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ATTACHMENT C

Risk Screen to Support the Title Transfer of the K-1330 Building at the East Tennessee Technology Park, Oak Ridge, Tennessee

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Risk Screen to Support the Title Transfer of the K-1330 Building at the East Tennessee Technology Park, Oak Ridge, Tennessee

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BECHTEL JACOBS COMPANY LLC
managing the
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ACRONYMS

BJC	Bechtel Jacobs Company LLC
COPC	contaminant of potential concern
CROET	Community Reuse Organization of East Tennessee
DOE	U. S. Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
EBS	Environmental Baseline Survey
EPA	U. S. Environmental Protection Agency
ESU	exterior survey unit
ETTP	East Tennessee Technology Park
EU	exposure unit
ISU	interior survey unit
mrem/h	millirem per hour
mrem/year	millirem per year
NRC	Nuclear Regulatory Commission
ORGDP	Oak Ridge Gaseous Diffusion Plant
pCi/g	picocuries per gram
PRG	preliminary remediation goal
RAGS	*Risk Assessment Guidance for Superfund*
ROD	Record of Decision
SAIC	Science Applications International Corporation
UCL95	95% upper confidence limit
VOC	volatile organic compound

EXECUTIVE SUMMARY

The goal of this risk evaluation is to determine the potential for adverse health effects associated with Bldg. K-1330 and determine if conditions preclude the use of the facility for its intended purpose, i.e., as an office building for the private sector. The U. S. Department of Energy (DOE) is proposing to transfer title of this building to the Community Reuse Organization of East Tennessee (CROET). The K-1330 building has been used for office space since its construction in 1990. Building K-1330 has two floors with 7200 ft^2 on each of the two floors for a total of 14,400 ft^2. The building exterior is red clay brick, the interior is cinderblock with drywall covering it, and the facility primarily is carpeted.

The Bldg. K-1330 area was farmland prior to the construction of the Oak Ridge Gaseous Diffusion Plant (ORGDP), later known as the K-25 Site and now known as the East Tennessee Technology Park (ETTP), in the early 1940s. During the construction of ORGDP, the area was an undeveloped field and remained as such until Bldg. K-1330 was constructed, in 1990, for the Environmental Restoration offices. Environmental Restoration moved from the building in the 1990s, and since then it since has been occupied by other organizations, such as Human Resources and Public Relations. DOE is proposing to transfer title of this facility to CROET.

Sub-slab soil vapor was collected in January 2004 to determine if a potential source for volatile organic compounds (VOCs) exists under the building. The results were validated, and the average concentration for each VOC was calculated and compared to its respective trigger level. No VOC exceeded its trigger level. In addition, to ensure that VOCs did not cumulatively exceed trigger levels, the average concentration for each VOC was divided by its respective trigger level to determine what fraction the concentration represented. The resulting fractions were then added for all VOCs that had at least one detection. Collectively, the VOC concentrations did not exceed trigger levels. The results and comparisons show the vapor intrusion pathway is not complete beneath K-1330, and, therefore, it is not evaluated in this risk assessment.

For Bldg. K-1330, the representative exposure scenarios considered for the risk evaluation were for the industrial worker and the roving worker. The industrial worker scenario, defined by an individual who spends time doing light industrial activities or office work within the building, is intended to represent exposure to contaminants on interior building surfaces. The roving worker spends break times during the workday outside the building roaming accessible areas of the industrial park. The exposure scenario for this worker is intended to represent exposure to contaminants in soils in the area surrounding the building.

The risk calculations for Bldg. K-1330 were based on the most recent radiological survey data. For the surveys, the study area was divided into interior survey units (ISUs), furnishings survey units (FSUs), exterior survey units (ESUs), and a ground survey unit (GSU). For this risk assessment, it was assumed that furnishings remain in place and, thus, each ISU was assumed to include any furnishings. Because it was assumed that the worker would not engage in significant renovation of the building or spend significant amounts of time around the exterior of the building, exposures due to ESUs and the GSU were not quantitatively evaluated.

Building K-1330 risks were calculated for the industrial worker scenario assuming exposure by the inhalation, ingestion, and external exposure pathways. The potential radiological risks and doses from exposure to interior survey units (ISUs) in Bldg. K-1330 were calculated. A number of areas had risks of $\sim 9 \times 10^{-8}$, including ISUs 4, 6, 7, 8, 14, and 16. The highest single unit risk estimate was 8.9×10^{-8} for ISU 8. The conservative assumption that 10% of fixed contamination becomes removable resulted in the majority of the risk, accounting for twice the risk of the removable contamination.

The risk estimate is a value that represents the number of excess cancer incidences that might be expected due to the exposure scenario evaluated. The U. S. Environmental Protection Agency (EPA) has established a target risk range of 10^{-4} to 10^{-6}. The estimated risk of 9×10^{-8} for ISU 8 in Bldg. K-1330 is orders of magnitude below the EPA target range, indicating a low likelihood of adverse health effects due to the exposure scenarios considered.

The Bldg. K-1330 calculated doses indicated a maximum of ~ 0.006 millirem per year (mrem/year) due to ingestion and inhalation of removable and fixed contamination in ISU 8. The calculated average dose for the interior of Bldg. K-1330 was ~ 0.005 mrem/year.

The risks associated with an industrial worker at Bldg. K-1330 can be summarized as follows:

- the maximum risk associated with an individual survey unit was ~ 9×10^{-8} for ISU 8, located on the first floor in the southwest corner;
- the maximum calculated dose was ~ 0.006 mrem/year for ISU 8, located on the first floor in the southwest corner;
- the 95% upper confidence limit of the mean of the dose rate data was calculated to be ~ 0.003 mrem/h, and the maximum dose rate was 0.005 mrem/year, both of which are below the site background level of 0.007 mrem/h;
- the average risk associated with the interior of Bldg. K-1330 was ~ 7×10^{-8}, assuming a receptor is equally exposed to all interior areas; and
- the average calculated dose associated with the interior of Bldg. K-1330 was ~ 0.005 mrem/year for the building interior as a whole.

An additional scenario, known as the "rover" scenario was evaluated. It assumes that the industrial worker spends 2 h/d moving around accessible areas of ETTP outside the fence before the site has been fully remediated. The roving worker risk assessment considered quantitatively 39 surface soil contaminants of potential concern (10 metals, 18 organics, and 11 radionuclides) for the accessible areas of ETTP. The risk to the roving worker was 8×10^{-6}, which is within the EPA acceptable range of 10^{-4} to 10^{-6}. The risk was mainly due to external exposure to ionizing radiation, as well as both ingestion and dermal contact with polycyclic aromatic hydrocarbons. The calculated hazard for the roving worker was 0.2, which is below the EPA acceptable level. For additional information, see Appendix A.

The risk evaluation for Bldg. K-1330 indicates that all risks and doses are considered to be within acceptable levels below EPA's target risk range (10^{-4} to 10^{-6}) and below a hazard index of 1.0, which correlates with a low likelihood of adverse health effects to an industrial worker. Therefore, the facility is considered acceptable for transfer for its intended use as an office building by the private sector.

1. INTRODUCTION

The goal of this risk screen is to determine the potential for adverse health effects associated with Bldg. K-1330, located in the southeastern portion of the East Tennessee Technology Park (ETTP). The U. S. Department of Energy (DOE) is proposing to transfer this facility to the Community Reuse Organization of East Tennessee (CROET) for its intended use by the private sector (e.g., use as an office building). DOE will use this evaluation and information in other documents to decide whether to proceed with the title transfer.

Specifically, the objectives of this evaluation are (1) to determine exposure to radiological constituents based on available data, and (2) to use these data to provide a screening-level estimate of the potential for adverse effects to human health. The risk screen approach used in this evaluation is based on the document *Risk Assessment Guidance for Superfund* (RAGS) [U. S. Environmental Protection Agency (EPA) 1989]. The following sections describe the process used to provide a quantitative analysis of the risks to human health from working in the facility. The risk screen prepared for Bldg. K-1330 also includes a "rover" scenario to address an occupant who might potentially be exposed to contaminated soils as he or she moves around the accessible areas of ETTP prior to completion of site cleanup.

2. DESCRIPTION AND HISTORY

The K-1330 area is located in the southeast portion of ETTP outside the control fence of the plant (see Fig. 2.1). The K-1330 building has been used for office space for different groups and has two floors (7200 ft^2 on each of the two floors for a total of 14,400 ft^2). The building exterior is red clay brick, the interior is cinderblock with drywall covering it, and the facility primarily is carpeted. In addition to the land under the building, small areas immediately adjacent on the west–northwest corner and east–southeast corner of the building and extending around the dedicated support equipment are included for transfer.

The area where Bldg. K-1330 is located was farmland prior to the construction of the Oak Ridge Gaseous Diffusion Plant (ORGDP), later known as the K-25 Site and now designated as ETTP, in the early 1940s. During the construction of ORGDP, the area was an undeveloped field and remained as such until Bldg. K-1330 was constructed, in 1990, for the Environmental Restoration Offices. Environmental Restoration moved from the building in the 1990s, and it since has been occupied by other organizations of DOE's prime contractor. The building has always been outside the control fence of the plant.

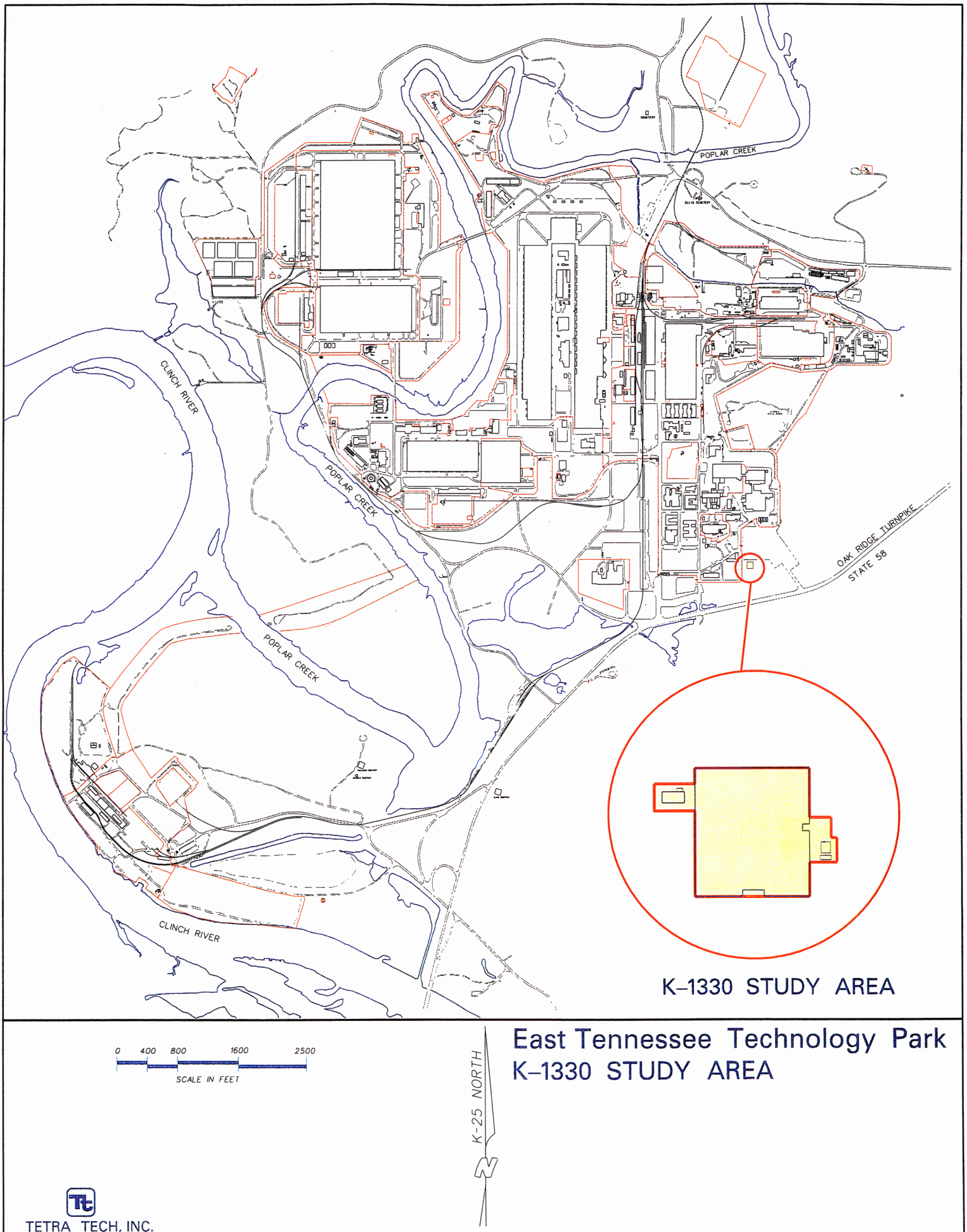

Fig. 2.1. Location of K-1330 within the East Tennessee Technology Park.

3. RADIOLOGICAL SURVEYS AND OTHER DATA

A total of 56 radiological surveys have been performed on Bldg. K-1330. Historical surveys consist of two equipment surveys that were conducted in October and December 1997 of pneumatic piston vibrators and a pallet of material. No elevated activity above background levels was detected for the direct and removable contamination readings.

In 2002, 54 radiological surveys were conducted in the interior of Bldg. K-1330. Scanned areas on the interior included the walls, floors, ceilings, work areas, and furnishings. Scanned areas on the exterior included walls, roofs, sidewalks, and exterior equipment shelves. Statistical evaluation of the most recent surveys indicated that the K-1330 study area had no areas of elevated residual radioactivity present above DOE surface contamination limits [*Environmental Baseline Survey Report for Title Transfer for K-1330 Building at the East Tennessee Technology Park, Oak Ridge, Tennessee*; Bechtel Jacobs Company LLC (BJC) 2004] and within acceptable dose-equivalent rate range for building interiors and, therefore, can be released without radiological restrictions. Note that none of the surveys included sampling of the underlying fee. Furthermore, there have been no sampling events inside the building to evaluate potential chemical contamination. The Environmental Baseline Survey (EBS) report (BJC 2004) concluded that there were no asbestos-containing materials in the building, based on a 1995 survey, and that it is improbable that the building contains lead-based paint due to the fact that the building was constructed in 1990.

