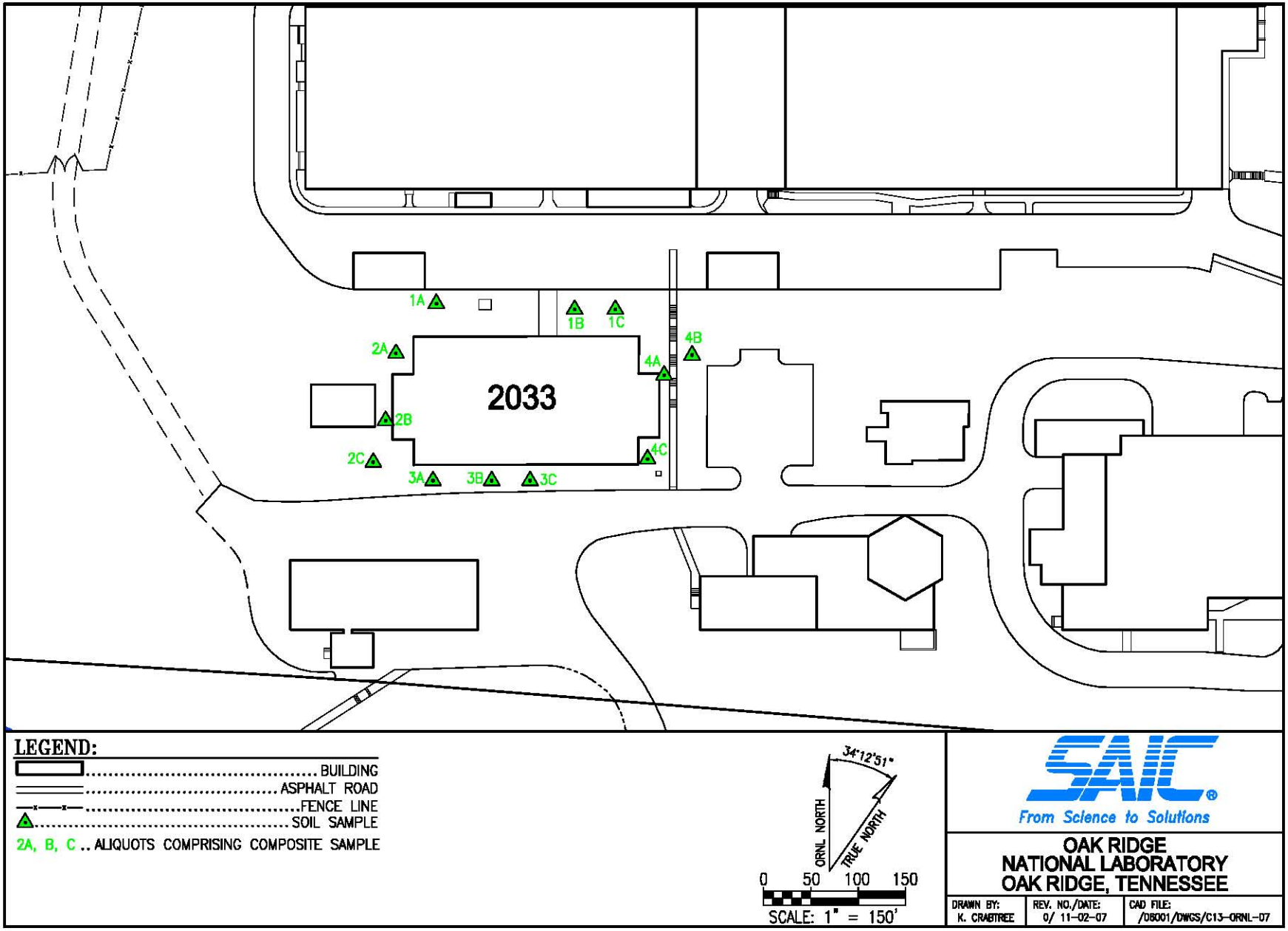

Fig. 6.2. Soil sample locations for Building 2033.

surface (bgs). All four composite samples were analyzed for VOCs, SVOCs, metals, PCBs, pesticides, herbicides, and radionuclides (results for radiological analyses are provided in Sect. 6.2).

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

Four soil samples were evaluated, with 895 discrete analyses (i.e., analytes) validated for the project (EPA 1999; EPA 2004). The samples were collected on December 5, 2007. The five antimony results were rejected due to unacceptable recoveries for the associated laboratory QC samples. There were 890 acceptable results with 5 results (all for the metal antimony) rejected during validation. Note that estimated values are considered acceptable information for data interpretation. Table 6.1 summarizes the validation results.

Table 6.1. Building 2033 non-radiological validation summary

	Number of results		
Analysis type	**Usable (U, J, UJ, and =)**	**Rejected ®**	**Total**
PCBs	45	0	45
VOCs	230	0	230
SVOCs	350	0	350
Metals	125	5	120
Pesticides	105	0	105
Herbicides	40	0	40
Total	890	5	895

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 6.6) were interpreted in the risk screen report (see Appendix D). 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 at which the maximum concentration was detected, and
- if detected concentrations exceed industrial preliminary remediation goals (PRGs).

Table 6.2. Building 2033 chemical analytical results summary

Analysis type	Frequency of detections	Minimum concentration	Maximum concentration	Locations at which maximum detected	Industrial preliminary remediation goal exceeded?
PCBs (mg/kg)	5/45	0.0061	0.0089	SS01	No
VOCs (mg/kg)	0/230	NA	NA	NA	NA
SVOCs (mg/kg)	5/350	0.014J	0.149J	SS04	No
Pesticides (mg/kg)	0/105	NA	NA	NA	NA
Herbicides (mg/kg)	0/40	NA	NA	NA	NA
Metals (mg/kg)	107/120	0.0352	35,900	SS02	Yes

mg/kg = milligrams per kilogram.
NA = not applicable.
PCB = polychlorinated biphenyl.
SVOC = semivolatile organic compound.
VOC = volatile organic compound.

There were detected levels for PCBs, SVOCs, and metals in soil samples collected at Building 2033. The chemical concentrations for soils are discussed below.

Chemical Results

PCBs

A total of 45 PCB results were reported, with 5 results (11%) detected. The concentration of the PCB results ranged from 0.0061 to 0.0089 mg/kg for Aroclor-1254 and -1260 (Table 6.3). The detected values were well below the PRG. PCBs have been used for their heat-resistant properties in oils, paints, and other materials subjected to the effects of high temperature. The maximum detected PCB concentrations were detected at location SS01. The detected PCB results are likely due to the deposition of paint chips from Buildings 2000/2001.

VOCs

A total of 230 VOC results were reported, with no results detected.

Table 6.3. Building 2033 study area polychlorinated biphenyls results

Analysis type	Frequency of detections	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Locations at which maximum detected	Industrial soil preliminary remediation goal[a]	Industrial preliminary remediation goal exceeded?
Aroclor-1254	2/5	0.0061	0.0074	SS01	7.44	No
Aroclor-1260	3/5	0.0072J	0.0089	SS01	7.44	No

[a] Based upon U. S. Environmental Protection Agency Region 9 published preliminary remediation goals.
mg/kg = milligrams per kilogram.

SVOCs

A total of 350 SVOC results were reported, with 5 results (1.4 %) detected. The concentrations of the SVOC results ranged from 0.014J mg/kg for Fluoranthene to 0.149J mg/kg for Diethylphthalate (Table 6.4). The detected values were well below the PRG. SVOCs are used in various industries and found in asphalt, lubricants, and as components of fuel. The maximum detected SVOC results were found at sample location SS04. The detected SVOC results could be the result of asphalt runoff from parking lots adjacent to Building 2033.

Table 6.4. Building 2033 semivolatile organic compounds results

Analysis type	Frequency of detections	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Locations at which maximum detected	Industrial soil preliminary remediation goal[a]	Industrial preliminary remediation goal exceeded?
Benzo(*b*)fluoranthene	2/5	0.0152J	0.0155J	SS04	21.1	No
Diethylphthalate	1/5	0.149J	0.149J	SS04	492,485	No
Fluoranthene	2/5	0.014J	0.0174J	SS04	22,000	No

[a] Based upon U. S. Environmental Protection Agency Region 9 published preliminary remediation goals.
mg/kg = milligrams per kilogram.

Metals

A total of 120 metal results were reported, with 107 results (89%) detected. The concentrations of the metal results ranged from 0.0352 mg/kg for mercury to 35,900 mg/kg for iron (Table 6.5). As mentioned previously, all antimony results were rejected during data validation because of a low matrix spike recovery and were not included in the risk assessment.

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. Only arsenic at 22.7 mg/kg from location SS02 exceeded its respective PRG of 15.9 mg/kg. As mentioned previously, metals are ubiquitous in natural soils and it is not unexpected that slightly elevated metal concentrations occur in shallow soils. Further, average remediation levels (RLs) for the industrial area of Bethel Valley have been established in the IROD (DOE 2002), and the RL for arsenic is set at 330 mg/kg, which is an order of magnitude above the maximum concentration found in the soils near Building 2033.

Table 6.5. Building 2033 metals results

Analysis type	Frequency of detections	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Location at which maximum detected	Industrial soil preliminary remediation goal[a]	Industrial preliminary remediation goal exceeded?
Aluminum	5/5	12,600	24,600	SS02	921,072	No
Arsenic	5/5	2.5	22.7	SS02	15.9	Yes
Barium	5/5	46.6J	115J	SS01	66,577	No
Beryllium	5/5	0.45	0.99	SS01	1,940	No
Boron	3/5	4J	7.3J	SS01	200,000	No
Cadmium	5/5	0.33J	0.43J	SS01	451	No
Calcium	5/5	2,200J	7,550J	SS04	NA	NA
Chromium	5/5	13.1J	28.6J	SS02	640	No
Cobalt	5/5	7.9J	14.9J	SS03	13,331	No
Copper	5/5	4J	8.3J	SS03	40,877	No
Iron	5/5	9,910	35,900	SS02	306,412	No
Lead	5/5	14.7J	48J	SS03	NA	NA
Magnesium	5/5	1,010J	2,590J	SS01	NA	NA
Manganese	5/5	590J	1,840J	SS03	19,458	No
Mercury	5/5	0.0352	0.0866	SS01	307	No
Nickel	5/5	5.4J	11J	SS03	20,439	No
Potassium	5/5	412J	460J	SS03	NA	NA
Selenium	0/5	ND	ND	NA	5,100	No
Silicon	5/5	395J	862J	SS02	NA	NA
Silver	4/5	0.34J	0.65J	SS01	5,100	No
Sodium	0/5	ND	ND	NA	NA	NA
Thallium	5/5	0.17J	0.31	SS02	67	No
Vanadium	5/5	16J	40.1J	SS02	1,022	No
Zinc	5/5	21.4J	40.4J	SS03	306,412	No

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

Pesticides

A total of 105 pesticide results were reported, with no detections.

Herbicides

A total of 40 herbicide results were reported, with no detections.

6.2 RADIOLOGICAL SURVEYS AND SAMPLING

Radiological characterization surveys were conducted to determine if contamination levels were within DOE release criteria for unrestricted use of the proposed lease space. Additionally, radiological and chemical data have been collected to characterize contamination within the adjacent areas and are addressed in the risk screen in Appendix D. 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.

Process history of the ORNL Site indicates that uranium isotopes, fission products, activation products, and transuranics (TRUs) are radiological contaminants potentially present in Building 2033 due to tracking of contamination from other on-site buildings.

6.2.1 Radiological Surveys

6.2.1.1 Historical surveys

Building 2033 has received routine radiological surveys of portions of the building, including annual surveys of the first floor men's and women's change rooms, semiannual surveys of the first floor break room, and quarterly surveys of the basement and rooms 101, 103, 108, 116, and 117. The results of the latest routine surveys obtained from June through October of 2007 showed all direct probe readings to be < 100 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) alpha and < 1000 dpm/100 cm^2 beta/gamma. Removable results were all < 20 dpm/100 cm^2 alpha and < 200 dpm/100 cm^2 beta/gamma. The survey numbers reviewed are shown in Table 6.6.

Table 6.6. ORNL radiological surveys reviewed

WEST-215949	WEST-220310	WEST-220379
WEST-215950	WEST-220375	WEST-222017
WEST-219620	WEST-220376	WEST-222134

These surveys were reviewed to determine if there were any areas of fixed contamination exceeding the appropriate contamination release limits for ORNL given in Table 6.7. The building surveys reviewed indicate contamination levels do not exceed the contamination limits.

Table 6.7. Contamination limits (DCGLs) for all ORNL survey units

	DCGL (dpm/100 cm^2)	$DCGL_{EMC}$ (dpm/area)
Total alpha	100	300
Removable alpha	20	N/A
Total beta-gamma	1000	3000
Removable beta-gamma	200	N/A

DCGL = derived concentration guideline level.
$DCGL_{EMC}$ = derived concentration guideline level elevated measurement comparison
dpm = disintegrations per minute.
N/A = not applicable.
ORNL = Oak Ridge National Laboratory.

6.2.1.2 Current interior survey units

A total of eight radiological surveys (including all associated quality assurance/quality control (QA/QC) surveys and rechecks) were conducted in the footprint in support of the lease. The surveys were performed during December 2007, in accordance with the survey design document[1] (hereafter referred to as the "design document") and the survey plan (see Appendix C).

The radiological survey procedures and interior survey units (SUs) are described in the survey plan presented in the Appendix C. The SUs of Building 2033 were classified as Class 3 based upon historical

[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, Bechtel Jacobs Company LLC, Oak Ridge, TN, August 2006.

data and process knowledge, as described in the design document. See Appendix C for the locations of the SUs.

Hand-held meter and floor monitor survey results were taken for the survey area and compared to the values listed in Table 6.7, which are the appropriate 10 *Code of Federal Regulations* 835 and DOE Order 5400.5[2] surface contamination gross alpha or gross beta criteria. These criteria are referred to as derived concentration guideline levels (DCGLs) in the design document. The DOE contamination limits for TRUs for alpha activity and for ^{90}Sr for beta activity have been applied to this project's data since they are the most limiting contaminants present on-site. The $DCGL_{EMC}$ of three times the appropriate contamination limit equates to the contamination-averaging criteria, as set forth by DOE in 5400.5 for an elevated reading within a 1-m^2 maximum size area.

There were no Class 2 or 1 SUs per the survey plan. Identification of activity levels in excess of 50% of the DCGL requires reclassification of all, or part, of the area as Class 2 or Class 1 and requires further surveys. Each interior SU data set was first evaluated by comparing the maximum result after background subtraction to the screening level for the SU classification. If the net maximum survey result was less than the screening level for the specific SU (e.g., 50% DCGL limits), then the unit was said to pass [i.e., the null hypothesis, (H_o), that the residual contamination in each of the individual SUs exceeds the interior SU DCGL, was rejected]. If the net maximum result was greater than the screening level for any single reading, further readings were obtained in the 1-m^2 area to determine the average for the square meter. If the net average reading for the square meter was greater than the screening level for the specific SU, then Class 3 and 2 interior SUs were reclassified and resurveyed under the protocol of the new classification. If the net maximum result was greater than the DCGL for Class 1 units, the non-parametrical statistical Sign test was used to evaluate the data, as outlined in the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* [NRC 1997].[3]

No readings obtained from the interior of Building 2033 were considered to be elevated above background, although all of the interior SUs had results above the DCGL. Some of the results were from areas where the floor was comprised of ceramic tile. The highest values obtained were 2441 dpm/100 cm^2 alpha and 7985 dpm/100 cm^2 beta as shown in Table 6.8. A few of the high beta readings were obtained in a bathroom on a glazed clay tile floor. The total beta background above ambient established in the survey plan for this type of material was 1716 dpm/100 cm^2. After subtracting this background value, the results were still greater than the beta DCGL of 1000 dpm/100 cm^2. However, since the readings on the glazed clay tile floor were consistently elevated near 2900 dpm/100 cm^2, this level will be considered the background for the glazed clay tile floor material, and no reading in the restrooms will be interpreted as elevated. Similarly, the basement concrete floor readings all ranged between 1700 and 2650 dpm/100 cm^2 total beta activity. The highest values for the basement were 107 dpm/100 cm^2 alpha and 2643 dpm/100 cm^2 beta. No reference background was established in the survey plan for concrete. However, since all of the concrete floor readings were elevated similarly, regardless of location, the average of 2000 dpm/100 cm^2 was assumed to be the background for the concrete floor, and no reading in the restrooms was interpreted as elevated.

The remaining elevated readings were all on the upper level or entrances where there was carpet, except for one measurement on a landing in the stairwell. It was raining the day most of the initial measurements were made, and it was theorized that rain-out, or the radiological activity associated with short-lived radon daughters that drop to the ground surface with rainfall,

[2] (DOE 1990). *Radiation Protection of the Public and Environment*, DOE Order 5400.5, Fig. IV-1, "Surface Contamination Guidelines," p. IV-6, U. S. Department of Energy, February.

3 (NRC 1997). *Multi-Agency Radiation Survey and Site Investigation Manual, Final Edition*, NUREG-1575, Nuclear Regulatory Commission.

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.	
Interior survey units – Class 3									
ISU-1 Basement	< 20.7	106.9	< -0.3	< 2.3	456.1	2,642.9	< 9.7	99.8	3–7
ISU-2 First Floor	< 1.7	174.1	< -0.3	3.6	262.7	2,901.1	< 2.4	73.0	3–7
ISU-3 Second Floor Initial	< -6.9	2,441.4	< -0.3	3.6	387.3	7,985.3	< -59.0	73.0	2–4
ISU-3 Second Floor Recheck Replaced Initial Data	< -6.9	1,005.2	< -0.6	3.6	262.7	2,935.0	< -52.1	73.0	
ISU-4 East Stairwell	< 3.45	63.8	< -0.3	< 2.3	519.8	1,997. 5	< 12.2	34.1	4–6
ISU-5 West Stairwell	< 20.7	89.7	< -0.3	< 1.0	700.9	2,444.7	34.1	70.6	4–7
Exterior survey units – Class 3									
ESU-1 Parking Lot and Sidewalk	< 30	99	< -0.54	5.9	390	604	< -37	59	3-6
DOE contamination limits		100		20		1,000		200	20

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.
FSU = furnishings survey unit.
ISU = interior survey unit.
NEAD = no elevated activity detected (above background).
NR = not recorded.

was the cause of the elevated readings. This theory is consistent with observations throughout ORNL where alpha frisking is done on personnel and equipment. Therefore, a recheck of some of the highest biased measurement areas was performed several days later and several days after it had rained. The results were lower, but were still above the DCGL in many cases. The highest recheck values were 1005 dpm/100 cm^2 alpha and 1503 dpm/100 cm^2 beta. A summary of all the survey results is shown in Table 6.8.

All of the above results were maximum values and no average values across 1 m^2 were performed. Therefore, the remaining elevated areas were resurveyed on January 4, 2008, in order to obtain average readings. Elevated readings were again obtained near the original areas of elevated activity. With the assistance of ORNL Radiation Control (RADCON) personnel, the highest spots of activity were covered with tape in order to return to the spots at a later time, after radon/thoron activity would have decayed, to confirm that the activity was not due to radon and thoron. When the ORNL RADCON personnel did return to the spots 3 days later, they found all of the spots except one to have either no measurable activity above background or less than 25% of the DCGLs. The one spot that was confirmed not to be radon/thoron was located between the entry doors on the upper level. The entire entrance was scanned, and it was determined that the elevated area was confined to a small spot on the carpet. The contaminated spot was removed by removing that portion of the carpet.

Since all of the other elevated areas had both alpha and beta activity in close to 1:1 ratio (as would be expected for radon/thoron) and since they all showed no elevated activity after taping and rechecking several days later, it is concluded that they all were due to radon/thoron activity present when initially measured. This conclusion was also reached by the ORNL RADCON Organization,[4] and no areas were required to be posted as a result of the measurements. Therefore, results of the surveys performed in the study area indicate that all of the surfaces are below the DOE surface contamination limits and within the acceptable dose-equivalent rate range for interior surfaces. Because all results were assumed to be less than the DCGL, no statistical analysis of the data for each interior SU was required, and, therefore, the interior SUs can be released from a surface contamination standpoint. However, the original results shown in Table 6.8 were used in the risk assessment for conservatism. The maximum tissue-equivalent dose rate was 7 μrem/h, including background.

6.2.1.3 Current exterior survey units

One exterior radiological survey was conducted in support of the lease. The surveys were performed during April 2008, in accordance with the survey design document and the addendum of the survey plan (see Appendix C). The QC surveys were performed in May 2008.

The radiological survey procedures and exterior SU are described in the addendum of the survey plan presented in Appendix C. The exterior footprint consisted of one exterior SU that was classified as Class 3 based upon historical data and process knowledge, as described in the design document. See Appendix C for the location of the exterior SU. The same survey techniques, survey limits, and evaluation methods were used as for the interior SUs described in Sect. 6.2.1.2.

All results for the exterior SU were less than the DCGL, except for one total alpha reading obtained on a concrete sidewalk or platform that was just over the DCGL. The highest values obtained were 101 dpm/100 cm^2 alpha and 604 dpm/100 cm^2 beta, as shown in Table 6.8. No reference background was established in the survey plan for concrete. However, reference measurements were performed using the same equipment and procedures at an unaffected location on a concrete pad outside of a building at

[4] Personal Communication via email from Timothy Gilispie of ORNL Radiation Control Organization, January 15, 2008.

114 Union Valley Road in Oak Ridge, Tennessee. The reference area measurements ranged from 48 to 167 dpm/100 cm^2 alpha and from 306 to 621 dpm/100 cm^2 beta. This indicates that the results for the exterior SU may be in the background range for concrete. However, additional measurements were performed in the area of the one measurement that exceeded the DCGL to obtain an average for the 1-m^2 area. The five additional measurements averaged 87 dpm/100 cm^2 alpha. Therefore, this area passes the DCGL test even if the reference area background is not subtracted. Because all results were less than the DCGL, no statistical analysis of the data for the exterior SU was required, and, therefore, the exterior SUs can be released from a surface contamination standpoint. From an inspection of the individual surveys, including QA/QC surveys, all total activities were less than or equal to 100 dpm/100 cm^2 total alpha and 604 dpm/100 cm^2 total beta gamma, with all removable contamination results less than or equal to 6 dpm/100 cm^2 removable alpha and 59 dpm/100 cm^2 removable beta gamma. The maximum tissue-equivalent dose rate was 6 μrem/h, including background. See Table 6.8 for a summary of the survey results for the exterior SU.

6.2.2 Radiological Sampling

6.2.2.1 Historical samples

No historical radiological sampling data were found for the immediately adjacent land area.

6.2.2.2 2007 Soil and Sediment Samples

Biased sampling of surface soils was performed in the vicinity of Building 2033. The sample locations are shown on Fig. 6.2. All samples were collected to a depth of 0 to 0.5 ft bgs. These samples (SS01, SS02, SS03, and SS04) were analyzed for uranium isotopes (^{232}U, $^{233/234}U$, $^{235/236}U$, and ^{238}U), thorium isotopes (^{228}Th, ^{230}Th, and ^{232}Th), ^{3}H, ^{14}C, ^{99}Tc, ^{90}Sr, ^{237}Np, ^{238}Pu $^{239/240}P$, ^{241}Am, and gamma-emitting isotopes, including but not limited to, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{228}Ac, ^{214}Pb, ^{233}Pa, ^{234m}Pa, ^{234}Th, and ^{241}Am.

A total of four soil locations were sampled in the study area for radiological analysis during this effort. One field duplicate was also collected at soil sample location SS01.One equipment rinsate blank was also analyzed. During the data validation process, laboratory data were assigned appropriate data validation flags. Refer to Sect. 6.2.2.3 for the validation flags and their definitions.

6.2.2.3 Sample data analysis

Data Validation Summary

Four surface soil samples and one field duplicate from the Building 2033 surrounding area were validated. During the data validation process, laboratory data were assigned appropriate data validation flags. The total activity results were qualified as estimated (J) due to matrix spike results below the limit that resulted from the preparation method causing the loss of volatile analytes.

The sum of the analytical results, including daughters assumed in equilibrium, was compared with the total activity result for each sample. The comparison showed reasonable agreement with all samples.

Results

The radiological results were interpreted in a risk screen (Appendix D). The results are summarized in Table 6.9 for soil samples. For each analysis type for the soil samples, the following information is

listed: frequency of detection above background screening level, minimum and maximum concentrations, arithmetic mean, and comparison to background, Bethel Valley IROD RLs, and industrial PRGs.

The background evaluation method is based on the *Final Report on the Background Soil Characterization Project (BSCP) at the Oak Ridge Reservation, Oak Ridge, Tennessee, Volumes 1–3*, (DOE 1993). Backgrounds for ^{232}Th and ^{226}Ra and ^{238}U decay chain progeny are assumed to be equal to those established for their parents due to equilibrium in nature.

Although some individual sample results for all radionuclide analytes exceeded their background reference values (^{155}Eu and ^{230}Th) no radionuclides exceeded both the background reference value and the PRG, as shown in Table 6.9. In addition, no analytes exceeded the RLs established for radionuclides of concern in the Bethel Valley IROD (DOE 2002).

6.3 GROUNDWATER

The lease space includes the building only and no underlying fee. Therefore, access to groundwater will be restricted. However, to provide a complete environmental baseline report of the area, the following information regarding groundwater in the vicinity of Building 2033 is provided.

As shown on Fig. 6.1, groundwater flow in the vicinity of Building 2033 is from the north to the south. The nearest monitoring well to Building 2033 is #813 at the southeast corner of the building. A search of the OREIS database revealed VOC data from this well from the late 1980s through the early 1990s.

Over this timeframe seven VOCs were detected in this well at low concentrations, and the data are summarized in Table 6.10.

Table 6.9. Summary statistics for radionuclides in soil for the Building 2033 area

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	Remediation Level [b] (pCi/g)	Mean exceeds remedial level?	Industrial soil preliminary remediation goal (pCi/g)	Frequency of detects exceeding preliminary remediation goal
Americium-241	0/4	ND	ND	ND	0	0/4	450	No	57.00	0/4
Carbon-14	0/4	ND	ND	ND	0	0/4	NA	NA	12300.00	0/4
Cesium-137	4/4	0.0529	0.187	0.12	1	0/4	14	No	1.12	0/4
Cobalt-60	0/4	ND	ND	ND	0	0/4	7.4	No	0.60	0/4
Europium-152	0/4	ND	ND	ND	0	0/4	9.5	No	0.73	0/4
Europium-154	0/4	ND	ND	ND	0	0/4	11	No	0.85	0/4
Europium-155	1/4	0.0659	0.0659	0.07	0	1/4	710	No	62.90	0/4
Neptunium-237	0/4	ND	ND	ND	0	0/4	NA	NA	2.70	0/4
Plutonium-238	0/4	ND	ND	ND	0	0/4	NA	NA	166.00	0/4
Plutonium-239	0/4	ND	ND	ND	0	0/4	NA	NA	145.00	0/4
Radium-226 [d]	4/4	0.828	1.05	0.94	1.57	0/4	3	No	0.26	4/4[c]
Radium-228 [e]	4/4	0.823	1.4	1.11	1.84	0/4	3	No	0.02	4/4[c]
Technetium-99	0/4	ND	ND	ND	0	0/4	NA	NA	8940.00	0/4
Thorium-228	4/4	0.953	1.37	1.15	1.84	0/4	3	No	0.02	4/4[c]
Thorium-230	4/4	0.663	1.29	0.99	1.27	1/4	NA	NA	211.00	0/4
Thorium-232	4/4	0.724	1.43	1.02	1.45	0/4	3	No	0.02	4/4[c]
Tritium	0/4	ND	ND	ND	0.16	0/4	NA	NA	42.30	0/4
Uranium-232	0/4	ND	ND	ND	0	0/4	NA	NA	80.00	0/4
Uranium-234	4/4	0.697	1.35	1	1.22	1/4	NA	NA	334.00	0/4
Uranium-235	4/4	0.0423	0.0933	0.07	0.13	0/4	NA	NA	3.94	0/4
Uranium-238	4/4	0.811	1.19	1.08	1.19	0/4	310	No	17.90	0/4

[a] The background data is taken from Background Soil Characterization Project (BSCP) report (DOE/OR/01-1175, DOE 1993, Tables 7.1e and 7.2e). 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) mentions that the ^{137}Cs background is approximately 1 pCi/g. For this report, a background of 1.0 pCi/g is used for ^{137}Cs. In addition, a background for ^{228}Ra has been assumed based on equilibrium with ^{228}Th. Background values for other man-made radionuclides, including ^{99}Tc, ^{237}Np, ^{238}Pu, and Pu and other radionuclides for which data are not available are assumed to be zero.

[b] Remediation levels are from the Bethel Valley IROD.

[c] PRG for this radionuclide is orders of magnitude below background suggesting an ubiquitous source of this constituent that is not specific to Building 2033. PRG not applicable for this radionuclide, due to an exception in the Bethel Valley IROD. The exception takes background levels for these radionuclides into consideration.

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

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

Preliminary remediation goals are from EPA Region 9 for an industrial soil exposure at a risk level of 1E-05 and a hazard quotient of 1.

ND = Not detected

pCi/g = picocuries per gram.

Table 6.10. Monitoring well #813 volatile organic compounds results

Analysis type	Frequency of detections	Minimum concentration (µg/L)	Maximum concentration (µg/L)
1,1,1-Trichloroethane	2/7	2J	16
Benzene	1/7	7	7
Carbon Disulfide	2/7	1.4J	7
Carbon Tetrachloride	3/7	2	3
Chloroform	7/7	3	15
Methylene Chloride	1/7	3	3
Styrene	1/7	2J	2J
Trichloroethene	5/7	4J	11

7. CONCLUSIONS

Government records, title documents, and historical aerial photographs were researched; inspections of the property and adjacent properties were performed; historical data were evaluated; and interviews with current and former employees were conducted as part of the effort to determine the baseline condition of the Building 2033 study area (i.e., the proposed lease space). Based on the reviews, inspections, and interviews documented herein, DOE has determined that there is no evidence to indicate that activities involving hazardous substances took place on the property during the time the property was owned by the U. S. Government, or prior to that time.

There are no environmental waste management areas associated with the lease space. However, the lease space is part of a larger area listed in the CERCLA FFA. Based on historic data, the Bethel Valley IROD (DOE 2002) assumes no soil remediation in the lease space and defers groundwater investigations to the final Bethel Valley ROD.

Results of soil samples collected in the vicinity of Building 2033 indicate that, with the exception of arsenic, all chemical results are below PRGs and RLs established in the Bethel Valley IROD. The concentration of arsenic in soils exceeded its PRG at one sample location, but the concentration was an order of magnitude below the soil RL established for Bethel Valley. The risk evaluation of the soils indicated no associated risk of concern in the vicinity of Building 2033.

Results of the recent radiological surveys of the building interior indicate that all of the surfaces are below the DOE surface contamination limits and within the acceptable dose-equivalent rate range. In addition, because all results for the parking lot and associated sidewalk were less than the DCGL, these areas can be released from a surface contamination standpoint. Although some soil sample results for radionuclides exceeded either their background reference value or their PRG, no samples yielded results where both were exceeded.

The risk evaluation considered exposure to building interiors as well as potential soil exposure while entering or exiting Building 2033. The soil evaluation found that only a single arsenic detection was above the industrial worker PRGs. The risk calculation for the building interior indicated that risks were approximately 2E-08, which does not exceed the EPA target risk range of E-06 to E-04. The results indicate a low likelihood of adverse health effects associated with Building 2033 industrial/office worker exposure to the building interior surfaces or area soils. Based on the results of the evaluations presented in this report, Building 2033 is suitable for lease.

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APPENDIX A

REAL ESTATE ACQUISITION LETTER

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 Building 2033 at the Oak Ridge National Laboratory 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:

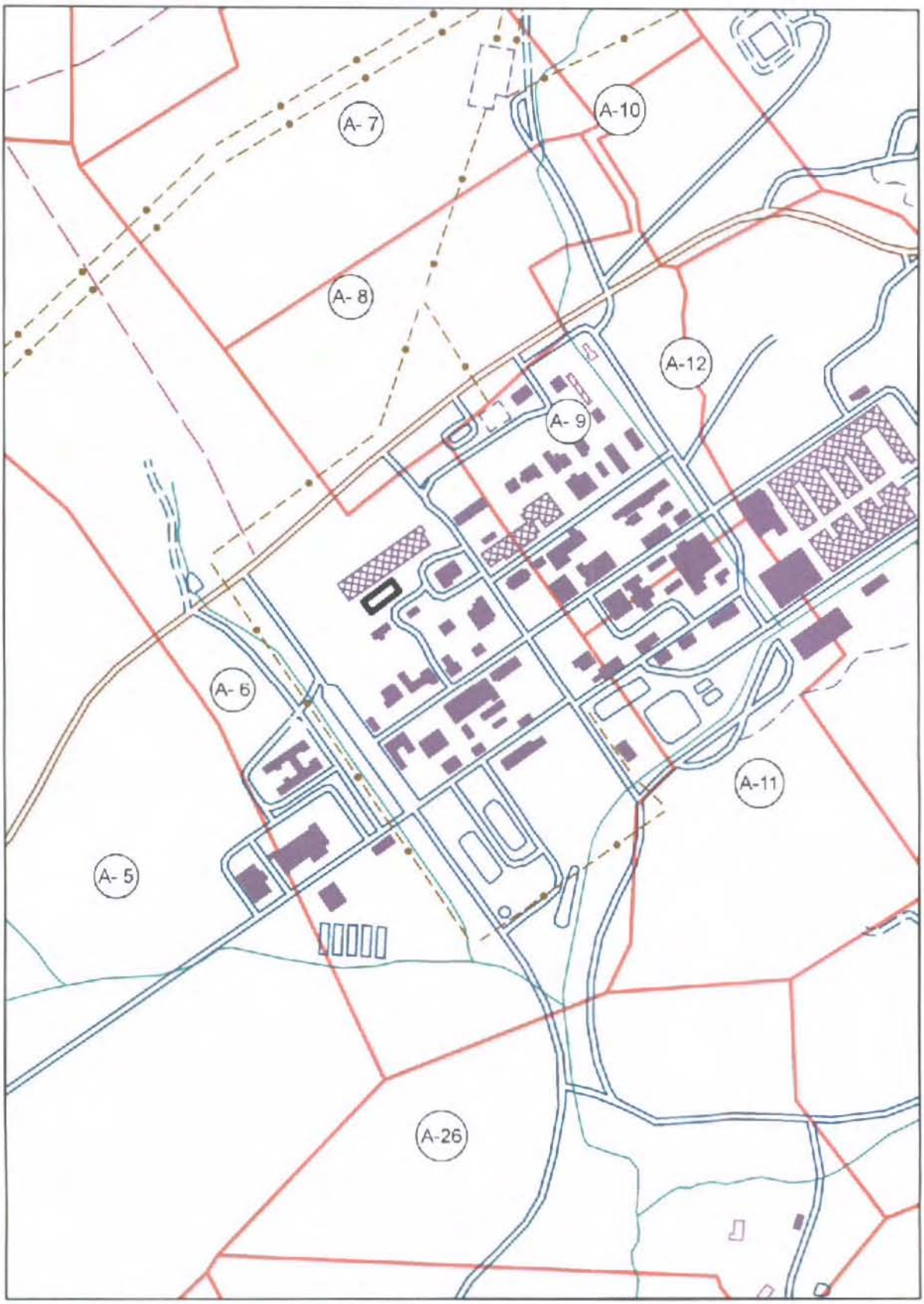
> Building 2033 is located on a portion of Tract A-6 and A-9. Title to this land was vested in the United States of America by Declaration of Taking No. 1. Judgment on Declaration of Taking was filed for public record on November 20, 1942, in Vol. X-5, Page 277, in the Roane County Register's Office, Tennessee.

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

Cindy B. Finn

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

Attachment
Acquisition Tract Map



Tract A-6: Acquired from J. H. Anderson, et ux. Deed Book \ Page: X-5/277.
Judgement of Taking: 1. Dated 11/20/42. Civil Action: 429. Approximated Acreage: 218.
Tract A-9: Acquired from Josiah Monger, et ux. Deed Book \ Page: X-5/277.
Judgement of Taking: 1. Dated 11/20/42. Civil Action: 429. Approximated Acreage: 59.4.

◯ = Acquisition Tract Numbers
▬ = Building 2033 Boundary

APPENDIX B

SAMPLING AND ANALYSIS PLAN FOR BUILDING 2033 AT THE OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE

Sampling and Analysis Plan for Building 2033 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

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

08-066(E)/052908

Sampling and Analysis Plan for Building 2033 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee

Date Issued—November 2007

Prepared by
Science Applications International Corporation
Oak Ridge, Tennessee
under subcontract BES-091907

Prepared for the
Community Reuse Organization of East Tennessee
under contract DE-PS07-06ID14760
for the
U. S. DEPARTMENT OF ENERGY

08-066(E)/052908

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ACRONYMS

bgs	below ground surface
CROET	Community Reuse Organization of East Tennessee
DOE	U. S. Department of Energy
EPA	U. S. Environmental Protection Agency
MCL	maximum contaminant level
ORNL	Oak Ridge National Laboratory
PCB	polychlorinated biphenyl
SAP	Sampling and Analysis Plan
SOP	standard operating procedure
SSC	sampling subcontractor
SVOC	semivolatile organic compound
TDEC	Tennessee Department of Environment and Conservation
VOC	volatile organic compound

B.1. INTRODUCTION

This Sampling and Analysis Plan (SAP) presents the objectives, rationale, and protocols for conducting surface soil sampling adjacent to Building 2033 at the Oak Ridge National Laboratory (ORNL) to support the lease of the building. The Community Reuse Organization of East Tennessee (CROET) is proposing to lease Building 2033 from the U. S. Department of Energy (DOE). Although only the building will be leased, surface soil samples will be collected to identify any potential contamination in soils at the surface surrounding the building.

Building 2033 is located among other office, laboratory, and support facilities at ORNL in the northwest quadrant of the main ORNL campus. The location of Building 2033 is depicted in Fig. B.1.1. The study area addressed by this SAP consists of the grass-covered areas immediately surrounding Building 2033. The proposed samples to be collected and the constituents selected for analysis are those identified in Chap. B.5 of this SAP.