Based on discussions with EPA, it has been agreed that the need to collect soil samples to support title transfer activities will be determined on a case-by-case basis. Factors such as a facility's past operational history and geographic location are considered. In addition, the history and knowledge of activities at adjacent properties are evaluated. As discussed in Sect. 6.2 of the EBS, historic and more recent document reviews of the K-1330 property and adjacent areas show no indication that the area has been contaminated from past activities; therefore, no soil sampling was conducted. There have been no chemical sampling events in the interior of the building, but given the use of the facility as an office building since its construction, no sampling was deemed necessary.

Information on the hydrogeologic environment (including contaminant plume shown in Fig. 3.1) was provided in Sect. 4.3 of the EBS to present the potential for vapor intrusion in this area. Sub-slab soil vapor was collected on January 15, 2004, to determine if a potential source for VOCs exists under the K-1330 building. The results were validated, and the average concentration for each VOC was calculated and compared to its respective soil vapor trigger level (see Appendix C of the EBS for K-1330 for a listing of the trigger levels). Based on the results of this winter sampling, no VOC exceeded its respective trigger level (see Sect. 6.2.1, Table 6.1 of the EBS for K-1330). In addition, to ensure that the VOCs did not cumulatively exceed trigger levels, the average concentration for each VOC was divided by its respective trigger level to determine what fraction the concentration represented. The resulting fractions were then added for all VOCs that had at least one detection. Collectively, the VOC concentrations did not exceed the trigger levels.

Based on the winter sampling event, the vapor intrusion pathway is not complete, and, therefore, it is not evaluated in this risk assessment. A summer 2004 sub-slab soil vapor sampling event has been completed, and the results will be posted on the World Wide Web.

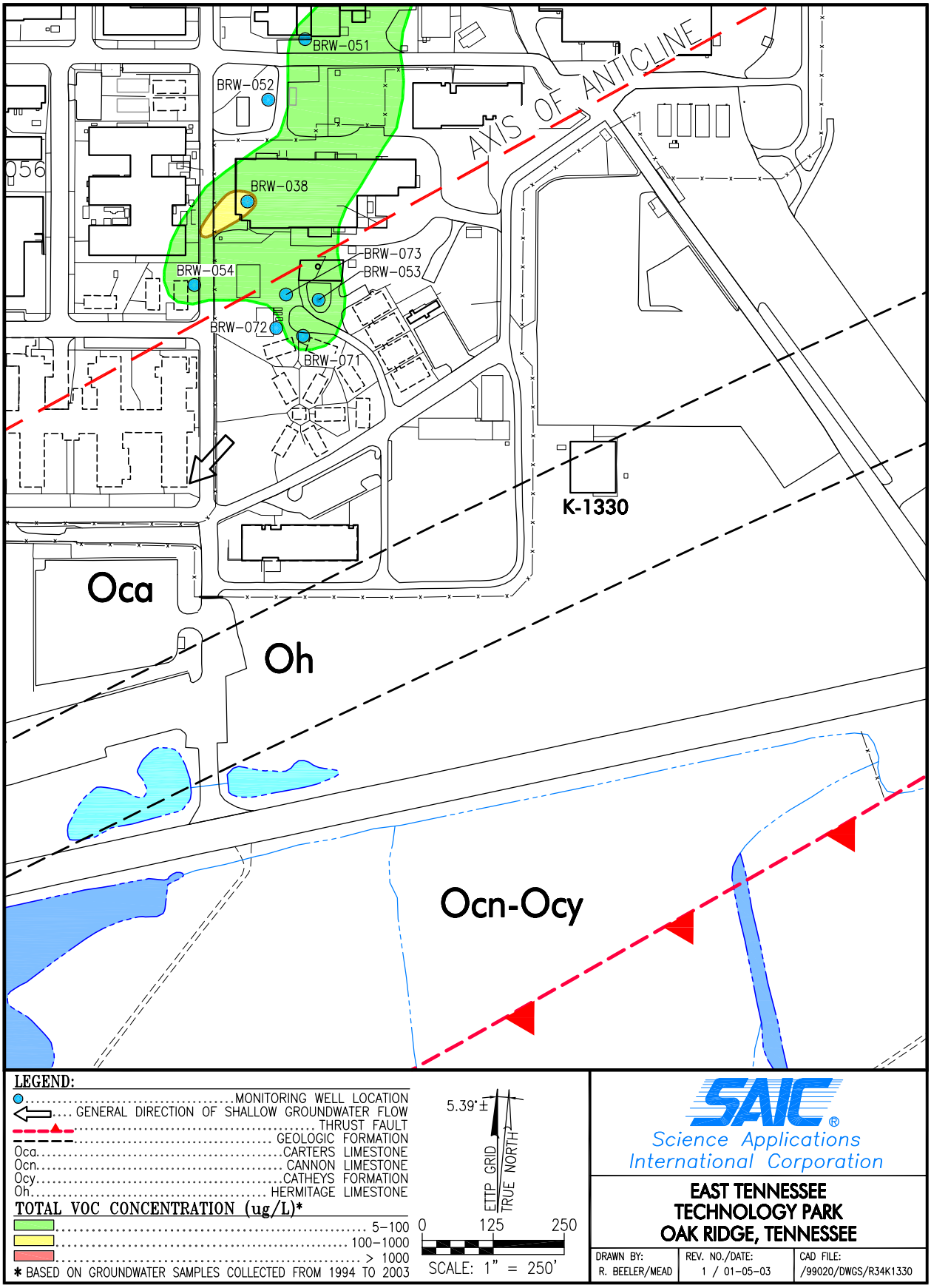

Fig. 3.1. Groundwater VOC concentrations in the vicinity of K-1330.

4. DATA DISCUSSION

The risk calculations for Bldg. K-1330 were based on the most recent radiological survey data as presented in the EBS report (BJC 2004). The facility was divided into interior survey units (ISUs), furnishings survey units, exterior survey units (ESUs), and a ground survey unit (GSU). For the risk assessment, it was assumed that the furnishings would remain in place. Therefore, each ISU was assumed to include any current furnishings. Within each survey unit, samples were taken to identify both removable contamination (smear activity data) and fixed contamination (total activity data). The risk assessment was based on data that were aggregated by sampling method (smear or total) and by survey unit. Table 4.1 provides a description of each of the 17 ISUs, and Figs. 4.1 and 4.2 show the survey units on a building map.

Data for each aggregate were summarized and statistical indicators were computed. The exposure concentration used in the risk calculation was either the computed 95% upper control limit (UCL95) of the mean or the maximum detection, whichever was smaller. Only detected values were considered in the calculation of the exposure concentration. In the case of ISUs where qualifiers were not available, it was assumed that values of zero, or negative values, were non-detects and all other values were detects.

In addition to the removable and fixed contamination sampling, measurements were made to determine external dose rates for the building interior. The dose rate data were used to estimate the dose to a hypothetical exposed individual.

Table 4.1. Interior survey unit descriptions

ISU Number	Description
ISU 1	1st floor, northeast corner
ISU 2	1st floor, southeast corner
ISU 3	1st floor, east open office space
ISU 4	1st floor, restrooms
ISU 5	Stairwell from 1st to 2nd floor
ISU 6	1st floor, corridor from south entrance to northern office area
ISU 7	1st floor, maintenance/mechanical/elevator rooms
ISU 8	1st floor, southwest corner
ISU 9	1st floor, northwest corner
ISU 10	2nd floor, northeast corner
ISU 11	2nd floor, southeast corner
ISU 12	2nd floor, east open office space and conference room
ISU 13	2nd floor, maintenance/storage/copier/elevator rooms
ISU 14	2nd floor, restrooms
ISU 15	2nd floor, corridor from south to main entrance
ISU 16	2nd floor, southwest corner
ISU 17	2nd floor, northwest corner

For this risk screen, it was necessary to convert the general survey measurements of beta/gamma activity [in units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2)] into isotopic concentrations [in units of picocuries per gram (pCi/g)].

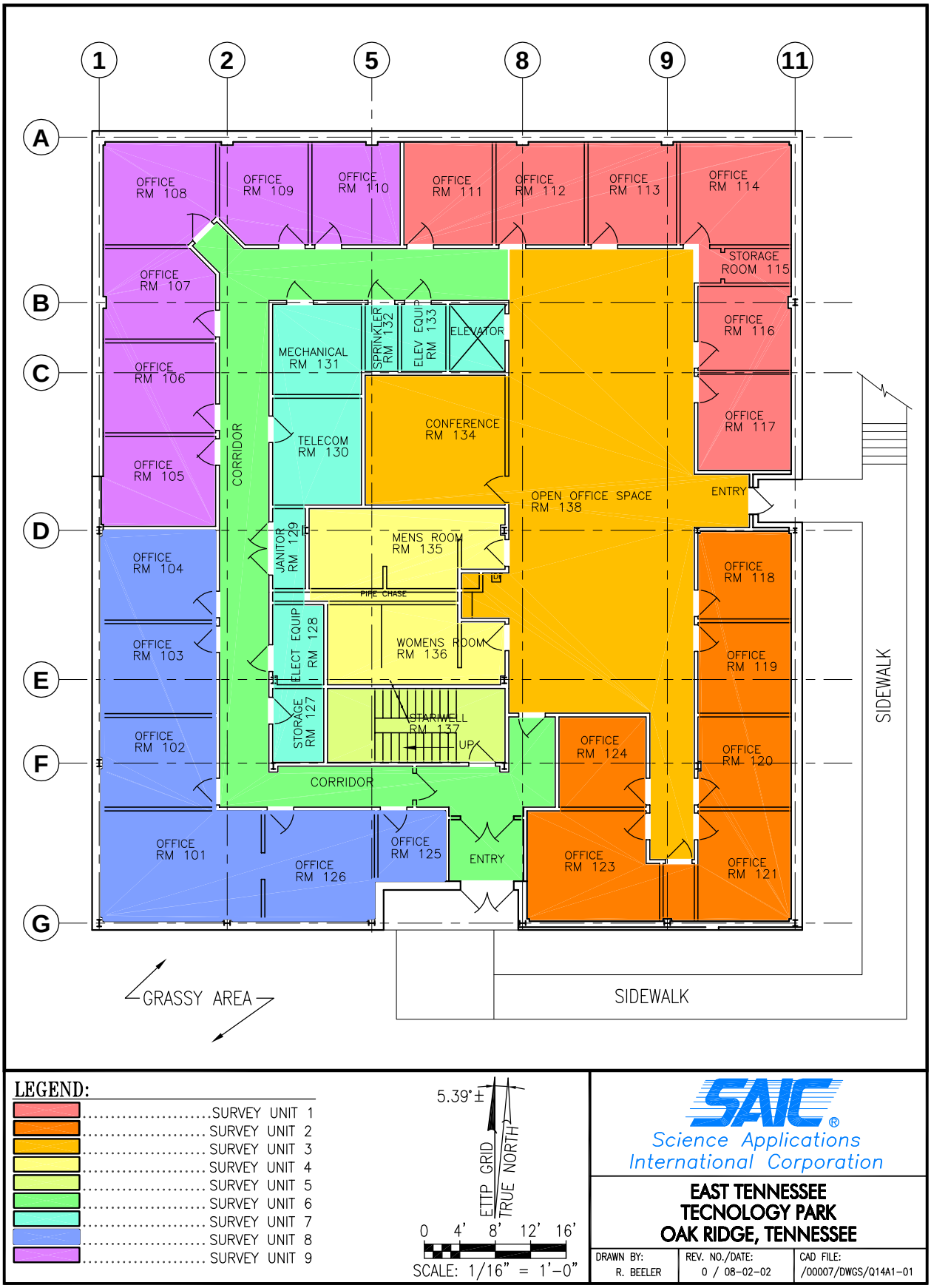

Fig. 4.1. First floor survey units.

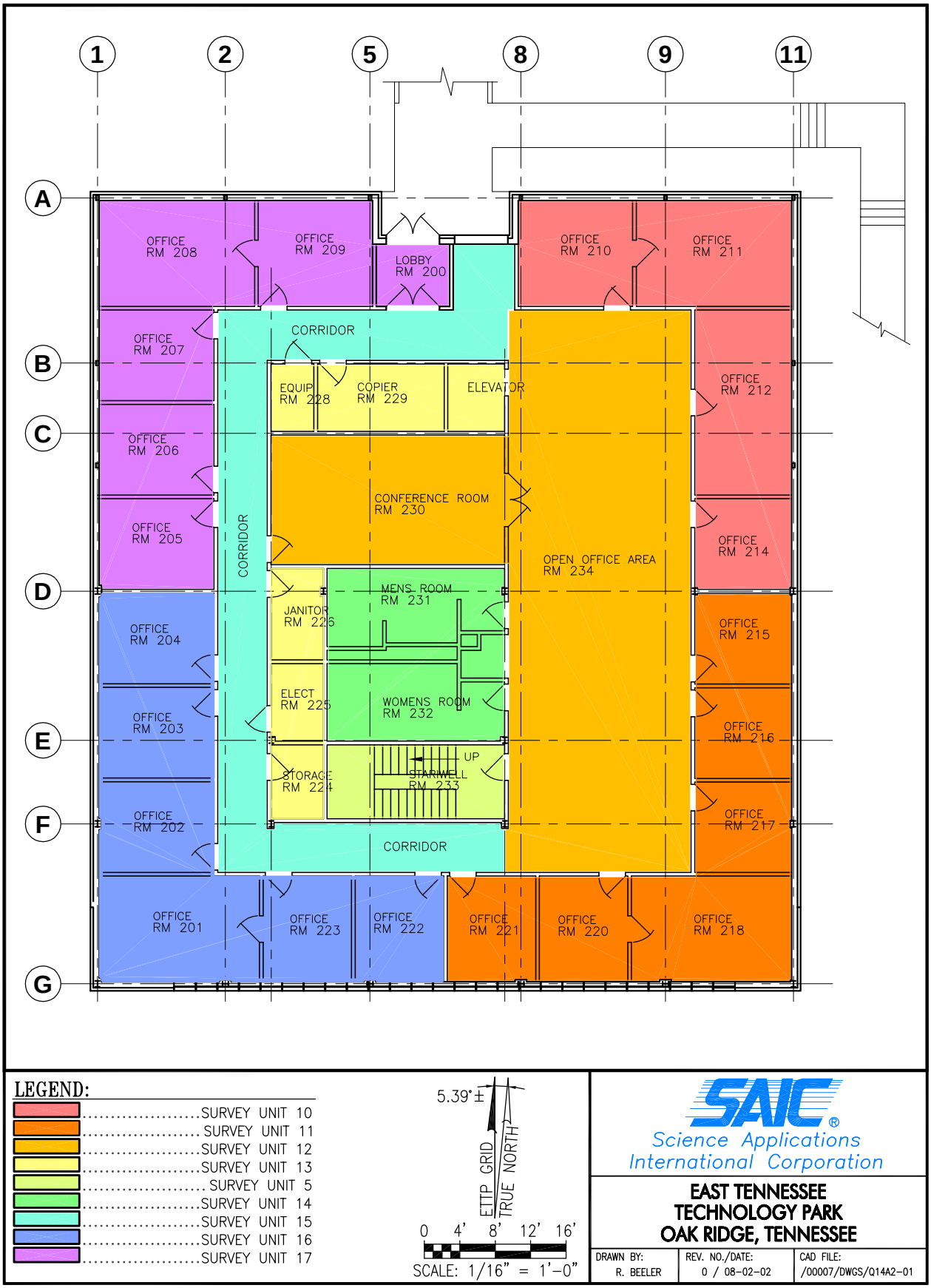

Fig. 4.2. K-1330 Second floor survey units.