B.2. SITE DESCRIPTION AND HISTORY

Building 2033, constructed in 1994, is a three-story office and laboratory building consisting of approximately 32,000 gross square feet of floor space. The building provided office and shop space for the Technical Support Section of the Instrumentation and Controls Division of ORNL. Building 2033 includes individual offices, several small maintenance shop rooms, a locker room, and conference rooms. The building is constructed of lightweight steel frame with composite metal insulating and finish panels and bronze-tinted insulating glass. Above-grade floors consist of concrete slab on metal form-deck supported by steel beams. The facility has a single elevator on the east end and stairs on both the east and west ends of the building. Building 2033 is situated on a sloping site such that grade-level access is afforded on the upper level on the north side and to the basement on the south side. The main entrance is on the upper (north) level. The building fronts on Hilltop Circle to the north, and a service drive connects to Second Street from the south and east sides of the building.

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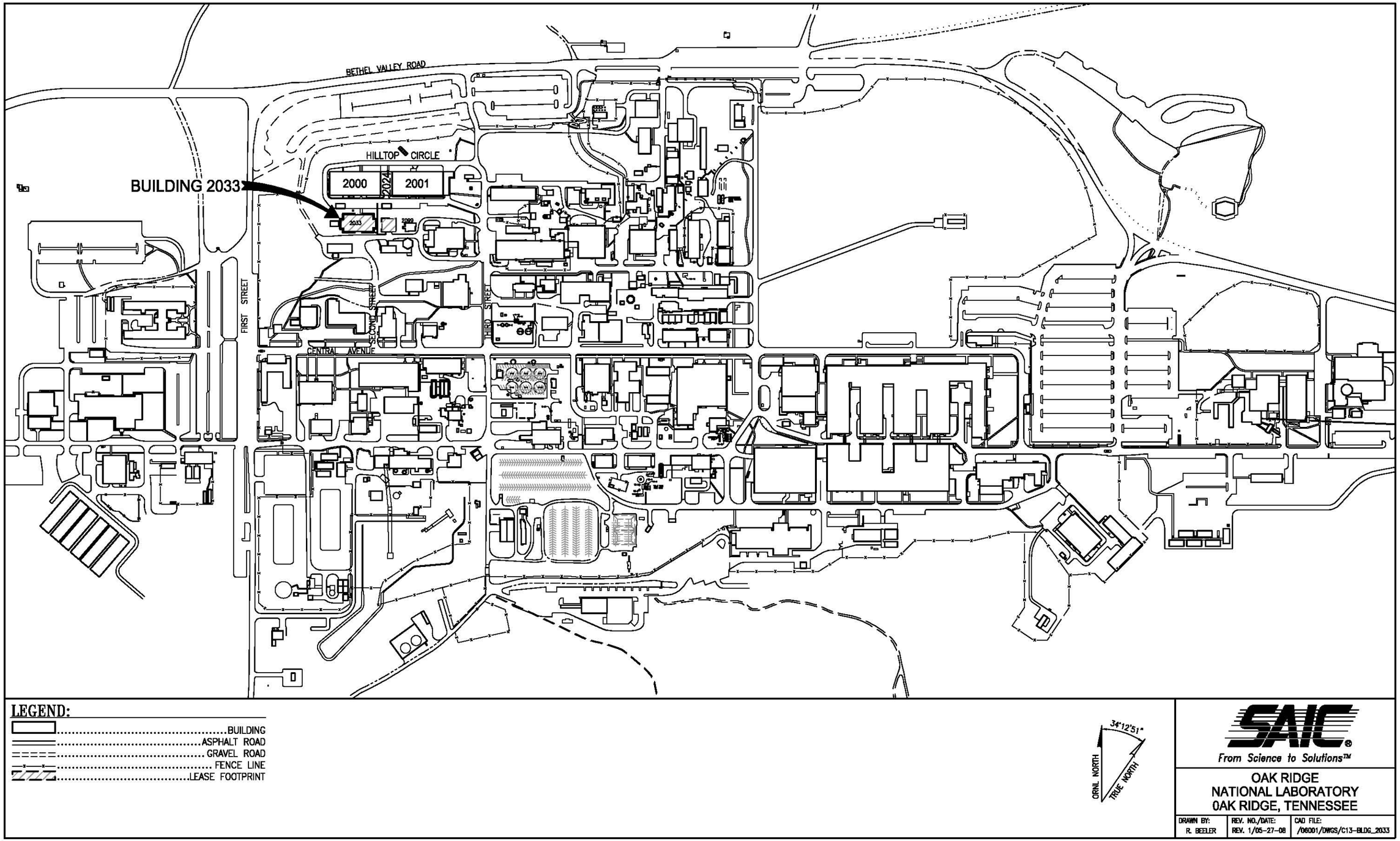

Fig. B.1.1. Location of the study area.

B.3. HISTORICAL DATA

Although some limited soil sampling has been conducted to the north of Building 2033, insufficient data are available for fully characterizing soils in the immediate vicinity of the building. The only historical sampling that has been conducted adjacent to Building 2033 is the collection of groundwater from a monitoring well (0813) located at the southeast corner of the building.

Building 2033 is underlain by bedrock of the Ordovician-age Chickamauga Supergroup. Surface mapping and core drilling in the Central Campus area indicate that the geologic structure is relatively uniform, with typical bedrock strike of about N55ºE and bedding dip of about 30 to 35 degrees to the southeast. According to Hatcher et al. (1992), bedrock beneath the 2033 area consists of the Rockdell Formation (Fig. B.3.1). The Rockdell Formation is a limestone, 80 to 85 m (260 to 280 ft) thick, and underlies the continuous low ridge near the middle of Bethel Valley. The lower portion of the Rockdell contains light-gray limestone, dark-gray calcareous siltstone, fossiliferous nodular limestone, and birdseye micritic limestone. Small chert nodules are common. The lower lithology grades upward to dense limestone, which contains subordinate amounts of birdseye micrite and nodular limestone. The common occurrence of bedded and nodular chert is distinctive of the upper portion of this formation.

Bedrock structure is important because it strongly influences the occurrence and movement of groundwater. Prominent fracture sets observed in rock core from Bethel Valley are bedding plane partings and joints. Bedding plane partings are the most abundant fracture features because most of the formations consist of thin-bedded limestone/shale interbeds. The more limestone-rich formations, such as the Rockdell Formation, contain thicker limestone beds that tend to fracture in the strike-set and dip-set orientations. Cavities have been reported in drilling logs from the Central Campus area, especially from boreholes drilled into the Rockdell Formation.

Historical groundwater data for well 0813 indicate the occurrence of low concentrations of some volatile organic compounds (VOCs); however, with only a rare exception, these concentrations were below the maximum contaminant levels (MCLs) established by the Tennessee Department of Environment and Conservation (TDEC) and U. S. Environmental Protection Agency (EPA) for these compounds. Of the VOCs detected, only benzene and carbon disulfide, on one occasion, and trichloroethene, on three occasions, have slightly exceeded their respective MCLs in samples collected in the early 1990s. No radiological constituents have exceeded MCLs in samples collected from well 0813.

Soils

The heterogeneous soils overlying bedrock in the Central Campus area of ORNL include a mixture of fill, reworked soils, and native residual soils. During construction of site facilities, soils were extensively modified by excavation and refilling of areas around waste storage tanks, underground piping, and buildings.

Historical soil samples have been collected within approximately 50 ft of Building 2033. These samples were collected as part of the ongoing monitoring program for the 2000/2001 buildings, which began in 1999. These samples have only been analyzed for polychlorinated biphenyls (PCBs). Under the monitoring program, a threshold of 40 mg/kg has been established as the threshold concentration for PCBs in soil. EPA must be notified if results exceed this threshold concentration. Since the initiation of the sampling program, total PCB concentrations in soil samples continue to be lower than the threshold concentration. The soil sampling locations nearest to Building 2033 (see Fig. B.3.1) have indicated that PCBs were not detected at the 99S5 and 00S6 locations directly north of 2033. At the 05S3 location, northeast of 2033, an estimated concentration of 0.012 mg/kg of total PCBs was reported for this sample, which was collected in 2005.

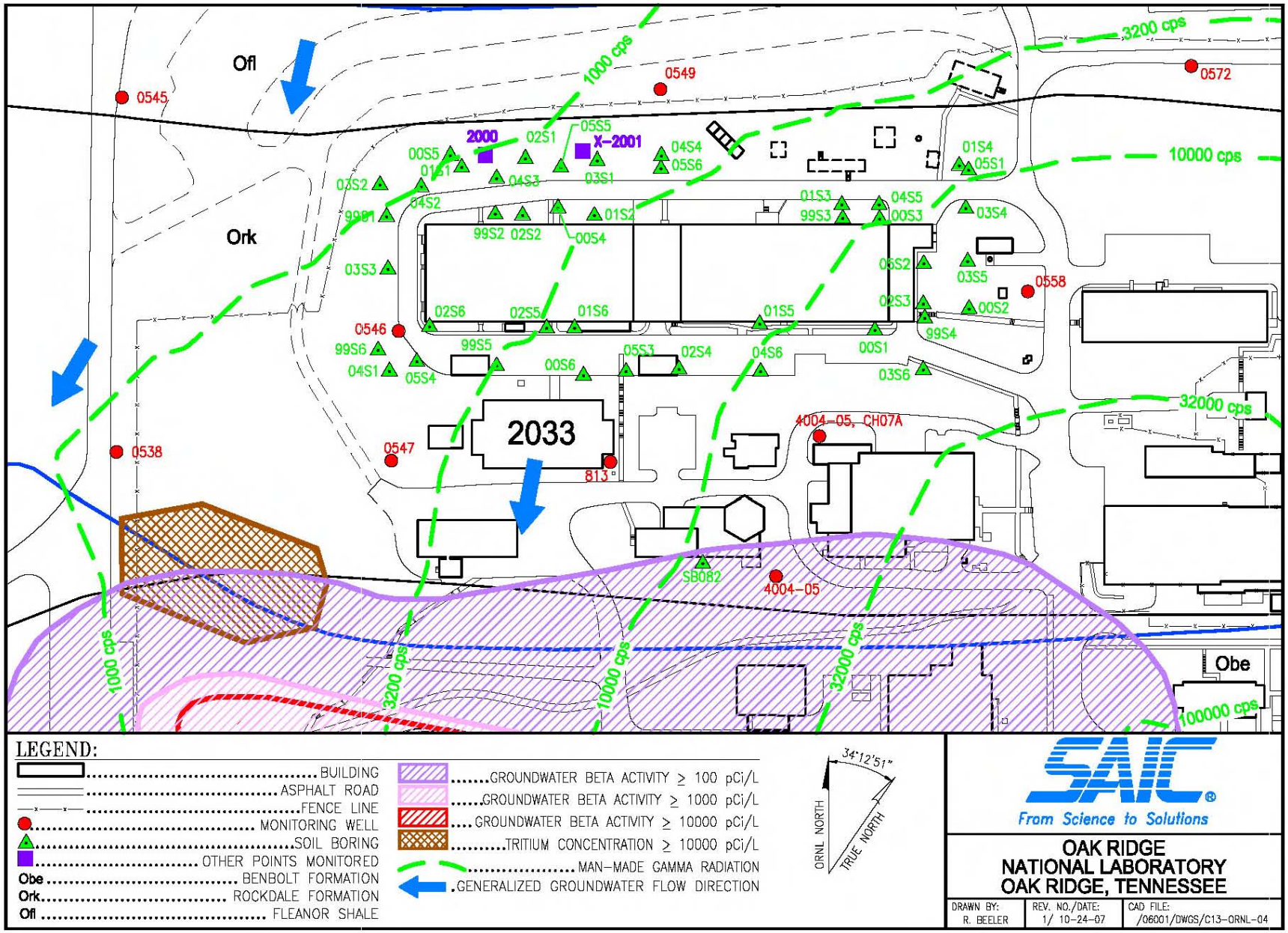

Fig. B.3.1. Geologic map and historical sample locations for Building 2033.

B.4. OBJECTIVES

The overall scope of this SAP is to determine potential soil contaminants (radiological and chemical) within surface soils located adjacent to Building 2033. These overall objectives will be met by conducting soil sampling at near surface (0 to 0.5 ft) using the approach discussed in Chaps. B.5 and B.6 of this SAP. Specific sampling locations and rationale are discussed within Chap. B.6 of this SAP.

B.5. SAMPLING DESIGN

In order to facilitate transfer of property, it is necessary to demonstrate that contamination from past activities has not occurred or is not present within the vicinity of Building 2033 at levels that would constitute an unacceptable risk due to potential exposures. To address this question, limited sampling will be undertaken to characterize the soils in the vicinity of the building. Data acquired from this sampling effort will be evaluated to meet the objectives specified within Chap. B.4 of this SAP.

Soil samples will be collected from the vicinity of Building 2033. The operations with the greatest potential to contribute contamination are likely to be incidental spills and leaks related to the handling of materials associated with the former maintenance and calibration activities conducted at Building 2033. The contaminants most likely to have resulted from these activities include VOCs and radionuclides. Asbestos is not considered to be of concern due to the age of construction of the building. Asbestos-containing construction products had been eliminated from the market at the time of construction of Building 2033. PCBs are a potential contaminant of concern due to the proximity of Buildings 2000 and 2001, which are under a monitoring program for PCBs. PCBs have been found in the paint flaking off these two buildings. These contaminants, if present, would be expected primarily in surface soils.

Biased sampling of surface soils will be performed in the vicinity of Building 2033. The proposed sample locations are indicated in Fig. B.5.1. All samples will be collected to a depth of 0 to 0.5 ft below ground surface (bgs). These samples (SS01, SS02, SS03, and SS04) will be analyzed for VOCs, semivolatile organic compounds (SVOCs), PCBs, metals, pesticides/herbicides, baseline radionuclides, and transuranic radionuclides. Table B.5.1 summarizes the soil sampling requirements for Building 2033.

One field duplicate will be collected at sampling location SS01. The field duplicate will be designated by the sample identifier CROET-SS01D-2033. One equipment rinsate will also be collected and designated by the identifier CROET-SSER1-2033. A trip blank will accompany each rigid container (ice chest) used to ship samples for volatile organic analysis. The trip blank will be designated as CROET-SSTB1-2033.

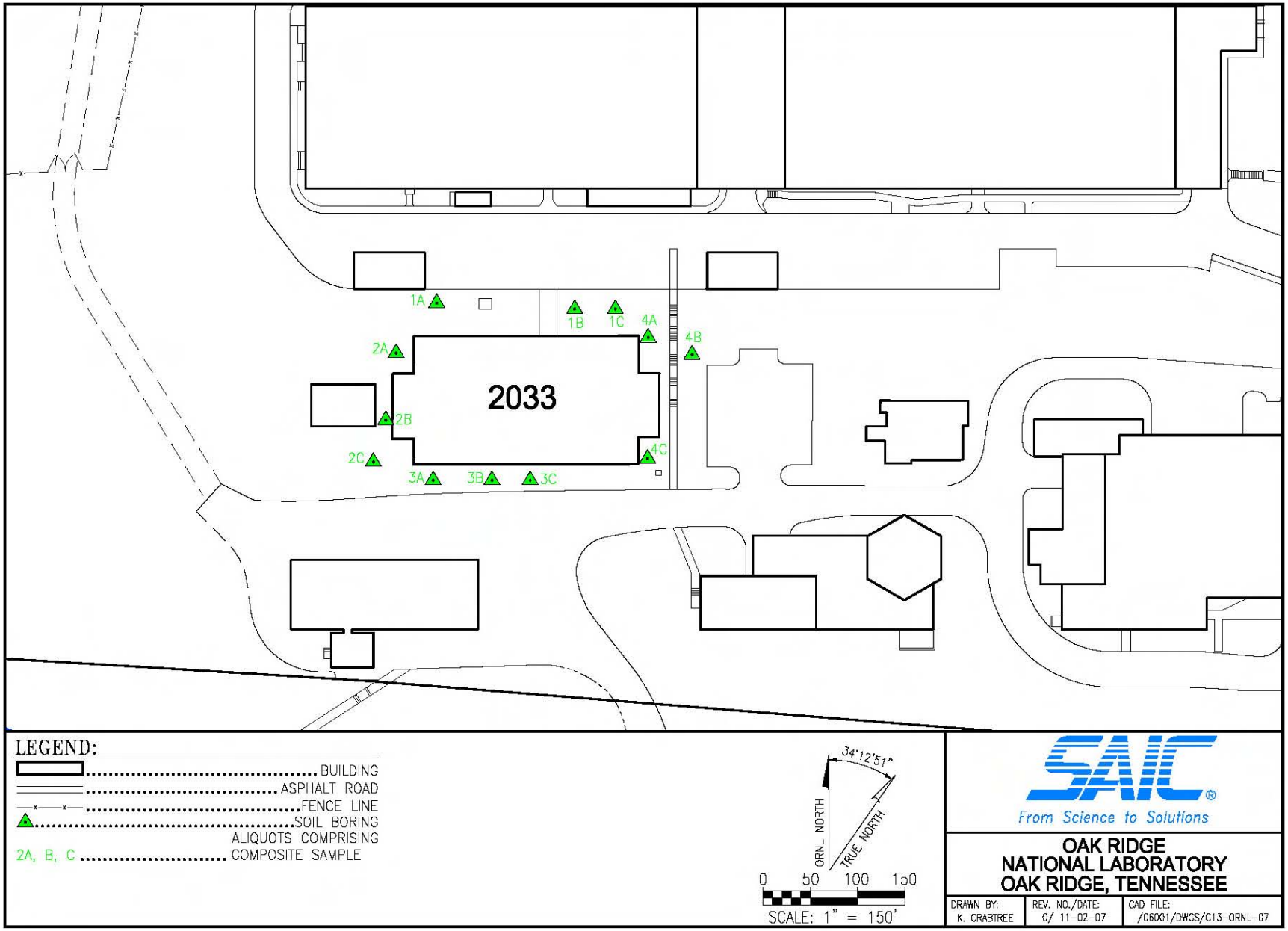

Fig. B.5.1. Proposed soil sample locations for Building 2033.

Table B.5.1. Summary of analyses for surface soil samples for Building 2033

Sample station	Metals[a]	VOCs[b]	SVOCs[b]	PCBs	Pesticides/ Herbicides	Baseline radionuclides[c]	TRU isotopes[d]	^{14}C	^{3}H
CROET-SS01-2033	X	X	X	X	X	X	X	X	X
CROET-SS02-2033	X	X	X	X	X	X	X	X	X
CROET-SS03-2033	X	X	X	X	X	X	X	X	X
CROET-SS04-2033	X	X	X	X	X	X	X	X	X
CROET-SS01D-2033	X	X	X	X	X	X	X	X	X
CROET-SSER1-2033	X	X	X	X	X	X	X	X	X
CROET-SSTB1-2033		X							
CROET-SSFB1-2033		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 (^{232}U, $^{233/234}U$, $^{235/236}U$, and ^{238}U), ^{99}Tc, ^{90}Sr, and gamma-emitting isotopes, including but not limited to, ^{60}Co, ^{137}Cs, ^{228}Ac, ^{214}Pb, ^{234m}Pa, and ^{234}Th. These samples shall also be quantitated for total alpha/beta activity.

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

PCB = polychlorinated biphenyl.

SVOC = semivolatile organic compound.

VOC = volatile organic compound.

B.6. FIELD SAMPLING PLAN

The soil samples specified in Chap. B.5 of this SAP will be obtained by the sampling subcontractor (SSC) in accordance with this SAP. Surface soil samples at each of the locations specified in Fig. B.5.1 shall be manually collected using a hand-held auger or scoop to obtain a soil sample (core) from 0.0- to 0.5-ft bgs. All vegetation should be removed from the soil surface prior to sample collection. Samples for VOC analyses shall be collected using three Encore® samplers that are pushed directly into the soil material until the sampler is completely filled. After collection of the sample material, the Encore® samplers shall be capped and placed in a plastic bag that is subsequently securely closed. The plastic bag containing the Encore® samplers shall be immediately transferred to an ice chest with ice packs. The holding time for VOC samples collected using Encore® samplers is 48 hrs.

After collection of the VOC samples, the remainder of the soil material shall be homogenized in a stainless steel bowl and transferred to appropriate sample containers. Requirements for sample containers, preservation, and holding times for all analytes of concern from soil sampling are summarized in Table B.6.1. All sample containers shall be sealed, cleaned, and secured in accordance with the SSC's standard operating procedures (SOPs). After filling, containers will be transferred to ice chests with ice packs and a temperature check bottle. Sampling equipment (e.g., auger, mixing bowls, etc.) shall be decontaminated in accordance with the SSC's SOPs prior to reuse at other sampling stations.

Samples shall be placed into appropriate laboratory containers for submittal to the laboratory for analysis immediately upon sample collection. Sample containers will be labeled to include the sample location, sample number, sampling date and time, sampler's name, and requested analyses. Chain-of-custody procedures shall be maintained throughout the sample collection effort. Sample container preservation and holding time requirements are provided in Table B.6.1.

Table B.6.1. Container, preservation, and holding time requirements for 2033 soil samples

Sample location	Parameters of concern	Container type/volume	Preservation	Holding time
Locations 01 through 04	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]
	Volatile organics[b]	3 Encore® samplers		48 hours
	Semivolatile organics[c]	8-oz A-glass – Teflon™ closure[c]	Cool 4°C	14 days[d]
	PCBs (Aroclors)	Taken from above	Cool 4°C	14 days[d]
	Herbicides/pesticides	Taken from above	Cool 4°C	14 days[d]
	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
	TRU isotopes[f]	Taken from above	Cool 4°C	180 days
	^{14}C	Taken from above	Cool 4°C	180 days
	^{3}H	Taken from above	Cool 4°C	180 days
	Total activity	Taken from above	Cool 4°C	180 days
Equipment rinsate	Volatile organics	(3) 40-mL VOA vials	pH<2, Cool to 4°C[g]	14 days
	Semivolatile organics	(2) 1-L A-glass – Teflon™[c]	Cool 4°C	7 days[h]
	PCBs	Taken from above	Cool 4°C	7 days
	Herbicides/pesticides	(2) 1-L A-glass – Teflon™[c]	Cool 4°C	7 days[d]
	Total metals	1-L Polybottle	pH<2, Cool 4°C[i]	180 days
	Uranium isotopes	(2) 1-gal Polybottles	pH<2, Cool 4°C[i]	180 days
	^{99}Tc	Taken from above	pH<2, Cool 4°C[i]	180 days
	^{90}Sr	Taken from above	pH<2, Cool 4°C[i]	180 days
	TRU isotopes[f]	Taken from above	Cool 4°C	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
	^{14}C	1-L A-glass – Teflon™[c]	None	180 days
	^{3}H	Taken from above	None	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 also be quantified by both alpha and gamma spectroscopy.

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

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

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

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

PCB = polychlorinated biphenyl.

TRU = transuranic.

VOA = volatile organic analysis (or analyte).

B.7. ANALYTICAL REQUIREMENTS

Analytical protocols for the analyte groups specified for the samples collected under this SAP are indicated in Table B.7.1. Samples for chemical analyses will be measured by the relevant SW-846 Methods. Uranium isotopes will be analyzed by alpha spectroscopy except that ^{235}U will also be measured by gamma spectroscopy.

Table B.7.1. Analytical requirements for Building 2033 soil samples

Parameters of concern	Analytical protocols
Total metals[a]	6010C
Mercury	7471A
Total volatile organics	8260B
Total semivolatile organics	8270C
Herbicides/pesticides	8151A/8081A
PCBs	8082
Gamma-emitting isotopes	Gamma spectroscopy
Total alpha/beta activity	Radiochemical counting method
Uranium isotopes	Alpha spectroscopy
Plutonium isotopes	Alpha spectroscopy
^{241}Am, ^{237}Np	Alpha spectroscopy
^{99}Tc	Radiochemical separation/beta count
^{14}C	Radiochemical separation/Liquid scintillation
^{3}H	Radiochemical separation/Liquid scintillation

[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.

PCB = polychlorinated biphenyl.

B.8. 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).

B.9. REFERENCES

CH2MHill 2007. *Facility Audit, Building 2033, Oak Ridge National Laboratory*, prepared by CH2MHill Lockwood Greene for Technology 2020, August.

DOE (U. S. Department of Energy) 2002. *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee*, DOE/OR/01-1862&D4, Office of Environmental Management, Oak Ridge, Tennessee, May.

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.

Hatcher, R. D. Jr., Lemiszki, P. J., Drier, R. B., Ketelle, R. H., Lee, R. R., Leitzke, D. A., McMaster, W. M., Foreman, J. L., and Lee, S. Y. 1992. *Status Report on the Geology of the Oak Ridge Reservation* ORNL/TM-12074, Environmental Sciences Division, Publication No. 3860, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

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APPENDIX C

RADIOLOGICAL SURVEY PLAN FOR LEASE OF BUILDING 2033 AT THE OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE

C.1. AREA TO BE SURVEYED

This Radiological Survey Plan (RSP) presents the objectives, rationale, and protocols for conducting radiological surveys of Building 2033 at the Oak Ridge National Laboratory (ORNL) to support the lease of the building. The Community Reuse Organization of East Tennessee (CROET) is proposing to lease Building 2033 from the U. S. Department of Energy (DOE). Building 2033 is located among other office, laboratory, and support facilities at ORNL in the northwest quadrant of the main ORNL campus. The location of Building 2033 is depicted in Fig. C.1.

Building 2033 is a three-story office and laboratory building consisting of approximately 32,000 gross square feet of floor area. The building floor plan is shown in Fig. C.2. Each floor has an approximate footprint of 11,000 gross square feet. The building includes individual offices, several small maintenance shop rooms, a locker room, and conference rooms. The building has a single elevator on the east end of the building and stairs on both the east and west ends of the building. The basement has a crawl space consisting of approximately 25% of the footprint on the north side. Survey of the crawl space is not required. The remaining area consists of corridors, mechanical, and other support space. The building is constructed of lightweight steel frame with composite metal insulating and finish panels and bronze-tinted insulating glass. Floor-to-floor height is 12 ft at each floor. Above-grade floors consist of concrete slab on metal form-deck supported by steel beams. Vertical chases at each end of each lab allow for conveyance of lab utilities up or down. Only surveys of the interior of the building are required for lease.

C.2. HISTORY OF THE AREA

Building 2033, constructed in 1994, is a three-story office and laboratory building consisting of approximately 32,000 gross square feet of floor space. The building provided office and shop space for the Technical Support Section of the Instrumentation and Controls Division of ORNL. Building 2033 includes individual offices, several small maintenance shop rooms, a locker room, and conference rooms. The building is constructed of lightweight steel frame with composite metal insulating and finish panels and bronze-tinted insulating glass. Above-grade floors consist of concrete slab on metal form-deck supported by steel beams. The facility has a single elevator on the east end and stairs on both the east and west ends of the building. Building 2033 is situated on a sloping site such that grade-level access is afforded on the upper level on the north side and to the basement on the south side. The main entrance is on the upper (north) level. The building fronts on Hilltop Circle to the north, and a service drive connects to Second Street from the south and east sides of the building.

There is no known history of Building 2033 being used for handling loose radioactive material. Fixed (sealed) radiological sources have been used in the facility for testing or calibration of instruments during maintenance in the maintenance shops. Rooms 101, 116, and 117 are posted as “Caution Low-Level Radiation Sources Are Stored and Used in This Area.” All other rooms are Non-Radiological Areas.

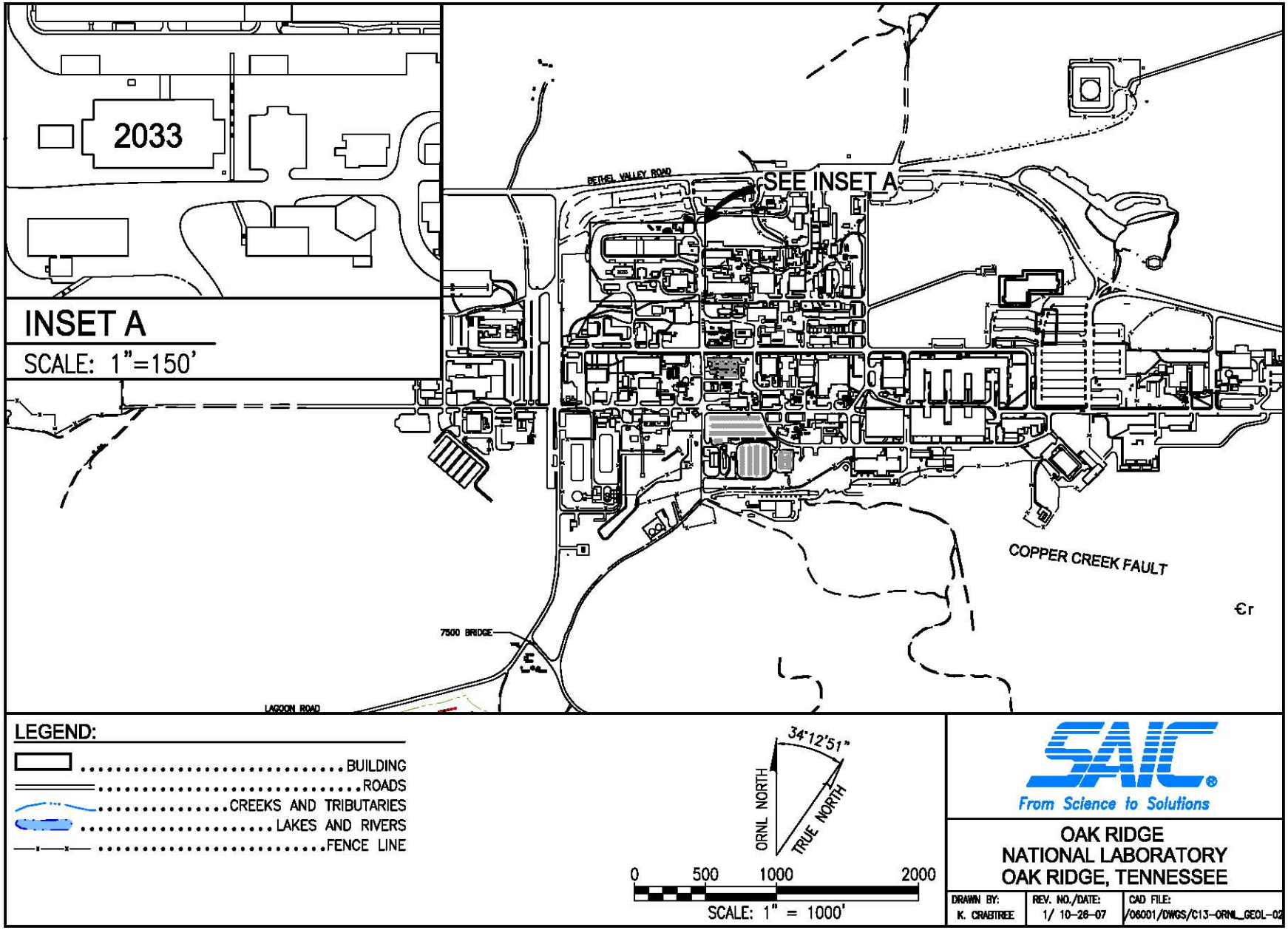
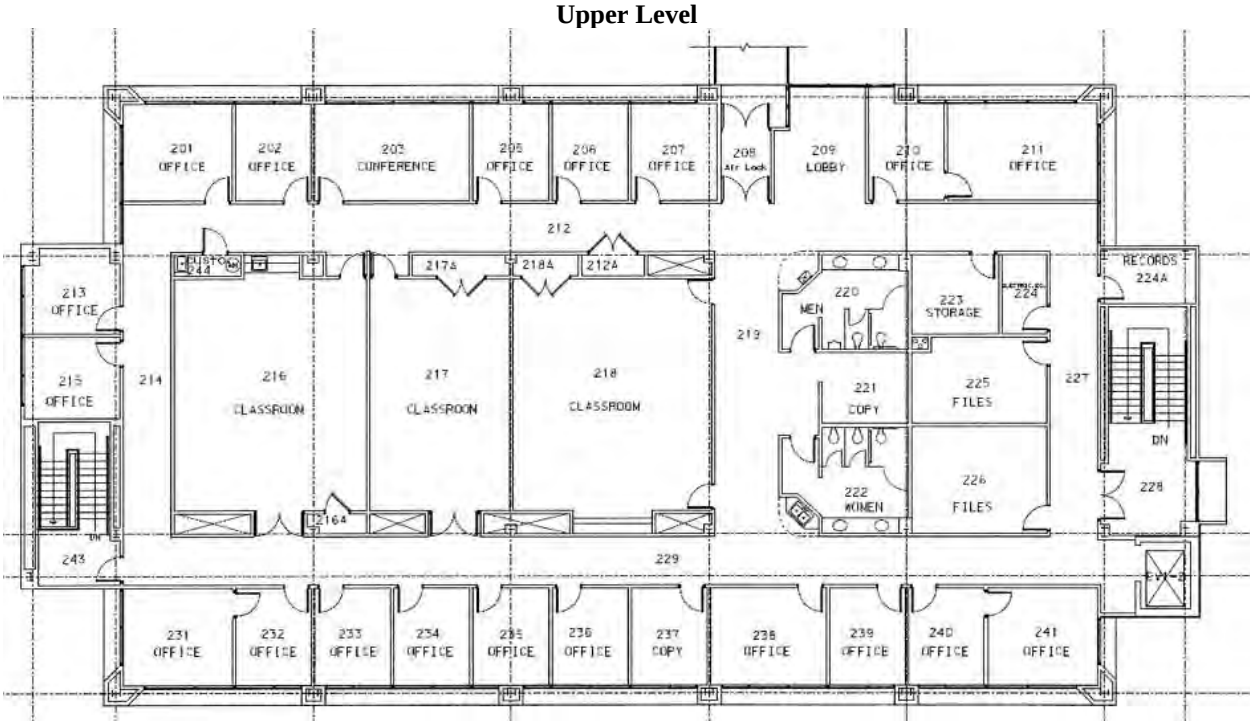


Fig. C.1. Building 2033 footprint.

Upper Level



Lower Level

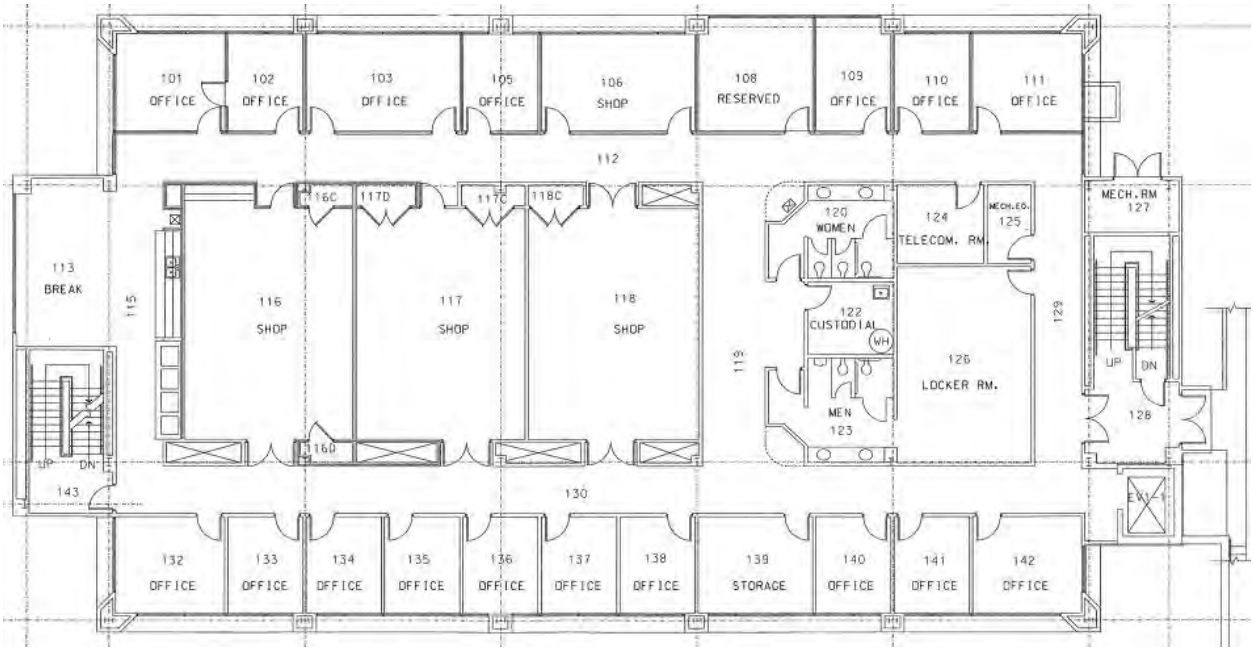


Fig. C.2. Building 2033 floor plan.

Basement

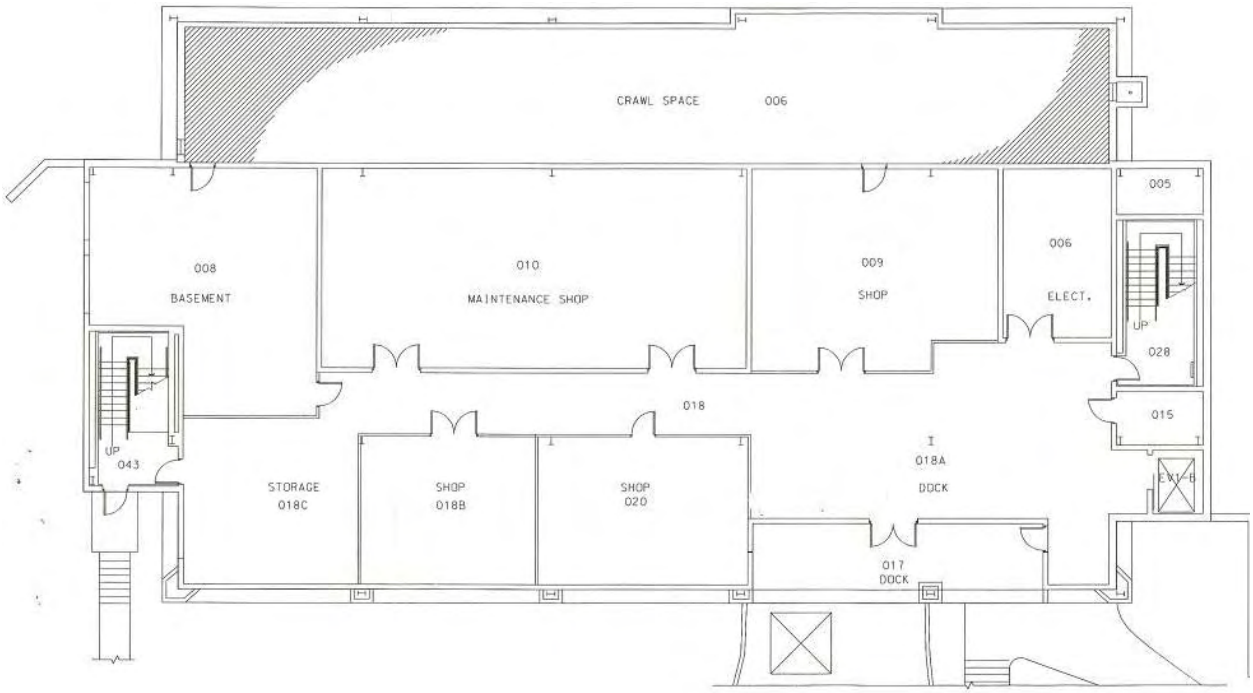


Fig. C.2. (continued).