Table 4.2. Isotopic activity ratios

Isotope	Ratio to[a] total beta activity
Am-241	5.70E-04
Np-237+D	2.20E-03
Pu-238	2.10E-04
Pu-239	1.70E-03
Tc-99	6.60E-01
Th-228+D	2.00E-03
Th-230	6.20E-03
Th-232	1.90E-03
U-234	2.70E-01
U-235+D	2.60E-02
U-238+D	1.60E-01

[a]Values reported in Rucker 1998.

Interior Survey Results

Survey results show that all total activities were less than 118 dpm/100 cm^2 total alpha and 1012 dpm/100 cm^2 total beta-gamma, with all removable contamination results less than 5.4 dpm/100 cm^2 removable alpha and 64 dpm/100 cm^2 removable beta-gamma. These results are below the DOE surface contamination limits.

Furnishings Survey Results

Activities were less than 117.2 dpm/100 cm^2 total alpha and 1241 dpm/100 cm^2 total beta-gamma, with all removable contamination results less than 19 dpm/100 cm^2 removable alpha and 94.2 dpm/100 cm^2 removable beta-gamma.

Exterior Survey Results

Survey results show that all total activities were less than 45.3 dpm/100 cm^2 total alpha and 2498 dpm/100 cm^2 total beta-gamma, with all removable contamination results less than 10.8 dpm/100 cm^2 removable alpha and 53.5 dpm/100 cm^2 removable beta-gamma.

Ground Survey Results

A sodium iodide walkover survey was performed, and no readings were three times the established background; thus no soil samples were collected. Tissue-equivalent dose rates ranged from 8 to 10 μrem/h.

5. EXPOSURE ASSESSMENT

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

- characterizing the exposure scenario based on site surveys and anticipated future building 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.

5.1 EXPOSURE SCENARIO EVALUATION

5.1.1 Industrial Worker Scenario

Exposure scenarios are selected based on site surveys and anticipated uses of Bldg. K-1330. The ETTP area is being transferred mainly for industrial uses ranging from light to heavy industrial applications. Because the K-1330 building has been used in the past for office space, it is unlikely that heavy industrial activities would be compatible with the building infrastructure. Therefore, the anticipated building use scenario is for light industrial activity represented by an industrial worker exposure scenario in this evaluation. Exposures to the building worker while spending time outside the building were included in the roving worker exposure scenario (see Sect. 5.1.2). Therefore, ESU and GSU data were not used in this risk assessment. Furthermore, none of these areas had elevated residual radioactivity present above DOE contamination limits.

The exposure scenario for the evaluation of the building interior is based on an industrial worker who may be present performing basic industrial activities during the workday. The industrial worker exposure scenario assumes the following:

- the industrial worker is employed at Bldg. K-1330 for a 25-year period,
- the worker is on-site for 250 d/year, and
- the worker spends an 8-h day working in the interior of Bldg. K-1330.

An industrial worker is assumed to spend 8 h every workday in a single ISU. Although it is unlikely a worker would be limited to such a small area of the building, this assumption is intended to overestimate potential exposures and provide a conservative estimate of the associated risks.

There is the possibility that an industrial worker would circulate throughout Bldg. K-1330 either in a supervisory or maintenance role. In that case, an average of the exposures for the individual survey units would be more representative of the potential risks or doses for the building as a whole. A risk estimate based on the average exposure throughout the building interior and representing a roaming receptor is presented in the summary table for comparison to the risk estimate for a non-roaming receptor.

5.1.2 Roving Worker Scenario

In addition to the 8-h working day spent in the interior of the K-1330 building, it is assumed that the worker spends an additional amount of time outdoors at the plant site. To address the potential for exposure outside of a title transfer area, it was assumed that an industrial worker might spend 2 h each day accessing adjacent areas of ETTP (including locations in both Zones 1 and 2) [see Fig. 5.1]. A roving worker might spend this time by walking throughout areas in the vicinity of ETTP and being exposed to contaminated media. Identification of the specific areas accessed by the "rover" was based on an evaluation of ETTP exposure units (EUs). EUs that could reasonably be accessed were selected based on the location of existing fencing and access controls.

Areas were eliminated if they were within security fencing (to which the rover cannot gain access) or were located at a distance that could not be reasonably accessed on a frequent basis. For example, data from sampling points within a fenced area southeast of Blair Road (in EU Z2-28) were eliminated from the evaluation because the area is inaccessible. The relevance of specific datasets was also a criterion in the selection of EUs for the evaluation. As an example, EU Z2-27, in the Mitchell Branch area, was represented only by sediment sample data and was eliminated since exposure to sediment was considered unlikely. Figure 5.1 presents all of the EUs designated in Zones 1 and 2 at ETTP and highlights the EUs selected for this roving worker evaluation.

The boundaries for Zone 1 EUs were created for the Zone 1 Record of Decision (ROD) [DOE 2002a]. The boundaries for the Zone 2 EUs were created for the Zone 2 focused feasibility study (DOE 2004). It is assumed that the roving worker spends an equal amount of time in each of the areas considered accessible and may be exposed to surface soil during each period of roving. Therefore, the aggregate of soil data with starting depths no deeper than 2 ft from all accessible areas outside the main plant fence was considered a representative dataset for the roving worker exposure scenario evaluation.

The roving building worker scenario applies to a worker who works at ETTP for a 25-year period. The risk calculations for the roving worker assumed that ETTP will be remediated to levels protective of human health by the year 2008 in accordance with the *Oak Ridge Performance Management Plan* (DOE 2002b). The roving worker would, therefore, be exposed to contaminated soil for a 5-year period (i.e., 2003 to 2008) and to acceptably clean soil (as designated by the ROD) for the remaining 20-year working lifetime. The rover is assumed to spend a 2-h period each day roaming the accessible areas of ETTP, for 250 d each year for 5 years.

5.2 EXPOSURE PATHWAY IDENTIFICATION

Evaluating the exposure pathways requires describing the mechanism by which an individual may become exposed to contaminants associated with Bldg. K-1330. 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 screen.

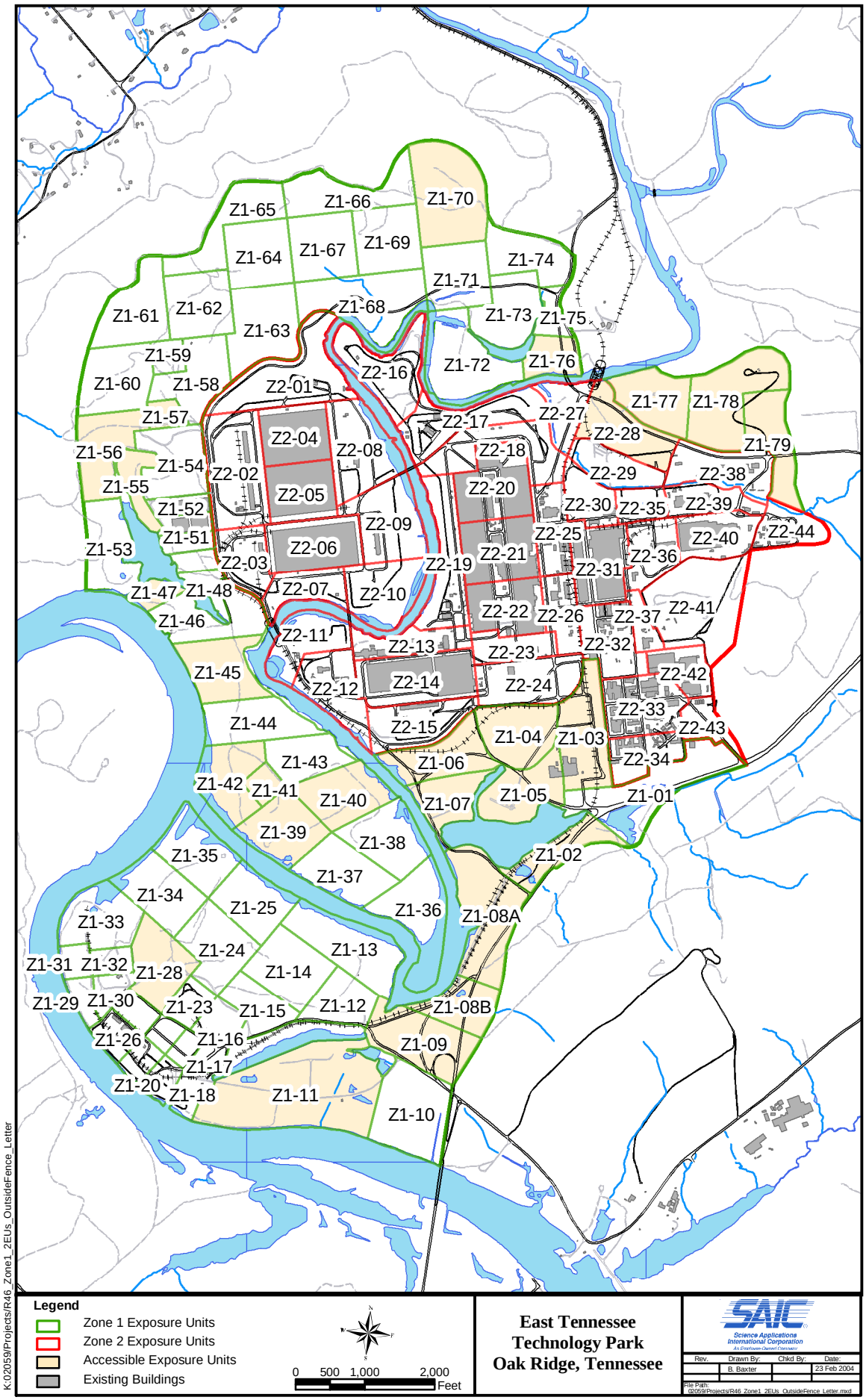

Fig. 5.1. Zone 1 and 2 Exposure Units Accessible to the roving worker outside the main plant fence.

Complete exposure pathways associated with Bldg. K-1330 include ingestion, inhalation, and external exposure to ionizing radiation. The ingestion pathway is complete because contaminated surfaces may be present, a receptor is present in the building, and a receptor may contact and ingest contaminants from the building surfaces. The inhalation pathway is complete because contaminated surfaces may be present, contaminants may become airborne during normal industrial activities, a receptor is present in the building, and a worker may inhale contaminants in the air. External exposure to ionizing radiation is a complete exposure pathway because radionuclides may be present on the building surfaces, ionizing radiation may be emitted, and a receptor is present to absorb the radiation. Potential exposure pathways for the roving worker include inhalation of suspended dust and volatile organics, ingestion of soil, dermal contact with soil, and external exposure to ionizing radiation from soil. The following section describes how each of these exposure pathways was quantified in the risk screen.

5.3 QUANTIFICATION OF EXPOSURE

Quantifying the exposure to the receptor requires:

- identification of the exposure concentration at the receptor exposure point,
- estimation of exposure parameters appropriate to the exposed individual, and
- calculation of the receptor exposure.

The purpose of the quantification of exposures is to provide a conservative estimate of exposures related to the exposure scenarios evaluated. At each step in the quantification process, assumptions are made in a conservative manner in an attempt to overestimate the risks/hazards and provide an upper bound estimate of risk that is protective of future workers in the building.

5.3.1 Industrial Worker

The ingestion and inhalation pathways for the building interior were quantified using the sampling data for removable contamination, as well as fixed contamination. For the industrial worker exposure scenario, it was assumed that 100% of the removable contamination is available for ingestion each workday, and 100% of the removable contamination is available for inhalation each workday. In this scenario, there is no depletion of the source material over the working lifetime of the industrial worker. This conservative assumption is evaluated because the anticipated industrial worker could contact the interior wall and ceiling surface over the course of normal activities.

The industrial worker scenario does not consider any renovation work; therefore, it is unlikely that any fixed contamination would be disturbed and be removed in any significant quantities. However, to provide greater conservatism in the risk screen for Bldg. K-1330, it was also assumed that some portion of the fixed contamination in each survey unit could be mobilized and become available for ingestion and inhalation.

An estimate of the amount of fixed contamination that could become removable was based on an evaluation of the ISU data. The percent of removable contamination to fixed contamination, based on the calculated exposure concentrations for smear and total data, respectively, ranged from ~ 1% for ISU 5 to ~ 12% for ISU 8 and averaged ~ 4% for all 17 units. Therefore, for conservatism, the risk associated with ingestion and inhalation is assumed to be 10% of the fixed contamination and was also included in the evaluation of survey units that showed detectable levels of removable contamination. All of the 17 ISUs had detectable removable contamination. As a result, all 17 ISUs were evaluated assuming 100% of removable contamination and 10% of fixed contamination were available for industrial worker exposure.