C.3. EXISTING SURVEY DATA SUMMARY

Building 2033 has received routine radiological surveys of portions of the building, including annual surveys of the first floor men's and women's change rooms, semiannual surveys of the first floor break room, and quarterly surveys of the basement and rooms 101, 103, 108, 116, and 117. The results of the latest routine surveys obtained from June through October of 2007 showed all direct probe readings to be < 100 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) alpha and < 1000 dpm/100 cm^2 beta/gamma. Removable results were all < 20 dpm/100 cm^2 alpha and < 200 dpm/100 cm^2 beta/gamma. The survey numbers reviewed are shown in Table C.1.

These surveys were reviewed to determine if there were any areas of fixed contamination exceeding the appropriate contamination release limits for ORNL given in Table C.2. The building surveys reviewed indicate contamination levels do not exceed the contamination limits.

Table C.1. ORNL radiological surveys reviewed

WEST-215949	WEST-220310	WEST-220379
WEST-215950	WEST-220375	WEST-222017
WEST-219620	WEST-220376	WEST-222134

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

	DCGL (dpm/100 cm^2)	$DCGL_{EMC}$ (dpm/area)
Total alpha	100	300
Removable alpha	20	N/A
Total beta-gamma	1000	3000
Removable beta-gamma	200	N/A

DCGL = derived concentration guideline level.
$DCGL_{EMC}$ = derived concentration guideline level elevated measurement comparison
dpm = disintegrations per minute.
N/A = not applicable.
ORNL = Oak Ridge National Laboratory.

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 Building 2033 through the use of a scoping survey and a final status survey. The survey provides assurance that the building is clean and does not require radiological controls. The data will also be used to evaluate the need for performing a risk analysis prior to lease. The data gathered, combined with process knowledge, will be used to lease the facility. The data quality objectives have been detailed in the Design of Radiological Survey and Sampling document (hereafter referred to as the "Design Document"[5] attached as Appendix A to this plan).

[5] *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.

C.5. MEASUREMENT TECHNIQUES/SURVEY APPROACH

C.5.1 RADIONUCLIDES OF CONCERN

Process history of the ORNL Site indicates that uranium isotopes, fission products, activation products, and transuranics (TRUs) are radiological contaminants potentially present in Building 2033 due to tracking of contamination from other on-site buildings.

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 any of the survey units (SUs). As shown by modeling, the dose and risk obtained from exposure to radioactivity at DOE surface contamination limits, as set forth in Title 10 *Code of Federal Regulations* 835[6] and also in DOE Order 5400.5,[7] 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 TRUs for alpha activity and for ^{90}Sr for beta activity (see Table 2), which are the most limiting contaminants present on-site. A separate limit for the maximum allowable contamination that is concentrated in a smaller area, the derived concentration guideline level$_{\text{elevated measurement comparison}}$ ($DCGL_{EMC}$), is normally calculated based upon modeling the dose obtained from an area determined by the number of samples taken in the SU and the spacing between them. However, the $DCGL_{EMC}$ 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-m^2 maximum size area.

C.5.3 IDENTIFICATION OF SURVEY UNITS AND CLASSIFICATIONS

Areas are classified as either Class 3, 2, or 1 based upon historical data and process knowledge. SUs must be of the same or similar material type. For example, an SU cannot contain both asphalt and soil; it would be divided into an SU of asphalt and another SU of soil. Refer to the design documents for complete descriptions of the different classifications of SUs. An area will be considered to be a Class 3 SU if it is not expected to have residual radioactivity levels above 25% of the DCGL (1250 dpm/100 cm^2 total activity or 250 dpm/100 cm^2 removable activity). A Class 2 SU is expected to have, or has had, residual radioactivity levels less than the DCGL. A Class 1 SU is expected to have, or has had, residual radioactivity levels above the DCGL.

Based on the historical data discussed in Chap. 3, the interior of the building will be initially classified as a Class 3. Each building level will be considered a separate SU. The building stairwells and elevator will be considered separate SUs. Since there is no limit on the size of Class 3 SUs, and since survey measurements will be performed at a minimum in each room, the building will not be further divided into SUs. The exterior, or roof, of the building will not be monitored for the lease survey since they are not expected to be accessed by the lessee. The Building 2033 SUs and classifications are shown in Table C.3.

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

[7] 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.3. Building 2033 survey units

Interior survey units	Class
ISU-1 Basement	Class 3
ISU-2 First Floor	Class 3
ISU-3 Second Floor	Class 3
ISU-4 East Stairwell	Class 3
ISU-5 West Stairwell	Class 3
ISU-6 Elevator	Class 3

C.5.4 INSTRUMENTATION SELECTION AND SURVEY TECHNIQUES

Refer to the design documents in Appendix A for details on instrumentation selection. In general, for both the lease and transfer surveys, alpha scintillation and beta-gamma Geiger-Müeller (GM) detectors will be attached to scalar rate meters and have minimum detectable activities (MDAs) less than 25% of the DCGL. Gas-proportional floor monitors or floor monitors with the probe detached from the monitor cart for usage as a hand-held probe, calibrated to detect both alpha and beta-gamma radiations, will be used for as much of the scan surveys as possible, including the primary work surfaces, walls, and ceilings. Sodium iodide (NaI) meters and Bicron MicroRem® meters[8] will also be used, as specified in this survey plan. Removable contamination surveys (i.e., smear surveys) will be conducted at all locations where 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. MDA equal to 50% of the DCGLs is required. Further supplemental protocols for the survey measurements are provided in Appendix A of the Design Document included as Appendix A of this RSP.

For Class 3 areas, 10% surface scan surveys will be performed over the primary traffic and work surfaces of the entire SU, as accessible. Scanning of walls and ceilings will be based on visual inspection and professional judgment. Emphasis will be placed upon entrances/high-traffic areas, suspect areas, and professional judgment for all scan surveys. There are currently no Class 2 or 1 SUs. Identification of activity levels in excess of 50% of the DCGL will require reclassification of all, or part, of the area as Class 2 or Class 1 and will require further surveys. If an SU has to be reclassified to a higher classification and survey requirements, an addendum to this RSP will be provided. 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.5.5 REFERENCE COORDINATE SYSTEM FOR LEASE AND TRANSFER SURVEYS

Class 3 areas do not require a sample grid. A reference coordinate system will be used in each SU to reference measurements so they can be relocated/verified as needed, unless the measurement is at an easily identifiable location, such as “Room A, 4 ft up on west wall, approximately 2 ft from south wall.” The starting point of the reference grid, if needed, will be the southwest corner of each SU, with the distance north being Y and the distance east being X in an X–Y coordinate system [i.e., (X,Y)], with the units in feet.

Class 2 and Class 1 SUs require a sample grid with systematic measurements taken based upon a random starting point. These survey grids are based upon the SU’s area and number of systematic sample measurements required in each.

[8] 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.

C.6. SURVEY DESIGN

C.6.1 LEASE SURVEY PROCEDURES

The survey measurements for surface activity will consist of a combination of surface scans, direct measurements, measurements of removable activity, and dose measurements. All surveys are to be performed in accordance with this RSP and the design document. *Note:* Survey technique is covered in the design document and will not be repeated in this plan. However, variations or clarifications of the design document will be included.

Any contamination detected in Class 3 areas would be incidental to the work performed in the area. Contamination of these areas could only be caused by tracking in contamination from other areas or transfer from contaminated tools or other items brought into the area. Therefore, scanning surveys with locations based on professional judgment will be adequate to identify the presence of any activity that would be detectable above background. Survey of 100% of the floor, walls, and office furniture will not be necessary if levels of activity distinguishable from background are not found in these scanning surveys (see Appendix A for definition of distinguishable from background).

In any area in which the survey indicates activity exceeding the limits provided in Table C.2 will be made following the establishment of a 1-m^2 grid to obtain data applicable to the DOE Order 5400.5 release criteria. 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 50% of the DCGL (when averaged over 1 m^2) will require that a Class 3 SU, or sections thereof, be reclassified as Class 2 and surveyed appropriately. Any activity in excess of the DCGL will require that a Class 3 or 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 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.

Any contamination detected in Class 3 areas would be incidental to the work performed in the area. Contamination of these areas could only be caused by tracking in contamination from other areas or transfer from contaminated tools or other items brought into the area. Therefore, scanning surveys with locations based on professional judgment will be adequate to identify the presence of any activity that would be detectable above background. Survey of 100% of the floor, walls, and office furniture will not

[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 32.26 (dpm/100 cm^2)/cpm for a planar radiation source.

be necessary if levels of activity distinguishable from background are not found in these scanning surveys (see Appendix A for definition of distinguishable from background).

C.6.1.1 Class 3 interior survey units

Scanning surveys of the entrances, primary traffic areas, and primary work surfaces in each room or facility will be performed. A minimum of 10% of the floor and work surfaces will be scanned. Scanning of walls and ceilings will be based on visual inspection and professional judgment. The scanning will be performed with a floor monitor at each entrance and in primary traffic areas. Hand-held survey instruments may be used in place of the floor monitor, if appropriate. In addition, computerized, motorized automatic scanning instrumentation may be used for the floor scans. Alpha and beta-gamma scanning with hand-held survey instruments will be performed at each primary work surface location (e.g., desks or counter tops). A dose rate scan will also be made using a tissue-equivalent micro rem (μrem) meter to search for elevated areas of external dose rate. If variations exist, then the location will be recorded. Dose-rate measurements will be obtained at a minimum of 1 per room and every 20 ft in hallways and large rooms.

Scanning is performed only to identify any areas of elevated activity distinguishable from background. If any elevated activity levels are found by any of the scanning surveys, a direct measurement (timed count) at the location of the highest activity will be recorded for both alpha and beta-gamma activity unless a computerized, motorized scanning instrument is used. A smear sample will also be collected from that location, by taking a 100-cm^2 swipe of the area for removable contamination and counting on a smear counter. If results greater than the DCGL are encountered, further measurements around the area around the highest reading will be made and recorded in order to determine the activity average over a square meter.

If no elevated activity above background levels is found by any of the scanning surveys, dose rate measurements will be made, at a minimum, in the center of each room at 1 m above the floor. In addition, at minimum, a single direct measurement (timed count) will be recorded for both alpha and beta-gamma activity in the center of each room, corridor, and stairwell. Further fixed measurements will not be required for leases because the scanning methodology is expected to provide an overall probability of detecting contamination at the DCGL of greater than 95% and because no statistical test will be performed for Class 3 areas. One removable contamination measurement, at a minimum, will also be recorded in the center of each room, hallway, or open space

The survey requirements are summarized in Table C.4.

Table C.4. Class 3 survey requirements summary

A minimum of 10% of the floor and work surfaces will be scanned.
Static total and removable alpha, beta/gamma, and dose rate measurements will be made at the highest scan location in each room or in the center of each room, corridor, and stairwell if no elevated areas are found during the scan.

C.6.2 SPECIFICATION OF SAMPLING LOCATIONS

All recorded survey measurement locations are to be on a random basis for Class 3 internal and external SUs. For Class 3 interior survey units and exterior survey units, the random points will be chosen on a judgmental basis and should include entrances, primary traffic areas, air vents, and primary

workspaces; these are the areas that would be expected to have the highest probability of having elevated readings. If needed, further survey locations for Class 2 or 1 will be based on systematic points on the survey grid plus measurements from the highest point of each surface determined from the scan.

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 (QA)/quality control (QC) 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 Radiation Control (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 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 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 contractor project QA manager, project manager, and site project health physicist for approval.

ADDENDUM

ADDITIONS DUE TO FOOTPRINT CHANGES

ADDITIONS DUE TO FOOTPRINT CHANGES

This addendum is being added to the survey plan to cover the addition of the parking lot and connecting sidewalks to the Building 2033 lease foot print. The parking lot is paved and the sidewalk is concrete. This footprint change requires the addition on one external survey unit (ESU). ESU 1 will be classified as Class 3. The revised footprint for the Building 2033 lease is shown on Figure Add-1. The protocols for survey of ESU 1 follow and are summarized in Table Add-1.

ADD.1 EXTERIOR SURVEY UNITS

All exterior areas will be surveyed with hand-held meters or with a gas-proportional probe and with an NaI meter. Exterior areas that are covered under this survey plan include the 2033 parking lot and sidewalks leading to the building. Although these are grouped together into one SU, at least one timed measurement will be made on each. Emphasis is to be placed upon wherever professional judgment would indicate a higher probability of finding elevated readings.

Add.1.1 Class 3 exterior survey units

Class 3 exterior surveys will have 10% of the surfaces scanned with hand-held meters or floor monitors with gas-proportional or scintillation probes, as appropriate. For exterior areas that have a potential for holding activity that would be difficult to detect by alpha and beta-gamma scans (e.g., drains, cracks/joints/penetrations, wall/floor interfaces), a scan will be performed using a NaI meter. Eleven measurements of total and removable contamination, at a minimum, will be recorded within each SU at locations determined during the scan survey to have the highest activity or based on professional judgement if no elevated readings are observed. At least one timed measurement will be made on each sidewalk or parking lot. Any Class 3 or 2 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.

Add.1.2 Class 2 exterior survey units

Although there are currently no Class 2 exterior areas, the potential exists for having a Class 3 area upgraded to a Class 1. Class 2 survey protocols are as follows: surfaces will be scan-surveyed using hand-held meters and/or floor monitors with gas-proportional or scintillation probes , as appropriate and with a NaI probe according to the values obtained during the Class 3 survey. The survey measurement locations will be systematically chosen per survey grid. In addition, smears and direct readings will be obtained from locations of the highest contamination with results greater than 25% of the DCGL, as indicated by the scanning surveys for each horizontal and vertical surface. Any Class 3 or 2 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.

Add.1.3 Class 1 exterior survey units

Although there are currently no Class 1 exterior areas, the potential exists for having a Class 3 or 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.

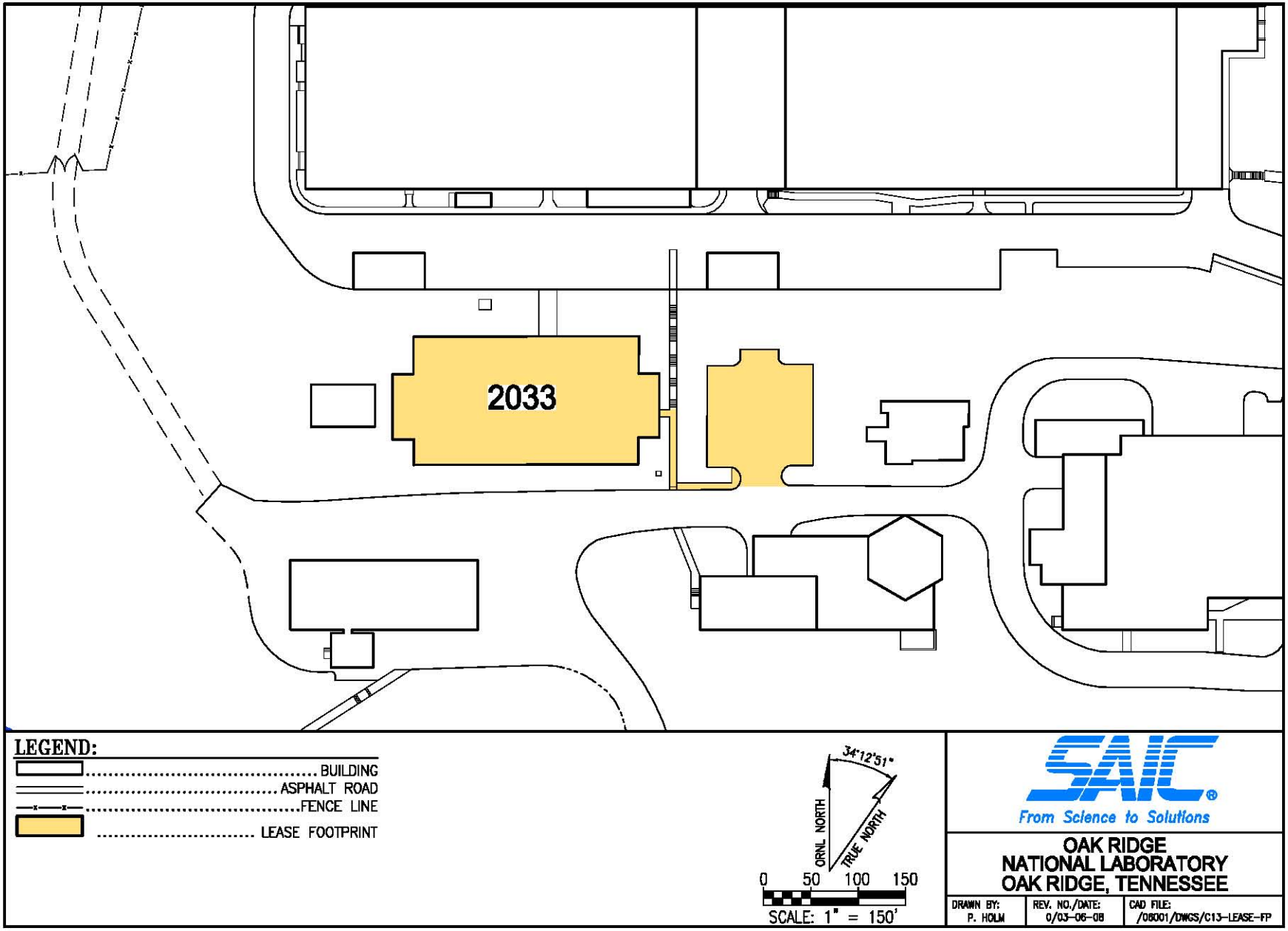

Fig. Add.1. Lease Footprint for Building 2033.

Table Add-1. Summary of survey unit requirements

Survey unit type	Class 3	Class 2	Class 1
Exterior	• Ten percent scan of accessible surfaces. • Eleven total and removable readings, at a minimum, per SU. • Reading locations based on professional judgment and scan survey; at least one timed measurement on each piece of exterior equipment and on each facing and roof for buildings. • Dose-rate walkover survey in the middle of each SU. • Dose-rate reading for each static measurement location. • NaI scan of pavement, soil, gravel, and other areas that have a potential for holding activity that would be difficult to detect by alpha and beta-gamma scans. • Upgrading to Class 2 if activity > 25% DCGL. • Upgrading to Class 1 if activity > DCGL.	• Scan of surfaces with scan % = % of DCGL. • Eleven total and removable readings, at a minimum, per SU. • Reading locations based upon a grid. • Dose-rate walkover survey in/on each SU. • One dose-rate reading per every 20 ft. • NaI scan of pavement, soil, gravel, and other 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. • Eleven total and removable readings, at a minimum, per SU. • Reading locations based upon a grid to be determined, as needed. • Dose-rate walkover survey in/on each SU. • One dose-rate reading per every 20 ft. • NaI scan of pavement, soil, gravel, and other areas that have a potential for holding activity that would be difficult to detect by alpha and beta-gamma scans.