External dose measurements [millirem per hour (mrem/h)] were used to quantify potential external exposure. The measurements were generally collected at areas of highest readings in the building interior. The UCL95 of the mean of the dose rate data was calculated to be ~ 0.003 mrem/h, and the maximum dose rate was 0.005 mrem/h, both of which are below the background level of 0.007 mrem/h. Therefore, the risks due to external exposure in the interior of the building were not quantified. The Nuclear Regulatory Commission (NRC) Decontamination and Demolition Code recommends the use of 10% removable unless data specifies a high number. In addition, the use of 10% has been negotiated with the Tennessee Department of Conservation and Environment and EPA.

Quantifying the exposure requires an estimate of the exposure parameters for the exposed individual. The industrial worker exposure scenario assumes the following:

- the industrial worker is employed at Bldg. K-1330 for a 25-year period (EPA 1989 default),
- the worker is on-site for 250 d/year (EPA 1989 default),
- the worker spends 8 h/d in the interior of Bldg. K-1330 (site-specific assumption),
- the worker ingests 50 mg of contaminated material each day (EPA 1989 default), and
- the worker inhales 20 m^3 of air each day (EPA 1989 default).

Two scenarios were evaluated:

1. The industrial worker is assumed to spend every workday, for the entire workday, in a single ISU. Although it is unlikely a worker would be limited to such a small area of the building, this assumption is intended to overestimate potential exposures and provide a conservative estimate of the associated risks.

2. The industrial worker is assumed to spend every workday spending equal amounts of time in all ISUs, and, thus, the exposure is an average of exposure in all the ISUs.

5.3.2 Roving Worker

Quantifying the exposure requires an estimate of the exposure parameters for the exposed individual. The roving worker exposure scenario assumes the following:

- the 2003 roving industrial worker may access contaminated soil for 5 years, until 2008 when remediation will be completed at ETTP;

- the roving worker is on-site for 250 d/year;

- the roving worker spends 2 h each day wandering ETTP among all accessible EUs;

- the roving worker ingests 50 mg of contaminated soil during each 2-h period of wandering,

- The roving worker inhales 20 m^3 of air during each 2-h period of wandering.

The assumptions of 50 mg soil ingested and 20 m^3 of air inhaled are generally used when considering exposure for an entire day. However, based on direction from EPA Region 4, these assumptions will not be reduced even though the exposure is only for 2 h each day. Using these parameters for a 2-h period will overestimate the actual risks to a roving worker and provide an upper bound estimate of the associated risks. (For more detail, see Appendix A.)

The quantification of receptor exposure forms the basis of the risk calculation. In the risk calculation step, the receptor exposure is compared to benchmark values to determine the probability of adverse health effects. The resulting risk calculations are presented in the attached tables and are summarized below. Prior to quantification, the data are screened, resulting in identification of contaminants of potential concern (COPCs). A list of COPCs is provided in Table A.3.

6. RISK RESULTS

6.1 INDUSTRIAL WORKER

Building K-1330 risks were calculated for the industrial worker scenario assuming exposure by the inhalation, ingestion, and external exposure pathways. Table 6.1 presents the risks and doses from exposure to ISUs in Bldg. K-1330. The table shows that a number of areas had risks of ~ 9×10^{-8}, including ISUs 4, 6, 7, 8, 14, and 16. The highest single unit risk estimate was 8.9×10^{-8} for ISU 8. The conservative assumption that 10% of the fixed contamination becomes removable resulted in the majority of the risk, accounting for twice the risk of the removable contamination.

The risk estimate is a value that represents the excess cancer incidence that might be expected due to the exposure scenario evaluated. The EPA has established a target risk range of 10^{-4} to 10^{-6}. The estimated risk of 9×10^{-8} for Bldg. K-1330 is orders of magnitude below the EPA target range, indicating a low likelihood of adverse health effects due to the exposure scenarios considered.

The Bldg. K-1330 calculated doses indicated a maximum of ~ 0.006 mrem/year due to ingestion and inhalation of removable and fixed contamination in ISU 8. The calculated average dose for the interior of Bldg. K-1330 was ~ 0.005 mrem/year.

The risks associated with an industrial worker at K-1330 can be summarized as follows:

- the maximum risk associated with an individual survey unit was ~ 9×10^{-8} for ISU 8 (see bolded text in Table 5.1), located on the first floor in the southwest corner;
- the maximum calculated dose was ~ 0.006 mrem/year for ISU 8 (see bolded text in Table 6.1), located on the first floor in the southwest corner;
- the UCL 95 of the mean of the dose rate data was calculated to be ~ 0.003 mrem/h, and the maximum dose rate was 0.005 mrem/year, both of which are below the site background level of 0.007 mrem/h;
- the average risk associated with the interior of Bldg. K-1330 was ~ 7×10^{-8}, assuming a receptor is equally exposed to all interior survey areas; and
- the average calculated dose associated with the interior of Bldg. K-1330 was ~ 0.005 mrem/year for the interior of the building as a whole.

6.2 ROVING WORKER

The roving worker risk assessment considered quantitatively 39 surface soil COPCs (10 metals, 18 organics, and 11 radionuclides) for the accessible areas of ETTP. The risk to the roving worker was 8×10^{-6}, which is within the EPA acceptable range of 10^{-4} to 10^{-6}. The risk was mainly due to external exposure to ionizing radiation, as well as both ingestion and dermal contact with polycyclic aromatic hydrocarbons. The calculated hazard for the roving worker was 0.2, which is below the EPA acceptable level of 1.0. For additional information, see Appendix A.

Table 6.1. Carcinogenic risk and radiological dose estimates for K-1330 interior and furnishings[a]

Carcinogenic risk (risk/lifetime)	Removable activity			10% of total activity			Overall total
Interior survey unit	Ingestion risk	Inhalation risk	Total	Ingestion risk	Inhalation risk	Total	
ISU1	1.19E-08	5.43E-11	1.20E-08	5.14E-08	2.34E-10	5.16E-08	6.36E-08
ISU2	1.88E-08	8.55E-11	1.89E-08	5.11E-08	2.33E-10	5.13E-08	7.02E-08
ISU3	8.19E-09	3.73E-11	8.23E-09	5.19E-08	2.37E-10	5.21E-08	6.04E-08
ISU4	1.64E-08	7.45E-11	1.64E-08	7.03E-08	3.20E-10	7.06E-08	8.70E-08
ISU5	2.34E-09	1.06E-11	2.35E-09	4.98E-08	2.27E-10	5.01E-08	5.24E-08
ISU6	1.97E-08	8.96E-11	1.97E-08	5.50E-08	2.50E-10	5.52E-08	7.49E-08
ISU7	2.35E-08	1.07E-10	2.37E-08	6.06E-08	2.76E-10	6.09E-08	8.45E-08
ISU8	4.74E-08	2.16E-10	4.76E-08	4.07E-08	1.85E-10	4.09E-08	**8.85E-08**
ISU9	3.00E-08	1.37E-10	3.01E-08	2.85E-08	1.30E-10	2.86E-08	5.87E-08
ISU10	1.31E-08	5.98E-11	1.32E-08	3.80E-08	1.73E-10	3.82E-08	5.14E-08
ISU11	2.10E-08	9.58E-11	2.11E-08	3.03E-08	1.38E-10	3.04E-08	5.16E-08
ISU12	1.26E-08	5.74E-11	1.26E-08	4.75E-08	2.17E-10	4.77E-08	6.04E-08
ISU13	1.40E-08	6.40E-11	1.41E-08	5.88E-08	2.68E-10	5.91E-08	7.32E-08
ISU14	2.08E-08	9.50E-11	2.09E-08	5.76E-08	2.63E-10	5.79E-08	7.88E-08
ISU15	2.82E-08	1.29E-10	2.83E-08	4.15E-08	1.89E-10	4.17E-08	7.01E-08
ISU16	1.87E-08	8.53E-11	1.88E-08	6.87E-08	3.13E-10	6.90E-08	8.78E-08
ISU17	8.80E-09	4.01E-11	8.84E-09	4.77E-08	2.18E-10	4.79E-08	5.68E-08
Average[b]	1.86E-08	8.46E-11	1.86E-08	5.00E-08	2.28E-10	5.02E-08	6.88E-08
Radiological dose (mrem/year)	**Removable activity**			**10% of total activity**			**Overall total**
Interior survey unit	**Ingestion dose**	**Inhalation dose**	**Total dose**	**Ingestion dose**	**Inhalation dose**	**Total dose**	
ISU1	8.24E-04	4.03E-06	8.28E-04	3.56E-03	1.74E-05	3.57E-03	4.40E-03
ISU2	1.30E-03	6.35E-06	1.30E-03	3.53E-03	1.73E-05	3.55E-03	4.85E-03
ISU3	5.66E-04	2.77E-06	5.69E-04	3.59E-03	1.76E-05	3.61E-03	4.18E-03
ISU4	1.13E-03	5.54E-06	1.14E-03	4.86E-03	2.38E-05	4.88E-03	6.02E-03
ISU5	1.62E-04	7.91E-07	1.62E-04	3.45E-03	1.69E-05	3.46E-03	3.62E-03
ISU6	1.36E-03	6.65E-06	1.37E-03	3.80E-03	1.86E-05	3.82E-03	5.18E-03
ISU7	1.63E-03	7.97E-06	1.64E-03	4.19E-03	2.05E-05	4.21E-03	5.85E-03
ISU8	3.28E-03	1.60E-05	3.29E-03	2.81E-03	1.38E-05	2.83E-03	**6.12E-03**
ISU9	2.07E-03	1.01E-05	2.08E-03	1.97E-03	9.64E-06	1.98E-03	4.06E-03
ISU10	9.07E-04	4.44E-06	9.12E-04	2.63E-03	1.29E-05	2.64E-03	3.55E-03
ISU11	1.45E-03	7.12E-06	1.46E-03	2.09E-03	1.03E-05	2.11E-03	3.57E-03
ISU12	8.70E-04	4.26E-06	8.74E-04	3.29E-03	1.61E-05	3.30E-03	4.18E-03
ISU13	9.71E-04	4.75E-06	9.75E-04	4.06E-03	1.99E-05	4.08E-03	5.06E-03

Table 6.1. Carcinogenic risk and radiological dose estimates for K-1330 interior and furnishings[a] (continued)

Radiological dose (mrem/year)	Removable activity			10% of total activity			Overall total
Interior survey unit	Ingestion dose	Inhalation dose	Total dose	Ingestion dose	Inhalation dose	Total dose	
ISU14	1.44E-03	7.05E-06	1.45E-03	3.98E-03	1.95E-05	4.00E-03	5.45E-03
ISU15	1.95E-03	9.55E-06	1.96E-03	2.87E-03	1.41E-05	2.89E-03	4.85E-03
ISU16	1.29E-03	6.33E-06	1.30E-03	4.75E-03	2.33E-05	4.77E-03	6.07E-03
ISU17	6.08E-04	2.98E-06	6.11E-04	3.30E-03	1.62E-05	3.32E-03	3.93E-03
Average[b]	1.28E-03	6.28E-06	1.29E-03	3.46E-03	1.69E-05	3.47E-03	4.76E-03

[a]Uses exposure concentration = lesser of max and 95% upper confidence limit (UCL95) of the mean (UCL95 may be larger than max if data are limited).
[b]Assumes receptor is equally exposed to each interior survey unit throughout the workday.
[c]**Bold** indicates maximum risk/dose.

6.3 RISK SUMMARY

The risk evaluation for Bldg. K-1330 indicates that all risks and doses are considered within acceptable levels of EPA's target risk range (see Table 6.2) and below a hazard index of 1.0 (see Table 6.2), which correlate with a low likelihood of adverse health effects to an industrial worker. Therefore, the facility is considered acceptable for transfer for its intended use as an office building by the private sector.

Table 6.2. Summary of risks/hazards for Building K-1330

Receptor	Hazard	Risk
Industrial worker		
Maximum ISU	N/A	9E-8
Average for all ISUs	N/A	7E-8
Roving worker	0.2	7.9E-6
Total	**0.2**	**8E-6**

ISU = interior survey unit.
N/A = not applicable.

7. EVALUATION OF UNCERTAINTIES

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

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

7.1 UNCERTAINTY IN THE SOURCE TERM

Several uncertainties are associated with the data set and the data evaluation process. These uncertainties include the selection of COPCs and the determination of the 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 preliminary remediation goals (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. Some of the data may not have been taken randomly, but rather may have come from biased sampling, aimed at identifying high contaminant concentration locations. In addition, the soil data used for the rover scenario come from multiple sampling events conducted in multiple years and are not necessarily representative of current conditions. Concentrations of constituents may be lower and, hence, the risks/hazards may be lower than what is reported here.

This evaluation has been performed using only the COPCs with available toxicity data. It should be noted that the qualitative COPCs determined for this study area could potentially increase the risks/hazards to a receptor.

7.2 UNCERTAINTY IN THE EXPOSURE ASSESSMENT

For each exposure pathway, assumptions are made concerning the parameters, the routes of exposure, the amount of contaminated media an individual can be exposed to, and intake rates for different routes of exposure. In the absence of site-specific data, the assumptions used in this assessment are consistent with EPA-approved parameters and default values. When several of these upper-bound values are combined in

estimating exposure for any one pathway, the resulting risks can be in excess of the 99th percentile and, therefore, outside the range that may be reasonably expected. It has been assumed that the worker ingests 50 mg of dust inside the building and an additional 50 mg of soil outdoors while roving. The total ingestion of 100 mg is very conservative and may produce an overestimation of the risks/hazards.

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.

7.3 UNCERTAINTY IN TOXICITY VALUES AND RISK PREDICTIONS

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

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

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

1. the slope factors may represent the mean but often represent the upper 95th percentile estimate of potency (the central estimate of 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; and

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

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

8. REFERENCES

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APPENDIX A

ROVING WORKER SCENARIO FOR TITLE TRANSFER FACILITIES LOCATED OUTSIDE THE MAIN PLANT AREA AT THE EAST TENNESSEE TECHNOLOGY PARK

CONTENTS

FIGURE

TABLES

A.1. INTRODUCTION

In order to address potential risks from areas that are not in the immediate vicinity of the facility, but could reasonably be accessible to the occupant, a roving worker (or "rover"), who may move within East Tennessee Technology Park (ETTP) areas that do not have access restrictions (i.e., portals or gates) for a general worker has been evaluated.

The areas accessible to the "rover" are based on the location of the title transfer area. The overall risk for a building worker will be calculated by adding the risks from the building to the risk calculated for areas accessible to the "rover" where applicable. The roving worker scenario for areas accessible outside the main plant area is described in detail in the following sections. (This scenario is also referred to as the "outside rover.")

A.2. EXPOSURE SCENARIO EVALUATION

It was assumed that a building worker might spend 2 h each day accessing areas of ETTP that are near his/her place of business. A roving worker might spend this time by walking throughout unfenced areas in the vicinity of ETTP and being exposed to contaminated media. Identification of the specific areas accessed by the "rover" was based on an evaluation of ETTP exposure units (EUs), which were previously delineated for risk assessment purposes. EUs that could reasonably be accessed by a general plant worker were selected based on the location of existing security fencing and access controls.

Areas were eliminated if they were within security fencing or were located at a distance that could not be reasonably accessed on a frequent basis. For example, data from sampling points within a security fence southeast of Blair Road (in EU Z2-28) were eliminated from the evaluation because they are inaccessible to a general worker. The relevance of specific datasets was also a criterion in the selection of EUs for the evaluation. As an example, EU Z2-27, in the Mitchell Branch area, was represented only by sediment sample data and was eliminated since exposure to sediment was considered unlikely. Figure A.1 presents all of the EUs designated in Zones 1 and 2 at ETTP and highlights the EUs selected for this roving worker evaluation.

Remediation at ETTP is scheduled to be completed by the year 2008. It was, therefore, assumed that exposure to exterior soils would be of a limited duration of 5 years (2003 through 2008). It was also assumed that a roving worker would be exposed to soils for 2 h on each of the 250 workdays each year. It is unlikely that an individual would spend such an extensive amount of time outdoors in a single area. Therefore, it was assumed that a roving worker might spend equal amounts of time traveling among all of the accessible EUs. This scenario would represent a worker who exercises and/or eats lunch at different locations at the site. Although conservative, this approach is considered more realistic than the alternative of assuming that a "rover" spends all of his time in one location. For these reasons, the rover that is exposed to all EUs is the preferred scenario.

A.3. EXPOSURE PATHWAY IDENTIFICATION

Complete exposure pathways for the roving worker include ingestion, inhalation, dermal contact, and external exposure.

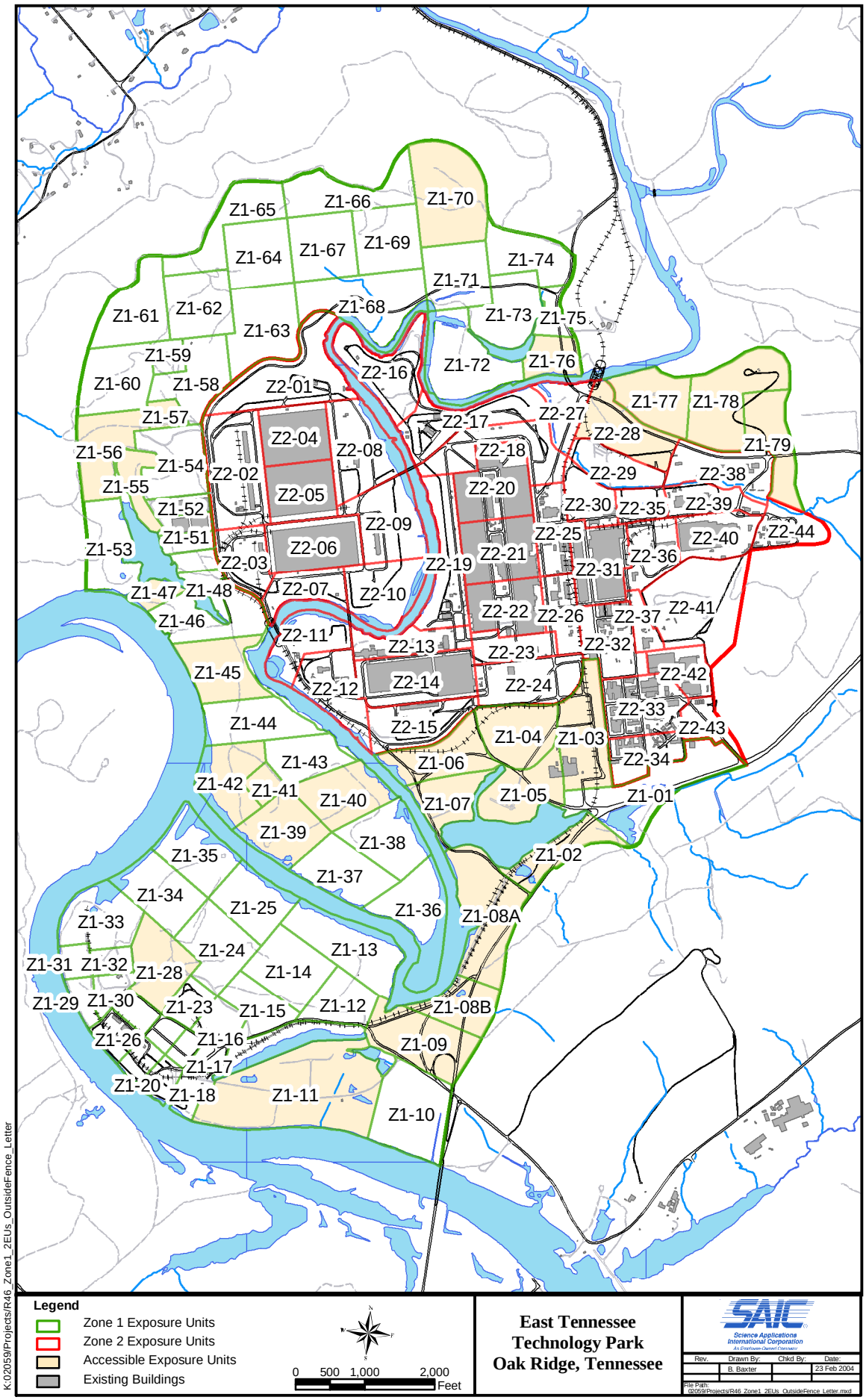

Fig. A.1. Zone 1 and 2 Exposure Units Accessible to the roving worker outside the main plant fence.

The ingestion pathway is complete because:

- contaminated media are present in EUs,
- a worker could be present in EUs, and
- a worker could inadvertently ingest media while spending time in EUs.

The inhalation pathway is complete because:

- contaminated media are present in EUs,
- the media may become airborne due to volatilization or dust resuspension,
- a worker could be present in EUs, and
- a worker could inhale some contaminated media while spending time in EUs.

The dermal pathway is complete because:

- contaminated media are present in EUs,
- a worker could be present in EUs, and
- a worker could inadvertently come into contact with contaminated media while spending time in the area.

External exposure to ionizing radiation is a complete exposure pathway because:

- radionuclides may be present in EUs media,
- ionizing radiation could be emitted, and
- a worker could be present in EUs to absorb emitted radiation.

The quantification of each of these exposure pathways is described in the following sections.

A.4. QUANTIFICATION OF EXPOSURE

Quantifying the exposure to the receptor requires:

- statistical evaluation of the representative dataset (Table A.1);
- selection of contaminants of potential concern (COPCs), based on comparison to background concentrations and preliminary remediation goals (PRGs) [Table A.2];
- identification of the COPCs that have available toxicity data and can be quantitatively evaluated (Table A.3);
- estimation of the exposure parameters appropriate to the roving worker (Table A.4);
- selection of toxicity data appropriate for the receptor and exposure pathways (Table A.5); and
- calculation of the intake, risks, and hazards to the roving worker (Tables A.6 and A.7) based on the calculated exposure concentrations.

The ingestion, inhalation, dermal contact, and external exposure pathways were quantified using available soil and radiological survey data for the accessible EU areas.

The list of COPCs was identified, based on comparison to PRGs and background concentrations. [Note: Discussions regarding use of background data are ongoing. Background data will continue to be used until an agreement on a different approach is reached.] A COPC list was also generated for the aggregated data representing all accessible EUs. Exposure concentrations represent the expected concentration the roving worker will encounter in soil and are typically the 95% upper confidence limit of the mean (UCL95) detected concentration or the maximum detected concentration, whichever is smaller. Exposure concentrations, the basis for the quantification of risk, were calculated from the available data for each EU and for the aggregated data for all accessible EUs.

Quantifying the exposure requires an estimate of the exposure parameters for the exposed individual. The roving worker exposure scenario assumes the following:

- the 2003 roving industrial worker may access contaminated soil for 5 years, until 2008 when remediation will be completed at ETTP;
- the roving worker is on-site for 250 d/year;
- the roving worker spends 2 h each day wandering ETTP among all accessible EUs;
- the roving worker ingests 50 mg of contaminated soil during each 2-h period of wandering; and
- the roving worker inhales 20 m^3 of air during each 2-h period of wandering.

The assumptions of 50 mg of soil ingested and 20 m^3 of air inhaled are generally used when considering exposure for an entire day. However, based on direction from EPA Region 4. these assumptions will not be reduced even though the exposure is only for 2 h each day. Using these parameters for a 2-h period will overestimate the actual risks to a roving worker and provide an upper-bound estimate of the associated risks.

A.5. RISK EQUATIONS

The calculation of risks and hazards for ingestion, inhalation, dermal contact, and external exposure to radiation used the equations presented in this section to calculate the intake of contaminants.

Inhalation exposure is evaluated with the following:

$$Intake\ (mg/kg\text{-}d) = C \times IR_a \times (1/VF + 1/PEF) \times EF \times ED / (BW \times AT)$$

$$Intake\ (pCi) = C \times IR_a \times (1/VF + 1/PEF) \times ET \times EF \times ED \times Cf_i$$

where

C = Contaminant concentration (mg/kg or pCi/g),
IR_a = Inhalation rate (m^3/d),
PEF = Particulate emission factor (m^3/kg),
VF = Volatilization factor (m^3/kg),

EF = Exposure frequency (d/year),
ED = Exposure duration (years),
AT = Averaging time (d),
BW = Adult body weight (kg),
Cf_i = Conversion factor (g/kg).

Ingestion exposure is evaluated with the following equation:

$$Intake\ (mg/kg\text{-}d) = C \times IR \times EF \times ED / (BW \times AT)$$

$$Intake\ (pCi) = C \times IR \times EF \times ED \times Cf$$

where

C = Contaminant concentration (mg/kg or pCi/g),
IR = Ingestion rate (kg/d),
EF = Exposure frequency (d/year),
ED = Exposure duration (years),
AT = Averaging time (d),
BW = Adult body weight (kg),
Cf = Conversion factor (g/kg).

The dermal contact with soil pathway is evaluated for chemicals with the following equation:

$$Intake\ (mg/kg\text{-}d) = C \times SA \times CF \times AF \times ABS \times EF \times ED / (BW \times AT)$$

where

C = Contaminant concentration (mg/kg or pCi/g),
SA = Surface area (m^2/event),
CF = Conversion factor (kg-cm^2)/(mg-m^2),
AF = Adherence (mg/cm^2),
ABS = Absorption factor (unitless),
EF = Exposure frequency (event/year),
ED = Exposure duration (years),
AT = Averaging time (d),
BW = Adult body weight (kg).

External exposure to ionizing radiation from contaminated soil is evaluated with the following equation:

$$Time\ integrated\ activity\ concentration\ (pCi\text{-}year/g) = CS \times (1\text{-}S_e) \times EF \times ED \times Te$$

where

CS = Contaminant concentration (pCi/g),
S_e = Gamma shielding factor (unitless),
EF = Exposure frequency (d/d),
ED = Exposure duration (years),
Te = Exposure time factor (h/h).

The parameters used in the quantification of exposure are presented in Table A.4. The quantification of receptor exposure forms the basis of the risk calculations.

A.6. CALCULATION OF RISK/HAZARDS

In the risk calculation step, the receptor exposure is compared with benchmark values to determine the probability of adverse health effects.

For carcinogens, risk is calculated as follows:

$$Risk = Intake \times Slope\ Factor$$

where

Risk = carcinogenic risk for receptor (unitless),
Intake = receptor intake for carcinogenic constituents via pathway under consideration (mg/kg-d),

Slope factor = toxicity data specific to the constituent and pathway [risk/(mg/kg-d)].

For non-carcinogens, the hazard is calculated as follows:

$$Hazard = Intake/Reference\ Dose$$

where

Hazard = noncarcinogenic hazard for receptor (unitless),
Intake = receptor intake for non-carcinogenic constituents via pathway under consideration (mg/kg-d),
Reference dose = toxicity data specific to the constituent and pathway (mg/kg-d).

Table A.5 presents the toxicity data used in the calculation of risks/hazards. The risk/hazard results are discussed below.

A.7. RISK RESULTS

Roving worker risks were calculated assuming exposure by ingestion, inhalation, dermal contact, and external exposure to ionizing radiation. Tables A.6 and A.7 present the risks/hazards for a roving worker exposed while moving among all accessible EUs, which are outside the main plant fence at ETTP.