DCGL = derived concentration guideline level.
NaI = sodium iodide.
SU = survey unit.

APPENDIX D

RISK ASSESSMENT FOR BUILDING 2033 AT THE OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE

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ACRONYMS

COPC	constituent of potential concern
EPA	U. S. Environmental Protection Agency
HI	hazard index
HQ	hazard quotient
PCB	polychlorinated biphenyl
PRG	preliminary remediation goal
RAGS	*Risk Assessment Guidance for Superfund*
SU	survey unit

EXECUTIVE SUMMARY

The goal of this risk assessment is to determine the potential for adverse health effects associated with the use of Building 2033 as an industrial facility or office building.

For Building 2033, the representative exposure scenario considered for the risk assessment was the industrial/office worker. The industrial/office worker scenario is defined by an individual who spends time doing light industrial activities or office work within the building. The industrial/office worker scenario also assumes that area soils are accessible to the receptors. Therefore, although outside the lease footprint, surface soil samples were collected and used to determine the potential exposures to workers as they entered and exited the building.

The process followed in performing this risk assessment includes screening the site data against nationally available preliminary remediation goals (PRGs) to determine constituents of potential concern (COPCs). If any COPCs are identified then the calculated risks and hazard index (HI) are compared with the established U. S. Environmental Protection Agency (EPA) acceptable target risk range of E-4 to E-6 (also expressed as 10^{-4} to 10^{-6}) and 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 risk assessment considered exposure to building interiors as well as potential soil exposure while entering or exiting Building 2033. Because no soil COPCs were identified based on the analytical results for the soil samples collected at Building 2033, potential exposures to soils were not evaluated further in this risk assessment. Therefore, an HI was not calculated. The risk calculation for the building interior was based on all the data obtained from radiological surveys, including the elevated readings that were resolved at a later date, and indicated that risks were approximately 2E-08, which does not exceed the EPA target risk range of E-06 to E-04. Thus, the results indicate a low likelihood of adverse health effects associated with Building 2033 industrial/office worker exposure to the building interior surfaces area soils, or the adjacent parking lot surface.

D.1. INTRODUCTION

The goal of this risk assessment is to determine the potential for adverse health effects associated with Building 2033, which is proposed for lease by the U. S. Department of Energy. The objectives of this evaluation are: (1) to determine exposure to constituents based on available data for the building and study area soils, 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 Building 2033 study area.

This risk assessment process includes screening the site data against nationally available preliminary remediation goals (PRGs) to determine constituents of potential concern (COPCs). The risks associated with the COPCs are then calculated for the exposure scenario being considered. For Building 2033, the representative exposure scenario is the industrial/office worker, defined by an individual who spends time doing light industrial activities or office work within the building and who is potentially exposed to soils while entering or exiting the building.

Because no nationally recognized PRGs are available for building interiors, a risk calculation will be performed for the industrial/office worker exposed to the interior surfaces of the building, assuming exposure by the inhalation, ingestion, and external exposure pathways. The risk calculations for the interior of Building 2033 are based on the radiological survey data collected in 2007 within the building. The risk assessment assumed that a worker would move throughout the building and be exposed equally to all survey units (SUs).

Results of the risk estimates are compared with the U. S. Environmental Protection Agency (EPA)-established acceptable target risk range of E-4 to E-6 (also expressed as 10^{-4} to 10^{-6}) and acceptable hazard index (HI) of 1. The risk estimate is a value that represents the excess cancer incidence that might be expected due to the particular exposure scenario evaluated. The HI is a value that represents the potential for toxic effects to an exposed individual. Results of the risk calculations were compared to the EPA range to determine the potential for adverse health effects.

The following sections describe the process used to provide a quantitative analysis of the risks to human health from exposure to the Building 2033 study area.

D.2. DESCRIPTION AND HISTORY

A full description and history of Building 2033, as well as a site map and photographs, are presented in Chaps. 1 through 5 of the Baseline Condition Report for Building 2033. Figure 1.1 in the Baseline Condition Report shows the location of Building 2033 within Oak Ridge National Laboratory.

D.3. AVAILABLE DATA

The available data for the Building 2033 study area include recent and historical soil samples and recent radiological survey results. These data are discussed below.

The soil data for the Building 2033 study area consist of recent sampling results from 12 locations (see Fig. 6.2 in the Baseline Condition Report) as well as additional historical sampling locations. The 2007 sampling event included soil (taken from 0 to 0.5 ft below ground surface) from 12 locations that were composited into 4 samples. The resulting four composite samples were analyzed for metals, organics, and radionuclides.

Historical soil samples have been collected within approximately 50 ft of Building 2033 (see Fig. 6.1 in the Baseline Condition Report). These samples were collected as part of the ongoing monitoring program for Buildings 2000/2001, which began in 1999. These samples have only been analyzed for polychlorinated biphenyls (PCBs). The soil sampling locations nearest to Building 2033 have indicated that PCBs were not detected at the 99S5 and 00S6 locations directly north of 2033. At the 05S3 location, northeast of 2033, an estimated concentration of 0.012 mg/kg of total PCBs was reported for this sample, which was collected in 2005.

Radiological surveys of the building interior and outdoor paved parking lot and connecting sidewalk were also conducted. The radiological surveys were conducted in accordance with the Building 2033 Radiological Survey Plan (Appendix C) and the results evaluated in this risk assessment. All of the data obtained during the surveys, including a small number of elevated readings that were subsequently resolved, were included in this analysis.

As discussed in Chap. D.1, soil data are included in the industrial/office worker evaluation to account for possible exposure while entering or exiting the building. Data collected during radiological surveys of the building interior and exterior are used to evaluate the exposures associated with Building 2033 surfaces (see Sect. 6.2 of the Baseline Condition Report).

D.4. EXPOSURE ASSESSMENT

An exposure assessment combines information about site characteristics and site-related data with exposure assumptions 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 and anticipated future property use,
- 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.

D.4.1 EXPOSURE SCENARIO EVALUATION

Exposure scenarios are selected based on site surveys and anticipated uses of Building 2033. The area is being evaluated for industrial uses ranging from light to heavy industrial applications. The anticipated use scenario for Building 2033 is for light industrial and office activity; therefore, the likely exposure scenario is an industrial/office worker exposed to the building interior surfaces and study area soils.

Exposures to the industrial/office worker associated with the building will be evaluated using available survey data. Soil sampling results were used to evaluate exposures to the industrial/office worker while entering and exiting the building. Groundwater is not a pathway for exposure to an industrial/office worker because it is not part of the lease and access will be prohibited. Therefore, groundwater is not included in this risk assessment. Uncertainties associated with the exposure scenario evaluation are presented in Chap. D.6.

D.4.1.1 Industrial/Office Worker Scenario

An industrial/office worker is anticipated to be present in Building 2033 in the future. It is assumed that the industrial/office worker is exposed to contaminated surfaces while working at the building and to contaminated soils while entering and exiting the building.

D.4.2 EXPOSURE PATHWAY IDENTIFICATION

Evaluating the exposure pathways requires describing the mechanism by which an individual may become exposed to contaminants associated with soils in the Building 2033 study area. 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 quantified in the risk assessment.

Complete exposure pathways associated with Building 2033 surfaces and soils include ingestion, inhalation, dermal contact, and external exposure to ionizing radiation. The ingestion pathway is complete because contamination may be present, a receptor may be present in the building or study area, and a receptor may contact and ingest contaminants. The inhalation pathway is complete because contamination may be present, contaminants may become airborne, a receptor may be present in the building or study area, and an individual may inhale contaminants in the air. The dermal pathway is complete because contamination may be present, a receptor may be present in or around the study area, and a receptor may contact and dermally absorb contaminants. External exposure to ionizing radiation is a complete exposure pathway because radionuclides may be present, ionizing radiation may be emitted, and a receptor may be present to absorb the radiation. The following section describes how each of the complete exposure pathways was quantified in the risk assessment.

D.4.3 QUANTIFICATION OF EXPOSURE

Quantifying the exposure to the receptor requires the following:

- statistical evaluation of the representative dataset;
- selection of 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 (Table D.4.1) appropriate to the exposure scenarios;
- selection of toxicity data appropriate for the receptor and exposure pathways; and
- calculation of the intake, risks, and hazard quotients (HQs) to the receptors based on the calculated exposure concentrations (Chap. D.5).

The ingestion, inhalation, dermal contact, and external exposure pathways were quantified using available soil and radiological survey 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 to provide an upper-bound estimate of risk that is protective of exposures associated with the Building 2033 study area.

D.4.3.1 Building Interior

The ingestion and inhalation pathways associated with the building surfaces will be quantified for the industrial/office worker assuming a 7-hr workday indoors. The assessment will use the sampling data for removable contamination, as well as fixed contamination for the SUs. External exposure will be evaluated using measured dose rates. Building interior survey data indicated that, on average, approximately 4% of the fixed contamination is removable. Therefore, for the industrial/office worker exposure scenario, it was assumed that 100% of the detected removable contamination is available for worker exposure each workday, and 4% of the detected total contamination is available for worker exposure for each SU that showed detectable levels of removable contamination. For Building 2033, all interior SUs have detectable levels of removable contamination; however, as discussed in the Baseline Conditions Report, these levels are below the allowable limits. To be conservative, these detectable levels were included in the evaluation of exposure. In these scenarios, there is no depletion of the source material over time. These assumptions are conservative and tend to result in an overestimation of risk.

Table D.4.1. Parameters for evaluation of exposures to the Building 2033 interior

Pathway	EF (d/year)	ED (year)	BW (kg)	CF (g/kg) [a]	IR_{soil} (kg/d)	FI (unitless)	IR_{air} (m^3/d)
			Industrial/office worker				
Ingestion	250	25	70	1000.00	0.000050	1.0	
Inhalation	250	25	70	1000.00			20

Other factors used:
PEF = 5.38E+09 m^3/kg for the inhalation pathway.
BW = body weight.
CF = conversion factor.
ED = exposure duration.
EF = exposure frequency.
FI = fraction ingested from contaminated source.
IR = intake rate.
PEF = particulate emission factor.

The industrial/office worker scenario does not consider any renovation work because the employees occupying the building for light industrial or office work would not be performing building renovations. Rather than develop a separate scenario for renovations, which would have limited benefit, and in an effort to be conservative, it was also assumed that the detected fixed contamination in each SU could be mobilized and become available for ingestion and inhalation. Pathways evaluated for the building interior include ingestion and inhalation of removable contamination. The dermal pathway is applicable to chemical exposure only; therefore, the available radiological swipe data cannot be used to evaluate this pathway for the building interior surfaces. External radiological exposures are evaluated based on direct measurements of dose rates during building sampling. Details regarding the use of surface swipe data in the risk assessment are presented in Attachment D.1, along with exposure equations used in the evaluation.

D.4.3.2 Study Area Soils

Quantifying the exposure requires an estimate of the exposure parameters for the exposed individual. For Building 2033 soil, the industrial/office worker[1] exposure scenario was evaluated based on the following assumptions:

- the industrial/office worker is present at Building 2033 for 25 years,[2]
- the industrial/office worker is on-site for 250 days/year,
- the industrial/office worker is outdoors exposed to soils for 1 hr/day,
- the industrial/office worker is dermally exposed over a skin surface area of 0.316 m^2,
- the industrial/office worker ingests 50 mg/day of soil, and
- the industrial/office worker inhales air at a rate of 20 m^3/day.

For the Building 2033 study area soils, detected concentrations were compared with EPA Region 9 industrial/office worker PRGs at a risk level of 1E-5 and an HQ of 1. To focus the evaluation on the significant risk contributors, constituents with maximum detected concentrations below their respective PRGs were eliminated from consideration in the risk assessment. Exposure assumptions utilized in the Region 9 PRG calculations were more conservative than those presented above in several instances and, therefore, provide a health-protective assessment of the potential for adverse effects.

[1] The U. S. Department of Energy intends to lease this building to the Community Reuse Organization of East Tennessee. The assumption that a lessee will remain in this building for 25 years is consistent with the standard EPA default for occupational exposure at one location.
[2] Ibid.

D.5. RISK RESULTS

The risk estimate is a value that represents the excess cancer incidence that might be expected due to the exposure scenario evaluated. EPA has established a target risk range of E-4 to E-6 (also expressed as 10^{-4} to 10^{-6}) and a target HI of 1. The following sections present the risk results for the Building 2033 study area.

D.5.1 INDUSTRIAL/OFFICE WORKER

Worker exposure included contact with building interior surfaces and exposure to soils surrounding the building while entering and exiting the building. The risks and hazards associated with the building and soils respectively, are discussed below.

D.5.1.1 Building 2033 Interior

The evaluation of the Building 2033 interior/exterior surfaces indicated that the risks were approximately 2E-08 and that all doses were below the background level of 0.006 mrem/year (see Table D.5.1), indicating a low likelihood of adverse health effects from exposure to the building surfaces.

D.5.1.2 Building 2033 Soils

EPA Region 9 PRGs were used to screen the study area soils based on an industrial/office worker exposure. Data collected for the study area soils were screened as follows:

- each detected result was compared with EPA Region 9 PRGs for the industrial/office worker scenario at risk level 1E-5 and an HQ of 1, and a frequency of detection above PRGs was developed; and

- detected results were compared with site background levels.

Table D.5.2 presents the Building 2033 study area soils constituents, detected concentrations, and their respective industrial soil PRGs. The data screening indicates that only arsenic and the radionuclides ^{228}Th and ^{232}Th were detected at concentrations above their respective PRGs. Background levels of the thorium isotopes are orders of magnitude greater than their respective PRGs indicating that these are site-wide COPCs, which are not specific to Building 2033. Arsenic has a PRG of 15.9 mg/kg compared with the background of 7.99 mg/kg. Because only a single arsenic detection exceeded the PRG, and since the average detected arsenic concentration (10.7 mg/kg) is below the PRG, arsenic is not considered a COPC. Since no COPCs were identified based on the PRG screening, there is a low likelihood of adverse health effects, and further risk calculations were not conducted. Therefore, an HI was not calculated.

Table D.5.1. Building 2033 – Industrial/office worker – carcinogenic risk estimates for building surfaces

Carcinogenic risk (risk/lifetime)	Removable activity			Potentially removable activity (4% of total activity)			Overall total
Location	**Ingestion risk**	**Inhalation risk**	**Total**	**Ingestion risk**	**Inhalation risk**	**Total**	
Upper Level	1.06E-08	8.41E-12	1.06E-08	1.10E-08	4.48E-11	1.10E-08	2.16E-08
Lower Level	6.98E-09	8.96E-12	6.99E-09	1.20E-08	7.53E-11	1.20E-08	1.90E-08
East Stair	7.56E-09	1.20E-11	7.57E-09	1.50E-08	2.15E-11	1.50E-08	2.26E-08
West Stair	1.42E-08	4.09E-12	1.42E-08	1.42E-08	3.51E-11	1.42E-08	2.84E-08
Average [a]	9.83E-09	8.37E-12	9.84E-09	1.30E-08	4.42E-11	1.31E-08	2.29E-08

[a] Assumes movement throughout the building interior over exposure duration.

Removable activity is directly measured by smear analysis. Potentially removable activity assumes a percentage of the total activity may become removable in the future.

The percent of potentially removable material is determined by the ratio of the measured removable activity to the measured total activity.

Table D.5.2. Building 2033 soils PRG screening

Analyte	Frequency of detections	Minimum detected concentration	Maximum detected concentration	Average detected concentration	Background reference level [a]	Frequency of detections exceeding background	Remediation level	Mean exceeds remedial level?	Industrial soil preliminary remediation goal	Frequency of detects exceeding preliminary remediation goal
Herbicides										
2,4,5-T	0/4	ND	ND	ND	NA	NA	NA	NA	6156.06	0/4
2,4,5-TP	0/4	ND	ND	ND	NA	NA	NA	NA	4924.85	0/4
2,4-D	0/4	ND	ND	ND	NA	NA	NA	NA	7683.33	0/4
Atrazine	0/4	ND	ND	ND	NA	NA	NA	NA	77.64	0/4
Caprolactam	0/4	ND	ND	ND	NA	NA	NA	NA	307803.15	0/4
Dalapon	0/4	ND	ND	ND	NA	NA	NA	NA	18468.19	0/4
Dinoseb	0/4	ND	ND	ND	NA	NA	NA	NA	615.61	0/4
MCPA	0/4	ND	ND	ND	NA	NA	NA	NA	307.80	0/4
MCPP	0/4	ND	ND	ND	NA	NA	NA	NA	615.61	0/4
Metals										
Aluminum	4/4	12600	24600	18100	18600	1/4	NA	NA	921072.50	0/4
Arsenic	4/4	2.5	22.7	10.65	7.99	2/4	330	No	15.90	1/4
Barium	4/4	46.6 J	115 J	82.9	103	1/4	NA	NA	66577.35	0/4
Beryllium	4/4	0.45	0.99	0.73	1.25	0/4	NA	NA	1940.69	0/4
Boron	2/4	4.6 J	7.3 J	5.95	NA	NA	NA	NA	200000.00	0/4
Cadmium	4/4	0.33 J	0.43 J	0.38	NA	NA	NA	NA	451.41	0/4
Calcium	4/4	2200 J	7550 J	4795	2560	2/4	NA	NA	NA	NA
Chromium	4/4	13.1 J	28.6 J	19.75	40.2	0/4	NA	NA	640.45	0/4
Cobalt	4/4	7.9 J	14.9 J	10.85	24.5	0/4	NA	NA	13331.00	0/4
Copper	4/4	4.1 J	8.3 J	6.25	20.6	0/4	NA	NA	40876.66	0/4
Iron	4/4	9910	35900	24452.5	41800	0/4	NA	NA	306412.11	0/4
Lead	4/4	14.7 J	48 J	31.8	51.1	0/4	NA	NA	NA	NA
Magnesium	4/4	1010 J	2590 J	1650	1660	1/4	NA	NA	NA	NA
Manganese	4/4	590 J	1840 J	1134	1440	1/4	NA	NA	19458.11	0/4
Mercury	4/4	0.0352	0.0866	0.06	0.19	0/4	NA	NA	306.60	0/4
Nickel	4/4	5.7 J	11 J	7.8	16.7	0/4	NA	NA	20439.16	0/4
Potassium	4/4	412 J	460 J	439.5	1890	0/4	NA	NA	NA	NA
Selenium	0/4	ND	ND	ND	0.93	0/4	NA	NA	5109.95	0/4
Silicon	4/4	550 J	862 J	709.75	583	3/4	NA	NA	NA	NA
Silver	3/4	0.34 J	0.65 J	0.54	NA	NA	NA	NA	5109.95	0/4
Sodium	0/4	ND	ND	ND	417	0/4	NA	NA	NA	NA
Thallium	4/4	0.17 J	0.31	0.23	NA	NA	NA	NA	67.45	0/4

Table D.5.2. Building 2033 soils PRG screening (continued)

Analyte	Frequency of detections	Minimum detected concentration	Maximum detected concentration	Average detected concentration	Background reference level [a]	Frequency of detections exceeding background	Remediation level	Mean exceeds remedial level?	Industrial soil preliminary remediation goal	Frequency of detects exceeding preliminary remediation goal
Vanadium	4/4	16 J	40.1 J	26.18	41.9	0/4	NA	NA	1022.00	0/4
Zinc	4/4	24.5 J	40.4 J	32.63	55.5	0/4	NA	NA	306412.11	0/4
Pesticides/PCBs										
4,4'-DDD	0/4	ND	ND	ND	NA	NA	NA	NA	99.51	0/4
4,4'-DDE	0/4	ND	ND	ND	NA	NA	NA	NA	70.25	0/4
4,4'-DDT	0/4	ND	ND	ND	NA	NA	NA	NA	70.25	0/4
Aldrin	0/4	ND	ND	ND	NA	NA	NA	NA	1.01	0/4
Aroclor-1016	0/4	ND	ND	ND	NA	NA	NA	NA	37.18	0/4
Aroclor-1221	0/4	ND	ND	ND	NA	NA	NA	NA	7.44	0/4
Aroclor-1232	0/4	ND	ND	ND	NA	NA	NA	NA	7.44	0/4
Aroclor-1242	0/4	ND	ND	ND	NA	NA	NA	NA	7.44	0/4
Aroclor-1248	0/4	ND	ND	ND	NA	NA	NA	NA	7.44	0/4
Aroclor-1254	1/4	0.0074	0.0074	0.01	NA	NA	NA	NA	7.44	0/4
Aroclor-1260	2/4	0.0072 J	0.0089	0.01	NA	NA	NA	NA	7.44	0/4
Aroclor-1262	0/4	ND	ND	ND	NA	NA	NA	NA	7.44	0/4
Aroclor-1268	0/4	ND	ND	ND	NA	NA	NA	NA	7.44	0/4
Dieldrin	0/4	ND	ND	ND	NA	NA	NA	NA	1.08	0/4
Endosulfan I	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Endosulfan II	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Endosulfan sulfate	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Endrin	0/4	ND	ND	ND	NA	NA	NA	NA	184.68	0/4
Endrin aldehyde	0/4	ND	ND	ND	NA	NA	NA	NA	184.68	0/4
Endrin ketone	0/4	ND	ND	ND	NA	NA	NA	NA	184.68	0/4
Heptachlor	0/4	ND	ND	ND	NA	NA	NA	NA	3.83	0/4
Heptachlor epoxide	0/4	ND	ND	ND	NA	NA	NA	NA	1.89	0/4
Methoxychlor	0/4	ND	ND	ND	NA	NA	NA	NA	3078.03	0/4
Toxaphene	0/4	ND	ND	ND	NA	NA	NA	NA	15.67	0/4
alpha-BHC	0/4	ND	ND	ND	NA	NA	NA	NA	3.59	0/4
alpha-Chlordane	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
beta-BHC	0/4	ND	ND	ND	NA	NA	NA	NA	12.58	0/4
delta-BHC	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
gamma-BHC (Lindane)	0/4	ND	ND	ND	NA	NA	NA	NA	17.41	0/4

Table D.5.2. Building 2033 soils PRG screening (continued)

Analyte	Frequency of detections	Minimum detected concentration	Maximum detected concentration	Average detected concentration	Background reference level [a]	Frequency of detections exceeding background	Remediation level	Mean exceeds remedial level?	Industrial soil preliminary remediation goal	Frequency of detects exceeding preliminary remediation goal
gamma-Chlordane	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Semivolatile organics										
1,2,4,5-Tetrachlorobenzene	0/4	ND	ND	ND	NA	NA	NA	NA	184.68	0/4
1,2,4-Trichlorobenzene	0/4	ND	ND	ND	NA	NA	NA	NA	215.93	0/4
1,2-Dichlorobenzene	0/4	ND	ND	ND	NA	NA	NA	NA	4084.23	0/4
1,3-Dichlorobenzene	0/4	ND	ND	ND	NA	NA	NA	NA	2090.84	0/4
1,4-Dichlorobenzene	0/4	ND	ND	ND	NA	NA	NA	NA	78.67	0/4
2,4,5-Trichlorophenol	0/4	ND	ND	ND	NA	NA	NA	NA	61560.63	0/4
2,4,6-Trichlorophenol	0/4	ND	ND	ND	NA	NA	NA	NA	61.56	0/4
2,4-Dichlorophenol	0/4	ND	ND	ND	NA	NA	NA	NA	1846.82	0/4
2,4-Dimethylphenol	0/4	ND	ND	ND	NA	NA	NA	NA	12312.13	0/4
2,4-Dinitrophenol	0/4	ND	ND	ND	NA	NA	NA	NA	1231.21	0/4
2,4-Dinitrotoluene	0/4	ND	ND	ND	NA	NA	NA	NA	25.35	0/4
2,6-Dinitrotoluene	0/4	ND	ND	ND	NA	NA	NA	NA	25.35	0/4
2-Chloronaphthalene	0/4	ND	ND	ND	NA	NA	NA	NA	23382.73	0/4
2-Chlorophenol	0/4	ND	ND	ND	NA	NA	NA	NA	235.77	0/4
2-Methyl-4,6-dinitrophenol	0/4	ND	ND	ND	NA	NA	NA	NA	61.56	0/4
2-Methylnaphthalene	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
2-Nitrophenol	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
3,3'-Dichlorobenzidine	0/4	ND	ND	ND	NA	NA	NA	NA	38.30	0/4
4-Bromophenylphenylether	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
4-Chloroaniline	0/4	ND	ND	ND	NA	NA	NA	NA	2462.43	0/4
4-Chlorophenylphenylether	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
4-Nitrophenol	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Acenaphthene	0/4	ND	ND	ND	NA	NA	NA	NA	29219.33	0/4
Acenaphthylene	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Acetophenone	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Anthracene	0/4	ND	ND	ND	NA	NA	NA	NA	238286.51	0/4
Benzaldehyde	0/4	ND	ND	ND	NA	NA	NA	NA	61560.63	0/4
Benzo(*a*)anthracene	0/4	ND	ND	ND	NA	NA	NA	NA	21.10	0/4
Benzo(*a*)pyrene	0/4	ND	ND	ND	NA	NA	NA	NA	2.11	0/4

Table D.5.2. Building 2033 soils PRG screening (continued)

Analyte	Frequency of detections	Minimum detected concentration	Maximum detected concentration	Average detected concentration	Background reference level [a]	Frequency of detections exceeding background	Remediation level	Mean exceeds remedial level?	Industrial soil preliminary remediation goal	Frequency of detects exceeding preliminary remediation goal
Benzo(*b*)fluoranthene	2/4	0.0152 J	0.0155 J	0.02	NA	NA	NA	NA	21.10	0/4
Benzo(*g*,*h*,*i*)perylene	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Benzo(*k*)fluoranthene	0/4	ND	ND	ND	NA	NA	NA	NA	210.96	0/4
Butylbenzylphthalate	0/4	ND	ND	ND	NA	NA	NA	NA	123121.26	0/4
Carbazole	0/4	ND	ND	ND	NA	NA	NA	NA	861.85	0/4
Chrysene	0/4	ND	ND	ND	NA	NA	NA	NA	2109.62	0/4
Di-n-butylphthalate	0/4	ND	ND	ND	NA	NA	NA	NA	61560.63	0/4
Di-n-octylphthalate	0/4	ND	ND	ND	NA	NA	NA	NA	24624.25	0/4
Dibenzo(*a*,*h*)anthracene	0/4	ND	ND	ND	NA	NA	NA	NA	2.11	0/4
Dibenzofuran	0/4	ND	ND	ND	NA	NA	NA	NA	1563.34	0/4
Diethylphthalate	1/4	0.149 J	0.149 J	0.15	NA	NA	NA	NA	492485.03	0/4
Dimethylphthalate	0/4	ND	ND	ND	NA	NA	NA	NA	6156062.91	0/4
Diphenylamine	0/4	ND	ND	ND	NA	NA	NA	NA	15390.16	0/4
Fluoranthene	2/4	0.014 J	0.0174 J	0.02	NA	NA	NA	NA	22000.35	0/4
Fluorene	0/4	ND	ND	ND	NA	NA	NA	NA	26281.43	0/4
Hexachlorobenzene	0/4	ND	ND	ND	NA	NA	NA	NA	10.77	0/4
Hexachlorobutadiene	0/4	ND	ND	ND	NA	NA	NA	NA	184.68	0/4
Hexachlorocyclopentadiene	0/4	ND	ND	ND	NA	NA	NA	NA	3658.72	0/4
Hexachloroethane	0/4	ND	ND	ND	NA	NA	NA	NA	615.61	0/4
Indeno(*1,2,3-cd*)pyrene	0/4	ND	ND	ND	NA	NA	NA	NA	21.10	0/4
Isophorone	0/4	ND	ND	ND	NA	NA	NA	NA	5119.79	0/4
N-Nitrosodipropylamine	0/4	ND	ND	ND	NA	NA	NA	NA	2.46	0/4
Naphthalene	0/4	ND	ND	ND	NA	NA	NA	NA	187.69	0/4
Nitrobenzene	0/4	ND	ND	ND	NA	NA	NA	NA	102.93	0/4
Pentachlorophenol	0/4	ND	ND	ND	NA	NA	NA	NA	89.98	0/4
Phenanthrene	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Phenol	0/4	ND	ND	ND	NA	NA	NA	NA	184681.89	0/4
Pyrene	0/4	ND	ND	ND	NA	NA	NA	NA	29126.20	0/4
Vinyl acetate	0/4	ND	ND	ND	NA	NA	NA	NA	1396.42	0/4
bis(2-Chloroethoxy)methane	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
bis(2-Chloroethyl) ether	0/4	ND	ND	ND	NA	NA	NA	NA	5.75	0/4
bis(2-Chloroisopropyl)ether	0/4	ND	ND	ND	NA	NA	NA	NA	73.52	0/4

Table D.5.2. Building 2033 soils PRG screening (continued)

Analyte	Frequency of detections	Minimum detected concentration	Maximum detected concentration	Average detected concentration	Background reference level [a]	Frequency of detections exceeding background	Remediation level	Mean exceeds remedial level?	Industrial soil preliminary remediation goal	Frequency of detects exceeding preliminary remediation goal
bis(2-Ethylhexyl)phthalate	0/4	ND	ND	ND	NA	NA	NA	NA	1231.21	0/4
m,p-Cresols	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
m-Nitroaniline	0/4	ND	ND	ND	NA	NA	NA	NA	184.68	0/4
o-Cresol	0/4	ND	ND	ND	NA	NA	NA	NA	30780.31	0/4
o-Nitroaniline	0/4	ND	ND	ND	NA	NA	NA	NA	1830.23	0/4
p-Nitroaniline	0/4	ND	ND	ND	NA	NA	NA	NA	820.81	0/4
tert-Butyl methyl ether	0/4	ND	ND	ND	NA	NA	NA	NA	364.35	0/4
Volatile organics										
1,1,1-Trichloroethane	0/4	ND	ND	ND	NA	NA	NA	NA	6947.42	0/4
1,1,2,2-Tetrachloroethane	0/4	ND	ND	ND	NA	NA	NA	NA	9.29	0/4
1,1,2-Trichloroethane	0/4	ND	ND	ND	NA	NA	NA	NA	16.05	0/4
1,1-Dichloroethane	0/4	ND	ND	ND	NA	NA	NA	NA	1738.65	0/4
1,1-Dichloroethylene	0/4	ND	ND	ND	NA	NA	NA	NA	413.33	0/4
1,2,3-Trichlorobenzene	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	0/4	ND	ND	ND	NA	NA	NA	NA	11.00	0/4
1,2-Dibromoethane	0/4	ND	ND	ND	NA	NA	NA	NA	0.63	0/4
1,2-Dichloroethane	0/4	ND	ND	ND	NA	NA	NA	NA	6.03	0/4
1,2-Dichloropropane	0/4	ND	ND	ND	NA	NA	NA	NA	7.42	0/4
1,4-Dioxane	0/4	ND	ND	ND	NA	NA	NA	NA	1567.00	0/4
2-Butanone	0/4	ND	ND	ND	NA	NA	NA	NA	113264.39	0/4
2-Hexanone	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
4-Methyl-2-pentanone	0/4	ND	ND	ND	NA	NA	NA	NA	47001.43	0/4
Acetone	0/4	ND	ND	ND	NA	NA	NA	NA	54320.99	0/4
Benzene	0/4	ND	ND	ND	NA	NA	NA	NA	14.09	0/4
Bromochloromethane	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Bromodichloromethane	0/4	ND	ND	ND	NA	NA	NA	NA	18.31	0/4
Bromoform	0/4	ND	ND	ND	NA	NA	NA	NA	2182.00	0/4
Bromomethane	0/4	ND	ND	ND	NA	NA	NA	NA	13.08	0/4
Carbon disulfide	0/4	ND	ND	ND	NA	NA	NA	NA	1201.72	0/4
Carbon tetrachloride	0/4	ND	ND	ND	NA	NA	NA	NA	5.49	0/4
Chlorobenzene	0/4	ND	ND	ND	NA	NA	NA	NA	530.47	0/4

Table D.5.2. Building 2033 soils PRG screening (continued)

Analyte	Frequency of detections	Minimum detected concentration	Maximum detected concentration	Average detected concentration	Background reference level [a]	Frequency of detections exceeding background	Remediation level	Mean exceeds remedial level?	Industrial soil preliminary remediation goal	Frequency of detects exceeding preliminary remediation goal
Chloroethane	0/4	ND	ND	ND	NA	NA	NA	NA	64.85	0/4
Chloroform	0/4	ND	ND	ND	NA	NA	NA	NA	4.70	0/4
Chloromethane	0/4	ND	ND	ND	NA	NA	NA	NA	155.75	0/4
Cyclohexane	0/4	ND	ND	ND	NA	NA	NA	NA	9432.09	0/4
Dibromochloromethane	0/4	ND	ND	ND	NA	NA	NA	NA	25.54	0/4
Dichlorodifluoromethane	0/4	ND	ND	ND	NA	NA	NA	NA	308.06	0/4
Ethylbenzene	0/4	ND	ND	ND	NA	NA	NA	NA	7416.62	0/4
Isopropylbenzene	0/4	ND	ND	ND	NA	NA	NA	NA	520.80	0/4
Methyl acetate	0/4	ND	ND	ND	NA	NA	NA	NA	91530.83	0/4
Methylcyclohexane	0/4	ND	ND	ND	NA	NA	NA	NA	8715.87	0/4
Methylene chloride	0/4	ND	ND	ND	NA	NA	NA	NA	205.27	0/4
Styrene	0/4	ND	ND	ND	NA	NA	NA	NA	18122.11	0/4
Tetrachloroethylene	0/4	ND	ND	ND	NA	NA	NA	NA	13.09	0/4
Toluene	0/4	ND	ND	ND	NA	NA	NA	NA	2212.57	0/4
Trichloroethylene	0/4	ND	ND	ND	NA	NA	NA	NA	64.68	0/4
Trichlorofluoromethane	0/4	ND	ND	ND	NA	NA	NA	NA	1276.07	0/4
Trichlorotrifluoroethane	0/4	ND	ND	ND	NA	NA	NA	NA	68749.70	0/4
Vinyl chloride	0/4	ND	ND	ND	NA	NA	NA	NA	7.46	0/4
Xylenes (total)	0/4	ND	ND	ND	NA	NA	NA	NA	897.49	0/4
cis-1,2-Dichloroethylene	0/4	ND	ND	ND	NA	NA	NA	NA	146.30	0/4
cis-1,3-Dichloropropylene	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	0/4	ND	ND	ND	NA	NA	NA	NA	234.82	0/4
trans-1,3-Dichloropropylene	0/4	ND	ND	ND	NA	NA	NA	NA	NA	NA
Radionuclides										
Americium-241	0/4	ND	ND	ND	0	0/4	450	No	57.00	0/4
Carbon-14	0/4	ND	ND	ND	0	0/4	NA	NA	12300.00	0/4
Cesium-137	4/4	0.0529	0.187	0.12	1	0/4	14	No	1.12	0/4
Cobalt-60	0/4	ND	ND	ND	0	0/4	7.4	No	0.60	0/4
Europium-152	0/4	ND	ND	ND	0	0/4	9.5	No	0.73	0/4
Europium-154	0/4	ND	ND	ND	0	0/4	11	No	0.85	0/4
Europium-155	1/4	0.0659	0.0659	0.07	0	1/4	710	No	62.90	0/4
Neptunium-237	0/4	ND	ND	ND	0	0/4	NA	NA	2.70	0/4

Table D.5.2. Building 2033 soils PRG screening (continued)

Analyte	Frequency of detections	Minimum detected concentration	Maximum detected concentration	Average detected concentration	Background reference level [a]	Frequency of detections exceeding background	Remediation level	Mean exceeds remedial level?	Industrial soil preliminary remediation goal	Frequency of detects exceeding preliminary remediation goal
Plutonium-238	0/4	ND	ND	ND	0	0/4	NA	NA	166.00	0/4
Plutonium-239	0/4	ND	ND	ND	0	0/4	NA	NA	145.00	0/4
Radium-226 [d]	4/4	0.828	1.05	0.94	1.57	0/4	3	No	0.26	4/4 [c]
Radium-228 [e]	4/4	0.823	1.4	1.11	1.84	0/4	3	No	0.02	4/4 [c]
Technetium-99	0/4	ND	ND	ND	0	0/4	NA	NA	8940.00	0/4
Thorium-228	4/4	0.953	1.37	1.15	1.84	0/4	3	No	0.02	4/4[c]
Thorium-230	4/4	0.663	1.29	0.99	1.27	1/4	NA	NA	211.00	0/4
Thorium-232	4/4	0.724	1.43	1.02	1.45	0/4	3	No	0.02	4/4 [c]
Tritium	0/4	ND	ND	ND	0.16	0/4	NA	NA	42.30	0/4
Uranium-232	0/4	ND	ND	ND	0	0/4	NA	NA	80.00	0/4
Uranium-234	4/4	0.697	1.35	1	1.22	1/4	NA	NA	334.00	0/4
Uranium-235	4/4	0.0423	0.0933	0.07	0.13	0/4	NA	NA	3.94	0/4
Uranium-238	4/4	0.811	1.19	1.08	1.19	0/4	310	No	17.90	0/4

[a] The background data are taken from the Background Soil Characterization Project (BSCP) report (DOE/OR/01-1175, DOE 1993, Tables 7.1e and 7.2e). 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) mentions that the ^{137}Cs background is approximately 1 pCi/g. For this report, a background of 1.0 pCi/g is used for ^{137}Cs. In addition, a background for ^{228}Ra has been assumed based on equilibrium with ^{228}Th. Background values for other man-made radionuclides, including ^{99}Tc, ^{237}Np, ^{238}Pu, and ^{239}Pu, and other radionuclides for which data are not available, are assumed to be zero.

[b] Remediation levels are from the Bethel Valley Interim Record of Decision (IROD).

[c] PRG for this radionuclide is orders of magnitude below background suggesting an ubiquitous source of this constituent that is not specific to Building 2033.

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

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

Preliminary remediation goals are from EPA Region 9 for an industrial soil exposure at a risk level of 1E-05 and a hazard quotient of 1.