Table A.1. Summary statistics for all measured analytes for the evaluation of surface soil exposures for ETTP outside rover locations

Analyte	Freq. detect	Min. non-detect conc.	Max. non-detect conc.	Arithmetic mean conc.	Standard deviation	Min. detect conc.	Max. detect conc.	UCL95 on mean	Dist. flag[a]	Exposure point conc.	Proceed with screening?	Justification[b]
Metals (mg/kg)												
Aluminum	106/106			2.22E+04	1.66E+04	6.13E+02	5.96E+04	2.49E+04	X	2.49E+04	Yes	
Antimony	31/89	1.15E-01	2.47E+01	3.37E+00	4.08E+00	2.33E-01	1.92E+01	4.09E+00	D	4.09E+00	Yes	
Arsenic	102/106	1.20E+00	2.30E+01	1.34E+01	1.01E+01	9.80E-01	4.72E+01	1.66E+01	L	1.66E+01	Yes	
Barium	106/106			9.17E+01	5.74E+01	1.42E+01	3.03E+02	1.06E+02	L	1.06E+02	Yes	
Beryllium	95/106	2.10E-01	4.87E-01	2.35E+00	1.40E+01	1.42E-01	1.45E+02	4.61E+00	X	4.61E+00	Yes	
Boron	5/5			4.16E+00	4.08E+00	1.50E+00	1.14E+01	1.97E+01	L	1.14E+01	Yes	
Cadmium	56/109	1.25E-02	2.75E-01	1.03E+00	1.78E+00	1.10E-01	1.56E+01	1.31E+00	X	1.31E+00	Yes	
Calcium	106/106			3.34E+04	5.44E+04	2.36E+02	2.63E+05	4.21E+04	X	4.21E+04	Yes*	Essential nutrient
Chromium	106/106			2.63E+01	1.44E+01	4.54E+00	1.03E+02	2.86E+01	X	2.86E+01	Yes	
Chromium, hexavalent	2/15	2.70E-01	3.85E-01	3.46E-01	1.03E-01	5.80E-01	6.00E-01	3.93E-01	D	3.93E-01	Yes	
Cobalt	106/106			1.44E+01	1.20E+01	1.22E+00	9.99E+01	1.64E+01	X	1.64E+01	Yes	
Copper	106/106			2.45E+01	1.59E+01	4.00E+00	1.05E+02	2.74E+01	L	2.74E+01	Yes	
Iron	106/106			2.81E+04	1.37E+04	3.50E+03	7.96E+04	3.03E+04	X	3.03E+04	Yes*	Essential nutrient
Lead	108/109	3.54E+01	3.54E+01	3.60E+01	3.46E+01	4.81E+00	2.80E+02	4.00E+01	L	4.00E+01	Yes	
Lithium	3/3			2.92E+01	1.85E+01	1.25E+01	4.91E+01	2.63E+03	L	4.91E+01	Yes	
Magnesium	106/106			9.26E+03	1.38E+04	1.07E+02	7.38E+04	1.65E+04	L	1.65E+04	Yes*	Essential nutrient
Manganese	106/106			1.03E+03	9.63E+02	3.87E+01	4.91E+03	1.35E+03	L	1.35E+03	Yes	
Mercury	76/109	9.50E-03	6.50E-02	1.15E-01	1.86E-01	2.00E-02	1.30E+00	1.45E-01	X	1.45E-01	Yes	
Molybdenum	4/8	4.95E-01	5.50E-01	4.09E+00	5.03E+00	4.80E-01	1.16E+01	7.46E+00	X	7.46E+00	Yes	
Nickel	109/109			3.20E+01	2.84E+01	3.81E+00	1.69E+02	3.73E+01	L	3.73E+01	Yes	
Potassium	106/106			3.39E+03	3.81E+03	1.31E+02	1.65E+04	4.00E+03	X	4.00E+03	Yes*	Essential nutrient
Selenium	46/109	1.14E-01	1.91E+01	2.26E+00	3.37E+00	4.80E-01	1.32E+01	2.80E+00	D	2.80E+00	Yes	
Silver	8/109	3.00E-02	5.25E+00	6.52E-01	1.30E+00	1.30E-01	1.11E+01	8.59E-01	D	8.59E-01	Yes	
Sodium	74/97	6.10E+00	3.56E+02	1.83E+02	5.33E+02	1.04E+01	5.20E+03	2.73E+02	X	2.73E+02	Yes*	Essential nutrient
Strontium	3/3			7.08E+01	1.01E+02	5.70E+00	1.87E+02	2.10E+16	L	1.87E+02	Yes	
Thallium	26/104	5.50E-02	7.80E+01	4.28E+00	8.06E+00	1.40E-01	1.35E+01	5.59E+00	D	5.59E+00	Yes	
Uranium	20/23	2.88E+00	3.31E+00	4.23E+00	2.68E+00	4.00E-01	1.07E+01	5.19E+00	N	5.19E+00	Yes	
Vanadium	106/106			3.95E+01	1.96E+01	4.30E+00	9.55E+01	4.27E+01	N	4.27E+01	Yes	
Zinc	106/106			7.93E+01	1.36E+02	8.30E+00	1.30E+03	1.01E+02	X	1.01E+02	Yes	
Pesticides/herbicides/polychlorinated biphenyls (mg/kg)												
4,4'-DDD	0/5	6.00E-03	4.00E-01	9.56E-02	1.71E-01			2.58E-01	D	2.58E-01	No	No detects
4,4'-DDE	0/5	6.00E-03	4.00E-01	9.56E-02	1.71E-01			2.58E-01	D	2.58E-01	No	No detects
4,4'-DDT	0/5	6.00E-03	4.00E-01	9.56E-02	1.71E-01			2.58E-01	D	2.58E-01	No	No detects
Aldrin	0/5	3.00E-03	2.00E-01	4.79E-02	8.52E-02			1.29E-01	D	1.29E-01	No	No detects
Dieldrin	0/5	6.00E-03	4.00E-01	9.56E-02	1.71E-01			2.58E-01	D	2.58E-01	No	No detects

Table A.1. Summary statistics for all measured analytes for the evaluation of surface soil exposures for ETTP outside rover locations (continued)

Analyte	Freq. detect	Min. non-detect conc.	Max. non-detect conc.	Arithmetic mean conc.	Standard deviation	Min. detect conc.	Max. detect conc.	UCL95 on mean	Dist. flag[a]	Exposure point conc.	Proceed with screening?	Justification[b]
Endosulfan I	0/5	3.00E-03	2.00E-01	4.79E-02	8.52E-02			1.29E-01	D	1.29E-01	No	No detects
Endosulfan II	0/5	6.00E-03	4.00E-01	9.56E-02	1.71E-01			2.58E-01	D	2.58E-01	No	No detects
Endosulfan sulfate	0/5	6.00E-03	4.00E-01	9.56E-02	1.71E-01			2.58E-01	D	2.58E-01	No	No detects
Endrin	0/5	6.00E-03	4.00E-01	9.56E-02	1.71E-01			2.58E-01	D	2.58E-01	No	No detects
Endrin ketone	0/5	6.00E-03	4.00E-01	9.56E-02	1.71E-01			2.58E-01	D	2.58E-01	No	No detects
Heptachlor	0/5	3.00E-03	2.00E-01	4.79E-02	8.52E-02			1.29E-01	D	1.29E-01	No	No detects
Heptachlor epoxide	0/5	3.00E-03	2.00E-01	4.79E-02	8.52E-02			1.29E-01	D	1.29E-01	No	No detects
Lindane	0/5	3.00E-03	2.00E-01	4.79E-02	8.52E-02			1.29E-01	D	1.29E-01	No	No detects
Methoxychlor	0/5	3.00E-02	2.00E+00	4.79E-01	8.52E-01			1.29E+00	D	1.29E+00	No	No detects
PCB-1016	1/91	1.80E-03	2.00E-01	2.77E-02	3.95E-02	1.20E-01	1.20E-01	3.45E-02	D	3.45E-02	Yes	
PCB-1221	1/91	1.80E-03	3.85E-01	4.37E-02	6.65E-02	1.20E-01	1.20E-01	5.52E-02	D	5.52E-02	Yes	
PCB-1232	1/91	1.80E-03	2.00E-01	2.77E-02	3.95E-02	1.20E-01	1.20E-01	3.45E-02	D	3.45E-02	Yes	
PCB-1242	1/91	1.80E-03	2.00E-01	2.77E-02	3.95E-02	1.20E-01	1.20E-01	3.45E-02	D	3.45E-02	Yes	
PCB-1248	3/91	1.80E-03	2.00E-01	2.96E-02	4.19E-02	5.30E-02	1.60E-01	3.69E-02	D	3.69E-02	Yes	
PCB-1254	20/91	1.80E-03	1.90E-01	6.61E-02	1.66E-01	2.10E-03	1.20E+00	9.49E-02	D	9.49E-02	Yes	
PCB-1260	22/91	1.80E-03	2.00E-01	5.64E-02	1.48E-01	3.10E-03	1.00E+00	8.21E-02	D	8.21E-02	Yes	
Toxaphene	0/5	6.00E-02	4.00E+00	9.56E-01	1.71E+00			2.58E+00	D	2.58E+00	No	No detects
alpha-BHC	0/5	3.00E-03	2.00E-01	4.79E-02	8.52E-02			1.29E-01	D	1.29E-01	No	No detects
alpha-Chlordane	0/5	3.00E-03	2.00E+00	4.19E-01	8.84E-01			1.26E+00	D	1.26E+00	No	No detects
beta-BHC	0/5	3.00E-03	2.00E-01	4.79E-02	8.52E-02			1.29E-01	D	1.29E-01	No	No detects
delta-BHC	0/5	3.00E-03	2.00E-01	4.79E-02	8.52E-02			1.29E-01	D	1.29E-01	No	No detects
gamma-Chlordane	0/5	3.00E-03	2.00E+00	4.19E-01	8.84E-01			1.26E+00	D	1.26E+00	No	No detects
Semivolatile organic compounds (mg/kg)												
1,2,4-Trichlorobenzene	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
1,2-Dichlorobenzene	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
1,2-Diphenylhydrazine	0/6	1.87E-01	1.10E+01	4.06E+00	4.35E+00			7.64E+00	D	7.64E+00	No	No detects
1,3-Dichlorobenzene	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
1,4-Dichlorobenzene	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
2,2'-Dichlorodiisopropyl ether	1/40	1.75E-01	1.85E+00	2.43E-01	2.62E-01	3.00E-02	3.00E-02	3.13E-01	D	3.00E-02	Yes	
2,3,4,6-Tetrachlorophenol	0/5	6.00E-01	1.10E+01	4.84E+00	4.38E+00			9.01E+00	D	9.01E+00	No	No detects
2,4,5-Trichlorophenol	0/86	1.75E-01	5.50E+01	1.76E+00	7.35E+00			3.08E+00	D	3.08E+00	No	No detects
2,4,6-Trichlorophenol	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
2,4-Dichlorophenol	1/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00	1.50E-01	1.50E-01	7.62E-01	D	1.50E-01	Yes	
2,4-Dimethylphenol	1/86	1.75E-01	1.10E+01	5.00E-01	1.45E+00	4.10E-02	4.10E-02	7.61E-01	D	4.10E-02	Yes	
2,4-Dinitrophenol	1/86	1.75E-01	5.50E+01	1.77E+00	7.35E+00	3.50E-02	3.50E-02	3.09E+00	D	3.50E-02	Yes	
2,4-Dinitrotoluene	4/86	1.80E-01	1.10E+01	4.97E-01	1.45E+00	2.50E-02	1.10E-01	7.58E-01	D	1.10E-01	Yes	

Table A.1. Summary statistics for all measured analytes for the evaluation of surface soil exposures for ETTP outside rover locations (continued)

Analyte	Freq. detect	Min. non-detect conc.	Max. non-detect conc.	Arithmetic mean conc.	Standard deviation	Min. detect conc.	Max. detect conc.	UCL95 on mean	Dist. flag[a]	Exposure point conc.	Proceed with screening?	Justification[b]
2,6-Dinitrotoluene	1/86	1.75E-01	1.10E+01	5.00E-01	1.45E+00	4.80E-02	4.80E-02	7.61E-01	D	4.80E-02	Yes	
2-Chloronaphthalene	2/86	1.75E-01	1.10E+01	5.00E-01	1.45E+00	2.50E-02	1.90E-01	7.60E-01	D	1.90E-01	Yes	
2-Chlorophenol	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
2-Methyl-4,6-dinitrophenol	0/86	1.75E-01	5.50E+01	1.77E+00	7.35E+00			3.09E+00	D	3.09E+00	No	No detects
2-Methylnaphthalene	18/86	1.80E-01	1.10E+01	6.28E-01	1.53E+00	2.20E-02	3.30E+00	9.01E-01	D	9.01E-01	Yes	
2-Methylphenol	2/86	1.75E-01	1.10E+01	4.99E-01	1.45E+00	2.20E-02	7.00E-02	7.59E-01	D	7.00E-02	Yes	
2-Nitrobenzenamine	1/86	1.75E-01	5.50E+01	1.77E+00	7.35E+00	5.30E-02	5.30E-02	3.09E+00	D	5.30E-02	Yes	
2-Nitrophenol	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
3,3'-Dichlorobenzidine	2/86	1.75E-01	2.20E+01	7.86E-01	2.95E+00	2.40E-02	5.80E-02	1.32E+00	D	5.80E-02	Yes	
3-Nitrobenzenamine	1/86	1.75E-01	5.50E+01	1.77E+00	7.35E+00	7.00E-02	7.00E-02	3.09E+00	D	7.00E-02	Yes	
4-Bromophenyl phenyl ether	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
4-Chloro-3-methylphenol	2/86	1.75E-01	2.20E+01	7.85E-01	2.95E+00	2.50E-02	2.90E-02	1.32E+00	D	2.90E-02	Yes	
4-Chlorobenzenamine	2/86	1.75E-01	2.20E+01	7.93E-01	2.95E+00	2.90E-01	4.20E-01	1.32E+00	D	4.20E-01	Yes	
4-Chlorophenyl phenyl ether	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
4-Methylphenol	3/86	1.75E-01	1.10E+01	4.96E-01	1.46E+00	2.20E-02	3.50E-02	7.57E-01	D	3.50E-02	Yes	
4-Nitrobenzenamine	1/86	1.75E-01	5.50E+01	1.77E+00	7.35E+00	2.80E-02	2.80E-02	3.09E+00	D	2.80E-02	Yes	
4-Nitrophenol	1/86	1.75E-01	5.50E+01	1.77E+00	7.35E+00	8.50E-02	8.50E-02	3.09E+00	D	8.50E-02	Yes	
Acenaphthene	6/86	1.75E-01	1.10E+01	4.99E-01	1.45E+00	7.80E-02	2.30E-01	7.60E-01	D	2.30E-01	Yes	
Acenaphthylene	13/86	1.80E-01	1.10E+01	5.83E-01	1.50E+00	2.60E-02	3.20E+00	8.52E-01	D	8.52E-01	Yes	
Aniline	0/5	6.00E-01	1.10E+01	4.84E+00	4.38E+00			9.01E+00	D	9.01E+00	No	No detects
Anthracene	17/86	1.80E-01	1.10E+01	5.26E-01	1.47E+00	1.00E-02	2.70E+00	7.90E-01	D	7.90E-01	Yes	
Benz(a)anthracene	29/86	3.60E-02	1.10E+01	9.53E-01	2.70E+00	2.80E-02	1.80E+01	1.44E+00	D	1.44E+00	Yes	
Benzenemethanol	0/5	1.20E+00	2.20E+01	9.78E+00	8.79E+00			1.82E+01	D	1.82E+01	No	No detects
Benzidine	0/2	3.05E+00	5.50E+01	2.90E+01	3.67E+01			1.93E+02	D	1.93E+02	No	No detects
Benzo(*a*)pyrene	27/86	5.50E-02	1.10E+01	1.24E+00	3.43E+00	3.60E-02	2.20E+01	1.86E+00	D	1.86E+00	Yes	
Benzo(*b*)fluoranthene	33/86	4.90E-02	1.10E+01	1.35E+00	3.64E+00	4.40E-02	2.10E+01	2.00E+00	D	2.00E+00	Yes	
Benzo(*g,h,i*)perylene	12/86	1.80E-01	1.10E+01	9.46E-01	2.61E+00	8.80E-02	1.60E+01	1.41E+00	D	1.41E+00	Yes	
Benzo(*k*)fluoranthene	26/86	5.50E-02	1.10E+01	1.19E+00	3.34E+00	3.90E-02	1.90E+01	1.79E+00	D	1.79E+00	Yes	
Benzoic acid	0/5	3.00E+00	5.50E+01	2.42E+01	2.19E+01			4.51E+01	D	4.51E+01	No	No detects
Bis(2-chloroethoxy)methane	1/86	1.75E-01	1.10E+01	5.00E-01	1.45E+00	3.50E-02	3.50E-02	7.61E-01	D	3.50E-02	Yes	
Bis(2-chloroethyl) ether	2/86	1.75E-01	1.10E+01	4.98E-01	1.45E+00	2.00E-02	2.60E-02	7.59E-01	D	2.60E-02	Yes	
Bis(2-chloroisopropyl) ether	0/46	1.80E-01	1.10E+01	7.24E-01	1.96E+00			1.21E+00	D	1.21E+00	No	No detects
Bis(2-ethylhexyl)phthalate	7/86	1.75E-01	1.10E+01	5.30E-01	1.48E+00	7.00E-02	3.10E+00	7.96E-01	D	7.96E-01	Yes	
Butyl benzyl phthalate	5/86	1.75E-01	1.10E+01	4.95E-01	1.46E+00	1.20E-02	1.20E-01	7.56E-01	D	1.20E-01	Yes	
Carbazole	11/84	1.75E-01	6.00E+00	3.84E-01	9.10E-01	1.20E-02	1.00E+00	5.49E-01	D	5.49E-01	Yes	
Chrysene	31/86	5.00E-02	1.10E+01	1.13E+00	3.01E+00	4.20E-02	2.00E+01	1.67E+00	D	1.67E+00	Yes	