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

ND = Not detected.

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

BHC = benzene hexachloride.

DDD = dichlorophenyl-dichloroethane.

DDE = dichlorodiphenyl-dichloroethylene.

DDT = dichlorophenyl-trichloroethane.

MCPA = 2-methyl-4-chlorophenoxyacetic acid.

MCPP = 2-(2-Methyl-4-chlorophenoxy)propionic acid.

PRG = preliminary remediation goal.

PCB = polychlorinated biphenyl.

D.5.1.3 Conclusion

The risk assessment considered exposure to building interiors as well as potential soil exposure while entering or exiting Building 2033. Because no soil COPCs were identified, potential exposures to soils were not evaluated further in this risk assessment. The risk calculation for the building interior, based on the data obtained during the radiological surveys, indicated that risks were approximately 2E-08, which does not exceed the EPA target risk range of E-06 to E-04. The results indicate a low likelihood of adverse health effects associated with Building 2033 industrial/office worker exposure to the building interior surfaces, area soils, or the adjacent parking lot surface. Based on the results of the evaluations presented in this report, Building 2033 is suitable for lease.

D.6. 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.

D.6.1 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 exposure point concentration.

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 assessment based on the assumption that the samples collected are truly random samples. As indicated in the Baseline Conditions Report, some of the data were obtained from biased sampling, aimed at identifying high contaminant concentration locations.

D.6.2 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.

D.6.3 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 HI 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 HQs presented in the risk assessment. This approach is consistent with RAGS (EPA 1989).

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. 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.

D.7. REFERENCES

DOE (U. S. Department of Energy) 1993. *Final Report on the Background Soil Characterization Project at the Oak Ridge Reservation, Oak Ridge, Tennessee, Volume 1 – Results of Field Sampling Program*, DOE/OR/01-1175/V1, Oak Ridge, TN, October.

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EPA 2001. Health Effects Assessment Summary Tables (HEAST), available on the World Wide Web at http://www.epa.gov/radiation/heast/index.html.

EPA 2002a. *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*, EPA 540-R-01-003, Office of Solid Waste and Emergency Response, Washington, D.C., found on the World Wide Web at http://www.epa.gov/superfund/programs/risk/background.pdf.

National Council on Radiation Protection and Measurements 1987. *Ionizing Radiation Exposure of the Population of the United States*.

ATTACHMENT D.1

This attachment presents the details of the risk assessment for Building 2033, including the conversion of building surface swipe data to concentration data for evaluation of risk, the soil data screening for identification of constituents of potential concern (COPCs), and the calculation of related risks and hazards.

Surface Swipe Isotopic Conversion

Building surface swipe data were reported in units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2), and must be converted to units of picocuries per gram (pCi/g) for use in the exposure equations presented below. The conversion is based on an assumed isotopic ratio for radionuclides, which is derived from process knowledge. In this case, Building 2033 discharged waste streams to the Gunite and Associated Tanks (GAAT); therefore, radiological characterization of the GAAT material is the basis for the isotopic ratios used in the conversion (see Table D.Att.1). The total activity reported in the swipes (either total alpha or total beta) is then multiplied by the appropriate isotopic fraction to provide the activity for each radionuclide. Results for each radionuclide are then converted in to units of pCi/g as described below.

Table D.Att.1. Isotopic activity ratios

Isotope	Fraction of total alpha	Fraction of total beta
Am-241	2.28E-01	--
C-14	--	3.17E-04
Cf-252	4.64E-05	--
Cm-244	4.35E-01	--
Co-60	--	2.43E-04
Cs-134	--	8.19E-05
Cs-137	--	2.61E-01
Eu-152	--	5.89E-04
Eu-154	--	3.25E-04
Eu-155	--	2.02E-04
H-3	--	4.69E-06
I-129	--	2.01E-08
Np-237	7.02E-04	--
Pu-238	1.08E-01	--
Pu-239	1.50E-01	--
Pu-240	1.58E-02	--
Pu-241	--	9.72E-04
Pu-242	5.15E-05	--
Pu-244	5.85E-09	--
Sr-90	--	3.68E-01
Tc-99	--	2.48E-04
Th-232	1.70E-03	--
U-233	2.49E-02	--
U-234	1.65E-02	--
U-235	7.69E-04	--
U-236	3.39E-05	--
U-238	1.76E-02	--

The equation below is used to convert the swipe data to mass units of pCi/g:

$$\text{Converted Result (pCi/g)} = \text{Total Activity Result (dpm/100 cm}^2) \times \text{Isotopic Fraction} \times \text{cf (pCi/dpm)} / \text{p (g/cm}^3) \times \text{d (cm)} \times 100\ (\text{cm}^2/100\ \text{cm}^2)$$

The calculation is based on an assumed a material density (p) of 1.5 g/cc, a material depth (d) of 0.1 cm, and a conversion factor (cf) of 2.22 pCi/dpm. The isotopic concentrations are then used in the risk assessment process to generate estimates of risk and hazard, as described in the following sections.

Soil COPCs

The available soil data (see Chap. D.3) were screened against U. S. Environmental Protection Agency (EPA) Region 9 industrial soil preliminary remediation goals (PRGs) to identify constituents with maximum detected concentrations above their respective PRGs. Those that exceed PRGs are considered to have the potential for adverse health effects and are carried through the risk assessment process as COPCs. The results of the screening process indicate that no COPCs were identified for Building 2033 soils. Although no COPCs were identified for further evaluation based on the screening, exposure equations are presented in the following section for completeness.

Risk Assessment Methods

The following sections present the equations and methods used to calculate risk and hazard estimates for the industrial worker exposure scenario under evaluation. Included in the methods section are equations used to determine exposure point concentrations (EPCs), calculate intake of constituents, and calculate risks and hazards.

Potential industrial worker exposures associated with the Building 2033 building surfaces and soils within the land parcel include ingestion, inhalation, dermal contact, and external exposure. Exposure equations for each of these pathways are presented below.

Ingestion pathway

Intakes for incidental ingestion of chemicals in soil were estimated as follows:

$$Chemial\ \ Intake(mg/kg-day) = \frac{C_s \times IR_s \times EF \times ED \times FI}{BW \times AT},$$

where

C_s = chemical concentration in soil (mg/kg),
IR_s = ingestion rate of soil (kg/day),
EF = exposure frequency (days/year),
ED = exposure duration (years),
FI = fraction ingested from contaminated area (unitless),
BW = body weight (kg),
AT = averaging time (days) for carcinogens or noncarcinogens.

For ingestion of radioactive material from building interiors the following equation was used:

$$\text{Radiological intake (pCi)} = C \times IR \times EF \times ED \times CF,$$

where

C = radionuclide concentration from survey data and isotopic conversion (pCi/g),
IR = ingestion rate of material (kg/day),
EF = exposure frequency (days/year),
ED = exposure duration (years),
CF = conversion factor of 0.001 (g/mg).

Inhalation of volatiles/particulates from soil pathway

Intakes for inhalation of chemicals in soil were calculated as follows:

$$Chemical \quad Intake\,(mg/kg-day) = \frac{C_s \times IR_a \times ET \times EF \times ED \times (VF^{-1} + PEF^{-1})}{BW \times AT},$$

where

C_s = chemical concentration in soil (mg/kg),
IR_a = inhalation rate (m^3/hr),
ET = exposure time (hr/day)
EF = exposure frequency (days/year),
ED = exposure duration (years),
VF = chemical-specific volatilization factor (m^3/kg; see Table 6-5),
PEF = particulate emission factor (m^3/kg),
BW = body weight (kg),
AT = averaging time (days) for carcinogens or noncarcinogens.

For inhalation of radioactive material from building interiors the following equation was used:

$$\text{Radiological intake (pCi)} = C \times IR \times EF \times ED \times CF$$

where

C = radionuclide concentration from survey data and isotopic conversion (pCi/g),
IR_a = inhalation rate (m^3/hr),
EF = exposure frequency (days/year),
ED = exposure duration (years),
CF = conversion factor of 1000 (g/kg).

The particulate emission factor (PEF) value used for all receptors is the default value for Atlanta, Georgia, assuming a 0.5-acre source area (PEF = 5.38E+09 m^3/kg). This PEF value was calculated using the EPA *Soil Screening Guidance: User's Guide* (EPA 1996) found on-line at http://risk.lsd.ornl.gov/epa/ssl1.shtml. Note that the chemical-specific volatilization factor (VF) for soil is only applicable for soil COPCs that are volatile organic compounds (VOCs).

Dermal contact with soil pathway

The dermal absorbed doses (DADs) from chemicals in soil were calculated as follows (EPA 2004a):

$$DAD\ (mg / kg - d) = \frac{DA_{event} \times EV \times EF \times ED \times SA}{BW \times AT}$$

where

DAD = dermal absorbed dose (mg/kg-day),
DA_{event} = absorbed dose per event in soil (mg/cm^2-event),
EV = event frequency (1 event/day),
EF = exposure frequency (days/year),
ED = exposure duration (years),
SA = surface area of skin exposed (cm^2),
BW = body weight (kg),
AT = averaging time (days) for carcinogens or noncarcinogens.

DA_{event} (mg/cm^2-event) was calculated as follows for soil COPCs:

$$DA_{event} = C_s \times CF \times AF \times ABS,$$

where

C_s = chemical concentration in soil (mg/kg),
CF = conversion factor (10^{-6} kg/mg),
AF = soil to skin adherence factor (mg/cm^2-event),
ABS = chemical-specific dermal absorption factor (unitless; see Table 6-5).

Note that per EPA's *Risk Assessment Guidance for Superfund* (RAGS) Part E (EPA 2004a), only certain chemicals have a value for the dermal absorption factor; therefore, the dermal contact with soil pathway is quantified only for these specific COPCs with a value for the dermal absorption factor.

Exposure Point Concentrations

The EPC represents the chemical concentration a receptor is likely to come in contact with over the duration of exposure. Exposure concentrations from direct contact with environmental media (e.g., groundwater and soil) are based on the sampling results of the media, as described below.

Exposure from direct contact pathways represents exposure to media at the source, and the EPC is based on data collected at the source. Current measured concentrations of chemicals were used to represent future concentrations in the media of interest.

When sample sizes are adequate (at least 10 results are available for analysis), the EPCs developed for each COPC represent a 95% upper control limit (UCL_{95}) of the mean or the maximum detected concentration (MDC) for all locations within each site whichever is smaller. When the sample size is less than 10, the distribution of the data is difficult to determine and, therefore, the MDC is used as the EPC.

EPCs are calculated using EPA guidance, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (EPA 2002b). The data were tested using the Shapiro-Wilk test to

determine distribution, normal or lognormal, of the concentrations. For chemicals with at least 10 results, the UCL_{95} of the mean was calculated using the normal distribution equation (see equation below) when the concentrations were normally distributed, when concentrations were not judged to be normally or lognormally distributed, or when the frequency of detection was less than 50%. For these situations, the UCL_{95} of the mean was calculated using the following equation:

$$UCL_{95}(\text{normal}) = \overline{x}_n + \frac{(t)(s_x)}{\sqrt{n}},$$

where

$\overline{x}_n$ = mean of the untransformed data,
t = student-t statistic,
s_x = standard deviation of the untransformed data,
n = number of sample results available.

For lognormally distributed concentrations and sample size of at least 10, the UCL_{95} of the mean is calculated using the following equation:

$$UCL_{95}(\text{lognormal}) = e\left[\overline{x}_1 + 0.5(s_1^2) + \frac{(s_1)(H)}{\sqrt{n-1}}\right],$$

where

e = constant (base of the natural log, equal to 2.718),
$\overline{x}_l$ = mean of the log-transformed data [$x_l = \log(x)$],
s_l = standard deviation of the log-transformed data,
H = H-statistic,
n = number of sample results available.

The EPCs are used as the representative concentrations for the various media evaluated in the intake and DAD equations (see Sect. D.6.2.2).

Intake Results

No COPCs were identified in building soils; therefore, no intakes were calculated.

TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to evaluate the potential for COPCs to cause adverse health effects in exposed individuals. Where possible, it provides an estimate of the relationship between the intake or dose of a COPC and the likelihood or severity of adverse health effects as a result of that exposure. Toxic effects have been evaluated extensively by EPA. This section provides the results of the EPA evaluation of the chemicals identified as COPCs.

Toxicity Information and EPA Guidance for Noncarcinogens

Noncarcinogenic effects are evaluated by comparing an exposure or intake/dose with a reference dose (RfD) or reference concentration (RfC). The RfDs and RfCs are determined using available dose-response data for individual chemicals. Scientists determine the exposure concentration or intake/dose below, which

no adverse effects are seen and add a safety factor (from 10 to 1,000) to determine the RfD or RfC. RfDs and RfCs are identified by scientific committees supported by EPA.

Chronic RfDs are developed for protection from long-term exposure to a chemical (from 7 years to a lifetime); subchronic RfDs are used to evaluate short-term exposure (from 2 weeks to 7 years) [EPA 1989]. The potential receptors evaluated in this human health risk assessment (HHRA) are conservatively evaluated by using only chronic RfDs [chronic RfDs generally result in hazard quotients (HQs) that are at least as large as (sometimes larger than) HQs calculated from subchronic RfDs].

Toxic effects are diverse and measured in various target body organs (e.g., they range from eye irritation to kidney or liver damage). EPA is currently reviewing methods for accounting for the difference in severity of effects; however, existing RfDs do not address this issue.

Toxicity Information and EPA Guidance for Carcinogens

For carcinogens, risks are estimated as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as excess or incremental cancer risk, which is cancer occurrence in addition to normally expected rates of cancer development. Excess cancer risk is estimated using a cancer slope factor (CSF). The CSF is defined as a plausible upper-bound estimate of the probability of a response (i.e., cancer) per unit intake/dose of a chemical over a lifetime (EPA 1989).

Estimated Toxicity Values for Dermal Exposure

Oral and inhalation RfDs and CSFs are currently available; however, dermal values are not. Dermal RfDs and CSFs were estimated from oral toxicity values using chemical-specific gastrointestinal absorption factors (GAFs) to calculate total absorbed dose. This conversion is necessary because most oral RfDs and CSFs are expressed as the amount of chemical administered per time and body weight; however, dermal exposure is expressed as an absorbed dose. Dermal toxicity factors are calculated from oral toxicity factors as shown below (EPA 2004a):

$$RfD_{dermal} = RfD_{oral} \times GAF$$

$$CSF_{dermal} = CSF_{oral}/GAF$$

Chemical-specific GAF values available from EPA's *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final* (EPA 2004a) are used whenever possible. Not all COPCs have specific GAF values. When quantitative data are insufficient, a default GAF is used. A default value of 1.0 for organic and inorganic chemicals is used (EPA 2004a). Per EPA guidance (EPA 2004a), dermal CSFs and RfDs are estimated from the oral toxicity values using chemical-specific GAFs to calculate the total absorbed dose only for chemicals with GAF values < 0.5 (i.e., for chemicals with GAF values between 0.5 and 1, oral toxicity values are used to evaluate the dermal pathway).

Assumptions Used in the Toxicity Assessment

Many, mostly conservative, assumptions are made in the process of defining toxicity factors, ranging from the use of linear low-dose extrapolation to the use of RfD uncertainty factors. These uncertainties are well documented by the science advisory boards that recommend the final toxicity values.

Chemicals without EPA Toxicity Values

No EPA-approved RfDs or CSFs are available for some detected chemicals evaluated in this HHRA because the noncarcinogenic and/or carcinogenic effects of these chemicals have not yet been determined. Although these chemicals may contribute to health effects from exposure to contaminated media at these exposure units (EUs), their effects cannot be quantified at the present time unless a provisional or surrogate toxicity value is used.

RISK CHARACTERIZATION

The purpose of the risk characterization is to evaluate the information obtained through the exposure and toxicity assessments to estimate potential risks and hazards. Potential carcinogenic effects are characterized by using projected intakes and chemical-specific dose-response data (i.e., CSFs) to estimate the probability that an individual will develop cancer over a lifetime. Potential noncarcinogenic effects are characterized by comparing projected intakes/doses of COPCs to toxicity values (i.e., RfDs). The numerical risk and hazard estimates presented in this Section must be interpreted in the context of the uncertainties and assumptions associated with the risk assessment process and with the data upon which the risk estimates are based (see Chap. D.6).

Risk Characterization Methodology

Risk characterization integrates the findings of the exposure and toxicity assessments to estimate the potential for receptors to experience adverse effects as a result of exposure to contaminated media evaluated in this HHRA.

Risk characterization for carcinogens

For carcinogens, risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as the Incremental Lifetime Cancer Risk (ILCR), or the increased chance of cancer above the normal background rate of cancer. In the United States, the background chance of contracting cancer is approximately 3 in 10, or 3×10^{-1} (American Cancer Society 2006). The calculated ILCRs are compared to the range specified in the National Oil and Hazardous Substances Pollution Contingency Plan of 10^{-6} to 10^{-4}, or 1 in 1 million to 1 in 10,000 exposed persons developing cancer (EPA 1990). Typically, ILCRs below 10^{-6} are considered acceptable and ILCRs above 10^{-4} are considered unacceptable. The range between 10^{-6} and 10^{-4} is an area of concern, and any decisions to address ILCRs further in this range, either through additional study or engineered control measures, should account for the uncertainty in the risk estimates.

The ILCR is calculated as follows (EPA 1989):

$$ILCR = I \times CSF$$

where

I = chronic daily intake or DAD calculated in the exposure assessment for a specific chemical and pathway (mg/kg-day),
CSF = cancer slope factor for a specific chemical and pathway $(mg/kg\text{-}day)^{-1}$.

For a given exposure pathway (e.g., ingestion of soil), the total risk to a receptor exposed to several carcinogenic COPCs is the sum of the ILCRs for each carcinogen for a specific exposure pathway as shown below:

$$ILCR_{total} = \sum_{i} ILCR_i$$

where

$ILCR_{total}$ = total probability of cancer incidence associated with all carcinogenic COPCs for a specific exposure pathway,
$ILCR_i$ = ILCR for the ith COPC.

Risk characterization for noncarcinogens

In addition to developing cancer from exposure to contaminants, an individual may experience other toxic effects. The term "toxic effects" is used here to describe a wide variety of systemic effects ranging from minor irritations, such as eye irritation and headaches, to more substantial effects such as kidney or liver disease and neurological damage. The risks associated with toxic (i.e., noncarcinogenic) chemicals are evaluated by comparing an estimated exposure (i.e., intake or dose) from site media to an acceptable exposure expressed as an RfD. The RfD is the threshold level below which no toxic effects are expected to occur in a population, including sensitive subpopulations. The ratio of intake over the RfD is the HQ (EPA 1989) and is calculated as:

$$HQ = I/RfD$$

where

I = daily intake of a COPC for a specific chemical and exposure pathway (mg/kg-day),
RfD = reference dose for a specific chemical and exposure pathway (mg/kg-day).

The HQs for each COPC are summed to obtain a hazard index (HI) for a specific exposure pathway as shown below:

$$HI = \sum_{i} HQ_i$$

where

HI = hazard index for all toxic effects,
HQ_i = hazard quotient for the ith COPC.

An HI greater than 1 has been defined as the level of concern for potential adverse noncarcinogenic health effects (EPA 1989). This approach differs from the probabilistic approach used to evaluate carcinogens. A HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates only that the estimated intake is 100 times less than the threshold level at which adverse health effects may occur.

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