Table A.1. Summary statistics for all measured analytes for the evaluation of surface soil exposures for ETTP outside rover locations (continued)

Analyte	Freq. detect	Min. non-detect conc.	Max. non-detect conc.	Arithmetic mean conc.	Standard deviation	Min. detect conc.	Max. detect conc.	UCL95 on mean	Dist. flag[a]	Exposure point conc.	Proceed with screening?	Justification[b]
Di-n-butyl phthalate	6/86	1.75E-01	1.10E+01	5.73E-01	1.49E+00	6.20E-02	2.60E+00	8.40E-01	D	8.40E-01	Yes	
Di-n-octylphthalate	3/86	1.75E-01	1.10E+01	4.98E-01	1.45E+00	2.80E-02	1.20E-01	7.58E-01	D	1.20E-01	Yes	
Dibenz(*a,h*)anthracene	6/86	1.80E-01	1.10E+01	6.00E-01	1.54E+00	1.10E-01	3.90E+00	8.75E-01	D	8.75E-01	Yes	
Dibenzofuran	13/86	1.80E-01	1.10E+01	5.36E-01	1.45E+00	4.10E-02	1.00E+00	7.97E-01	D	7.97E-01	Yes	
Diethyl phthalate	2/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00	3.00E-01	4.80E-01	7.62E-01	D	4.80E-01	Yes	
Dimethyl phthalate	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
Diphenylamine	2/73	1.75E-01	1.85E+00	2.32E-01	2.10E-01	4.60E-02	5.80E-02	2.73E-01	D	5.80E-02	Yes	
Fluoranthene	33/86	1.80E-01	1.10E+01	1.21E+00	3.70E+00	3.40E-02	2.90E+01	1.87E+00	D	1.87E+00	Yes	
Fluorene	7/86	1.75E-01	1.10E+01	4.87E-01	1.45E+00	6.10E-02	6.60E-01	7.46E-01	D	6.60E-01	Yes	
Hexachlorobenzene	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
Hexachlorobutadiene	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
Hexachlorocyclopentadiene	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
Hexachloroethane	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
Indeno(1,2,3-*cd*)pyrene	19/86	1.80E-01	1.10E+01	1.06E+00	2.85E+00	5.90E-02	1.80E+01	1.57E+00	D	1.57E+00	Yes	
Isophorone	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
N-Nitroso-di-n-propylamine	0/86	1.75E-01	1.10E+01	5.02E-01	1.45E+00			7.63E-01	D	7.63E-01	No	No detects
N-Nitrosodimethylamine	0/5	6.00E-01	1.10E+01	4.84E+00	4.38E+00			9.01E+00	D	9.01E+00	No	No detects
N-Nitrosodiphenylamine	0/13	1.95E-01	1.10E+01	1.99E+00	3.44E+00			3.70E+00	D	3.70E+00	No	No detects
Naphthalene	14/86	1.80E-01	1.10E+01	5.98E-01	1.48E+00	9.20E-02	2.30E+00	8.64E-01	D	8.64E-01	Yes	
Nitrobenzene	1/86	1.75E-01	1.10E+01	5.01E-01	1.45E+00	5.70E-02	5.70E-02	7.61E-01	D	5.70E-02	Yes	
Pentachlorophenol	3/86	1.75E-01	5.50E+01	1.77E+00	7.35E+00	3.49E-01	4.02E-01	3.09E+00	D	4.02E-01	Yes	
Phenanthrene	32/86	1.80E-01	1.10E+01	7.68E-01	1.69E+00	2.80E-02	5.70E+00	1.07E+00	D	1.07E+00	Yes	
Phenol	7/86	1.75E-01	1.10E+01	4.92E-01	1.46E+00	2.30E-02	2.30E-01	7.53E-01	D	2.30E-01	Yes	
Pyrene	34/86	1.80E-01	1.10E+01	1.13E+00	3.45E+00	3.70E-02	2.60E+01	1.75E+00	D	1.75E+00	Yes	
Pyridine	0/5	6.00E-01	1.10E+01	4.84E+00	4.38E+00			9.01E+00	D	9.01E+00	No	No detects
Volatile organic compounds (mg/kg)												
1,1,1-Trichloro-2,2,2-trifluoroethane	0/31	2.70E-03	3.80E-03	3.06E-03	2.16E-04			3.12E-03	D	3.12E-03	No	No detects
1,1,1-Trichloroethane	1/75	2.70E-03	7.25E-03	4.70E-03	1.68E-03	1.08E-02	1.08E-02	5.03E-03	D	5.03E-03	Yes	
1,1,2,2-Tetrachloroethane	1/75	2.70E-03	7.25E-03	4.62E-03	1.57E-03	8.60E-04	8.60E-04	4.92E-03	D	8.60E-04	Yes	
1,1,2-Trichloro-1,2,2-trifluoroethane	0/5	3.15E-03	3.50E-03	3.34E-03	1.39E-04			3.47E-03	D	3.47E-03	No	No detects
1,1,2-Trichloroethane	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
1,1-Dichloroethane	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
1,1-Dichloroethene	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
1,2-Dichloroethane	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
1,2-Dichloroethene	0/36	2.70E-03	3.80E-03	3.10E-03	2.28E-04			3.16E-03	D	3.16E-03	No	No detects
1,2-Dichloropropane	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects

Table A.1. Summary statistics for all measured analytes for the evaluation of surface soil exposures for ETTP outside rover locations (continued)

Analyte	Freq. detect	Min. non-detect conc.	Max. non-detect conc.	Arithmetic mean conc.	Standard deviation	Min. detect conc.	Max. detect conc.	UCL95 on mean	Dist. flag[a]	Exposure point conc.	Proceed with screening?	Justification[b]
1,2-Dimethylbenzene	2/41	2.80E-03	7.25E-03	5.82E-03	9.88E-04	1.70E-03	3.60E-03	6.08E-03	D	3.60E-03	Yes	
2-Butanone	0/53	2.70E-03	7.25E-03	4.13E-03	1.54E-03			4.48E-03	D	4.48E-03	No	No detects
2-Hexanone	0/52	2.70E-03	7.25E-03	4.09E-03	1.53E-03			4.44E-03	D	4.44E-03	No	No detects
4-Methyl-2-pentanone	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Acetone	9/58	2.70E-03	8.75E-03	7.79E-03	1.36E-02	4.20E-03	9.78E-02	1.08E-02	D	1.08E-02	Yes	
Benzene	5/76	2.70E-03	7.25E-03	4.55E-03	1.75E-03	4.50E-04	9.20E-03	4.88E-03	D	4.88E-03	Yes	
Bromochloromethane	0/39	5.25E-03	7.25E-03	6.07E-03	3.88E-04			6.17E-03	D	6.17E-03	No	No detects
Bromodichloromethane	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Bromoform	0/74	2.70E-03	7.25E-03	4.62E-03	1.53E-03			4.92E-03	D	4.92E-03	No	No detects
Bromomethane	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Carbon disulfide	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Carbon tetrachloride	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Chlorobenzene	0/74	2.70E-03	7.25E-03	4.62E-03	1.53E-03			4.92E-03	D	4.92E-03	No	No detects
Chloroethane	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Chloroform	1/75	2.70E-03	7.25E-03	4.60E-03	1.60E-03	2.70E-04	2.70E-04	4.91E-03	D	2.70E-04	Yes	
Chloromethane	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Dibromochloromethane	0/74	2.70E-03	7.25E-03	4.62E-03	1.53E-03			4.92E-03	D	4.92E-03	No	No detects
Dimethylbenzene	4/76	2.70E-03	7.25E-03	4.90E-03	3.06E-03	8.40E-04	2.75E-02	5.49E-03	D	5.49E-03	Yes	
Ethylbenzene	2/75	2.70E-03	7.25E-03	4.61E-03	1.54E-03	1.90E-03	5.30E-03	4.91E-03	D	4.91E-03	Yes	
Methylene chloride	19/75	2.70E-03	8.10E-03	4.57E-03	1.89E-03	1.20E-03	9.80E-03	4.93E-03	D	4.93E-03	Yes	
Styrene	0/73	2.70E-03	7.25E-03	4.65E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Tetrachloroethene	0/74	2.70E-03	7.25E-03	4.62E-03	1.53E-03			4.92E-03	D	4.92E-03	No	No detects
Toluene	12/76	2.75E-03	7.25E-03	4.41E-03	2.22E-03	3.60E-04	1.45E-02	4.83E-03	D	4.83E-03	Yes	
Trichloroethene	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Vinyl chloride	0/75	1.10E-03	7.25E-03	3.88E-03	2.36E-03			4.34E-03	D	4.34E-03	No	No detects
cis-1,2-Dichloroethene	0/39	5.25E-03	7.25E-03	6.07E-03	3.88E-04			6.17E-03	D	6.17E-03	No	No detects
cis-1,3-Dichloropropene	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
trans-1,2-Dichloroethene	0/39	5.25E-03	7.25E-03	6.07E-03	3.88E-04			6.17E-03	D	6.17E-03	No	No detects
trans-1,3-Dichloropropene	0/75	2.70E-03	7.25E-03	4.64E-03	1.53E-03			4.94E-03	D	4.94E-03	No	No detects
Radionuclides (pCi/g)												
Actinium-228	64/66	1.00E-01	1.50E-01	1.27E+00	4.89E-01	4.67E-01	3.10E+00	1.37E+00	X	1.37E+00	No	Daughter
Americium-241	13/69	-8.42E-02	9.93E-02	3.73E-02	3.81E-02	3.71E-02	1.50E-01	4.50E-02	D	4.50E-02	Yes	
Bismuth-214	36/37	-8.50E-02	-8.50E-02	9.49E-01	4.26E-01	3.32E-01	2.04E+00	1.11E+00	L	1.11E+00	No	Daughter
Cesium-134	0/30	-3.10E-02	4.80E-02	5.06E-03	1.91E-02			1.10E-02	D	1.10E-02	No	No detects
Cesium-137	145/211	-3.79E+00	2.18E+00	6.61E-01	3.59E+00	1.00E-02	4.80E+01	1.07E+00	X	1.07E+00	Yes	
Cobalt-57	0/30	-8.40E-02	8.50E-02	3.47E-03	3.33E-02			1.38E-02	D	1.38E-02	No	No detects

Table A.1. Summary statistics for all measured analytes for the evaluation of surface soil exposures for ETTP outside rover locations (continued)

Analyte	Freq. detect	Min. non-detect conc.	Max. non-detect conc.	Arithmetic mean conc.	Standard deviation	Min. detect conc.	Max. detect conc.	UCL95 on mean	Dist. flag[a]	Exposure point conc.	Proceed with screening?	Justification[b]
Cobalt-60	20/199	-1.25E-01	1.90E-01	1.44E-02	4.02E-02	-7.00E-02	1.20E-01	1.91E-02	D	1.91E-02	Yes	
Europium-154	0/11	3.00E-02	7.00E-02	4.55E-02	1.04E-02			5.11E-02	D	5.11E-02	No	No detects
Lead-212	29/30	1.60E-02	1.60E-02	3.68E+00	1.02E+01	2.42E-01	5.58E+01	6.83E+00	X	6.83E+00	No	Daughter
Lead-214	35/37	-8.90E-02	2.29E-01	1.08E+00	5.24E-01	4.21E-01	2.48E+00	1.22E+00	N	1.22E+00	No	Daughter
Neptunium-237	27/125	-2.55E-01	4.00E+00	1.97E-01	6.90E-01	1.20E-02	4.26E+00	2.99E-01	D	2.99E-01	Yes	
Niobium-94	0/11	3.00E-02	7.00E-02	3.91E-02	1.14E-02			4.53E-02	D	4.53E-02	No	No detects
Plutonium-238	10/114	-2.55E-01	1.00E+00	4.57E-02	1.43E-01	8.30E-03	6.64E-01	6.80E-02	D	6.80E-02	Yes	
Plutonium-239	22/125	-2.55E-01	4.20E-01	8.57E-01	4.87E+00	8.90E-03	4.72E+01	1.58E+00	D	1.58E+00	Yes	
Potassium-40	60/62	8.00E-02	6.74E+01	1.32E+01	1.07E+01	2.42E+00	4.78E+01	1.55E+01	X	1.55E+01	Yes	
Protactinium-234m	32/98	-3.54E+01	5.20E+02	8.99E+00	5.37E+01	4.74E-01	8.99E+01	1.80E+01	D	1.80E+01	No	Daughter
Radium-226	50/51	1.15E+00	1.15E+00	1.14E+00	4.73E-01	-8.70E-02	2.26E+00	1.25E+00	N	1.25E+00	Yes	
Radium-228	66/66			1.58E+00	3.24E+00	5.29E-02	2.63E+01	2.25E+00	X	2.25E+00	No	Daughter
Ruthenium-106	0/1	2.30E+01	2.30E+01	2.30E+01					D		No	No detects
Strontium-90	12/66	-3.35E-01	1.00E+00	2.89E-01	5.08E-01	6.40E-01	2.21E+00	3.93E-01	D	3.93E-01	Yes	
Technetium-99	67/207	-3.93E+01	3.66E+01	2.51E+01	1.75E+02	-9.18E+00	2.09E+03	4.52E+01	D	4.52E+01	Yes	
Thallium-208	29/30	2.00E-03	2.00E-03	1.14E+00	3.16E+00	7.10E-02	1.73E+01	2.12E+00	X	2.12E+00	No	Daughter
Thorium-228	183/202	-6.55E-02	1.70E-01	9.60E-01	1.96E+00	9.65E-03	2.63E+01	1.19E+00	X	1.19E+00	No	Daughter
Thorium-230	192/202	2.00E-02	2.35E+00	4.95E+00	2.58E+01	1.06E-02	2.04E+02	7.95E+00	X	7.95E+00	Yes	
Thorium-232	193/202	1.93E-03	1.00E-02	9.18E-01	1.96E+00	6.71E-03	2.63E+01	1.15E+00	X	1.15E+00	Yes	
Thorium-234	110/128	-1.23E+01	5.03E+00	1.39E+01	4.31E+01	2.91E-01	2.35E+02	2.02E+01	X	2.02E+01	No	Daughter
Titanium-44	0/11	3.00E-02	8.00E-02	4.45E-02	1.63E-02			5.35E-02	D	5.35E-02	No	No detects
Uranium-234	205/211	-2.45E-01	1.17E+00	1.42E+01	6.31E+01	2.09E-01	4.90E+02	2.13E+01	X	2.13E+01	Yes	
Uranium-235	112/198	-1.41E+00	3.96E-01	9.38E-01	3.99E+00	-1.00E-02	3.20E+01	1.41E+00	X	1.41E+00	Yes	
Uranium-236	30/73	-7.68E-02	2.14E-01	8.02E-02	5.78E-02	3.79E-02	2.31E-01	9.15E-02	D	9.15E-02	Yes	
Uranium-238	205/211	0.00E+00	3.60E-01	9.03E+00	3.51E+01	1.33E-01	2.28E+02	1.30E+01	X	1.30E+01	Yes	

[a]Distribution flags:
D = Not determined because fewer than 5 detects or < 50% detects; t-statistic used in calculations of 95% upper confidence limit on the mean.
L = Lognormal; H-statistic used in calculations of 95% confidence limit on the mean.
N = Normal; t-statistic used in calculations of 95% confidence limit on the mean.
X = Neither normal nor lognormal; t-statistic used in calculations UCL 95.

[b]Justifications for not proceeding with screening:
No detects = analyte is never detected and is not screened further.
Daughter = short-lived daughter product of isotope that is measured.
Have isotopic data = total activity not considered for further screening due to presence of isotopic data.

*Chemical detected in the soil is an essential nutrient; although unlikely to be site-related, this essential nutrient will be screened against background.

Table A.2. Comparison of maximum detected surface soil analytes to risk-based PRGs[a] and background criteria to determine contaminants of potential concern at ETTP outside rover locations

Analyte	Max detect conc.	Resid. soil PRG[b]	Max detect > resid. PRG?	Indust. soil PRG[c]	Max detect > indust. PRG?	Backgd. conc.[d]	Max detect > backgd.?	COPC?[e]	Justification
Metals (mg/kg)									
Aluminum	5.96E+04	7.6E+03	Yes		N/A	4.3E+04	Yes	Yes	
Antimony	1.92E+01	3.1E+00	Yes	1.1E+01	Yes	7.6E-01	Yes	Yes	
Arsenic	4.72E+01	3.9E-01	Yes	3.3E+00	Yes	2.0E+01	Yes	Yes	
Barium	3.03E+02	5.4E+02	No	7.4E+03	No	1.5E+02	Yes	No	Max detect < resid. PRG
Beryllium	1.45E+02	1.5E+01	Yes	1.8E-01	Yes	2.0E+00	Yes	Yes	
Boron	1.14E+01	1.6E+03	No	1.7E+04	No	2.8E+01	No	No	Max detect < resid. PRG
Cadmium	1.56E+01	3.7E+00	Yes	3.2E+00	Yes	0.0E+00	Yes	Yes	
Calcium	2.63E+05		N/A		N/A	3.3E+03	Yes	No	Essential nutrient
Chromium	1.03E+02	2.2E+01	Yes	1.5E+02	No	5.4E+01	Yes	Yes	
Chromium, hexavalent	6.00E-01	2.2E+01	No	1.5E+02	No	5.4E+01	No	No	Max detect < resid. PRG
Cobalt	9.99E+01	1.4E+02	No		N/A	3.1E+01	Yes	No	Max detect < resid. PRG
Copper	1.05E+02	3.1E+02	No		N/A	3.6E+01	Yes	No	Max detect < resid. PRG
Iron	7.96E+04	2.3E+03	Yes		N/A	5.8E+04	Yes	No	Essential nutrient
Lead	2.80E+02	4.0E+02	No		N/A	5.8E+01	Yes	No	Max detect < resid. PRG
Lithium	4.91E+01	1.6E+02	No		N/A	3.6E+01	Yes	No	Max detect < resid. PRG
Magnesium	7.38E+04		N/A		N/A	4.4E+03	Yes	No	Essential nutrient
Manganese	4.91E+03	1.8E+02	Yes	3.3E+03	Yes	2.0E+03	Yes	Yes	
Mercury	1.30E+00	2.3E+00	No	3.2E+01	No	3.5E-01	Yes	No	Max detect < resid. PRG
Molybdenum	1.16E+01	3.9E+01	No	8.8E+02	No	5.3E+00	Yes	No	Max detect < resid. PRG
Nickel	1.69E+02	1.6E+02	Yes	3.3E+03	No	3.6E+01	Yes	Yes	
Potassium	1.65E+04		N/A		N/A	5.0E+03	Yes	No	Essential nutrient
Selenium	1.32E+01	3.9E+01	No	8.9E+02	No	1.1E+00	Yes	No	Max detect < resid. PRG
Silver	1.11E+01	3.9E+01	No	7.6E+02	No	0.0E+00	Yes	No	Max detect < resid. PRG
Sodium	5.20E+03		N/A		N/A	4.9E+02	Yes	No	Essential nutrient
Strontium	1.87E+02	4.7E+03	No	9.3E+04	No	2.2E+01	Yes	No	Max detect < resid. PRG
Thallium	1.35E+01	5.2E-01	Yes	7.2E+00	Yes	5.4E-01	Yes	Yes	
Uranium	1.07E+01	1.6E+00	Yes	5.7E+02	No		N/A	Yes	
Vanadium	9.55E+01	5.5E+01	Yes	2.0E+02	No	8.3E+01	Yes	Yes	
Zinc	1.30E+03	2.3E+03	No	4.7E+04	No	1.7E+02	Yes	No	Max detect < resid. PRG
Polychlorinated biphenyls (mg/kg)									
PCB-1016	1.20E-01	3.9E-01	No	4.8E-01	No		N/A	No	Max detect < resid. PRG
PCB-1221	1.20E-01	2.2E-01	No	5.5E-01	No		N/A	No	Max detect < resid. PRG
PCB-1232	1.20E-01	2.2E-01	No	5.5E-01	No		N/A	No	Max detect < resid. PRG
PCB-1242	1.20E-01	2.2E-01	No	4.6E-01	No		N/A	No	Max detect < resid. PRG

Table A.2. Comparison of maximum detected surface soil analytes to risk-based PRGs[a] and background criteria to determine contaminants of potential concern at ETTP outside rover locations (continued)

Analyte	Max detect conc.	Resid. soil PRG[b]	Max detect > resid. PRG?	Indust. soil PRG[c]	Max detect > indust. PRG?	Backgd. conc.[d]	Max detect > backgd.?	COPC?[e]	Justification
PCB-1248	1.60E-01	2.2E-01	No	5.5E-01	No		N/A	No	Max detect < resid. PRG
PCB-1254	1.20E+00	1.1E-01	Yes	4.9E-01	Yes		N/A	Yes	
PCB-1260	1.00E+00	2.2E-01	Yes	4.8E-01	Yes		N/A	Yes	
Semivolatile organic compounds (mg/kg)									
2,2'-Dichlorodiisopropyl ether	3.00E-02	2.9E+00	No	3.6E+03	No		N/A	No	Max detect < resid. PRG
2,4-Dichlorophenol	1.50E-01	1.8E+01	No	3.5E+02	No		N/A	No	Max detect < resid. PRG
2,4-Dimethylphenol	4.10E-02	1.2E+02	No	1.8E+03	No		N/A	No	Max detect < resid. PRG
2,4-Dinitrophenol	3.50E-02	1.2E+01	No	2.5E+02	No		N/A	No	Max detect < resid. PRG
2,4-Dinitrotoluene	1.10E-01	7.2E-01	No	4.8E+00	No		N/A	No	Max detect < resid. PRG
2,6-Dinitrotoluene	4.80E-02	7.2E-01	No	4.8E+00	No		N/A	No	Max detect < resid. PRG
2-Chloronaphthalene	1.90E-01	4.9E+02	No	7.2E+03	No		N/A	No	Max detect < resid. PRG
2-Methylnaphthalene	3.30E+00		N/A		N/A		N/A	Yes	
2-Methylphenol	7.00E-02	3.1E+02	No	4.5E+03	No		N/A	No	Max detect < resid. PRG
2-Nitrobenzenamine	5.30E-02	1.7E-01	No	3.8E-01	No		N/A	No	Max detect < resid. PRG
3,3'-Dichlorobenzidine	5.80E-02	1.1E+00	No	5.6E+00	No		N/A	No	Max detect < resid. PRG
3-Nitrobenzenamine	7.00E-02		N/A		N/A		N/A	Yes	
4-Chloro-3-methylphenol	2.90E-02		N/A		N/A		N/A	Yes	
4-Chlorobenzenamine	4.20E-01	2.4E+01	No	3.6E+02	No		N/A	No	Max detect < resid. PRG
4-Methylphenol	3.50E-02	3.1E+01	No	5.2E+02	No		N/A	No	Max detect < resid. PRG
4-Nitrobenzenamine	2.80E-02		N/A		N/A		N/A	Yes	
4-Nitrophenol	8.50E-02		N/A		N/A		N/A	Yes	
Acenaphthene	2.30E-01	3.7E+02	No	4.0E+03	No		N/A	No	Max detect < resid. PRG
Acenaphthylene	3.20E+00		N/A		N/A		N/A	Yes	
Anthracene	2.70E+00	2.2E+03	No	3.3E+04	No		N/A	No	Max detect < resid. PRG
Benz(*a*)anthracene	1.80E+01	6.2E-01	Yes	2.6E+00	Yes		N/A	Yes	
Benzo(*a*)pyrene	2.20E+01	6.2E-02	Yes	2.6E-01	Yes		N/A	Yes	
Benzo(*b*)fluoranthene	2.10E+01	6.2E-01	Yes	2.6E+00	Yes		N/A	Yes	
Benzo(*g,h,i*)perylene	1.60E+01		N/A		N/A		N/A	Yes	
Benzo(*k*)fluoranthene	1.90E+01	6.2E+00	Yes	2.6E+01	No		N/A	Yes	
Bis(2-chloroethoxy)methane	3.50E-02		N/A		N/A		N/A	Yes	
Bis(2-chloroethyl) ether	2.60E-02	2.1E-01	No	3.8E-01	No		N/A	No	Max detect < resid. PRG
Bis(2-ethylhexyl)phthalate	3.10E+00	3.5E+01	No	9.4E+01	No		N/A	No	Max detect < resid. PRG
Butyl benzyl phthalate	1.20E-01	1.2E+03	No	2.0E+04	No		N/A	No	Max detect < resid. PRG
Carbazole	1.00E+00	2.4E+01	No	1.5E+02	No		N/A	No	Max detect < resid. PRG
Chrysene	2.00E+01	6.2E+01	No	2.5E+02	No		N/A	No	Max detect < resid. PRG

Table A.2. Comparison of maximum detected surface soil analytes to risk-based PRGs[a] and background criteria to determine contaminants of potential concern at ETTP outside rover locations (continued)

Analyte	Max detect conc.	Resid. soil PRG[b]	Max detect > resid. PRG?	Indust. soil PRG[c]	Max detect > indust. PRG?	Backgd. conc.[d]	Max detect > backgd.?	COPC?[e]	Justification
Di-n-butyl phthalate	2.60E+00	6.1E+02	No	1.3E+04	No		N/A	No	Max detect < resid. PRG
Di-n-octylphthalate	1.20E-01	2.4E+02	No	2.4E+03	No		N/A	No	Max detect < resid. PRG
Dibenz(*a,h*)anthracene	3.90E+00	6.2E-02	Yes	2.6E-01	Yes		N/A	Yes	
Dibenzofuran	1.00E+00	2.9E+01	No	4.6E+02	No		N/A	No	Max detect < resid. PRG
Diethyl phthalate	4.80E-01	4.9E+03	No	9.6E+04	No		N/A	No	Max detect < resid. PRG
Diphenylamine	5.80E-02	1.5E+02	No	2.3E+03	No		N/A	No	Max detect < resid. PRG
Fluoranthene	2.90E+01	2.3E+02	No	2.7E+03	No		N/A	No	Max detect < resid. PRG
Fluorene	6.60E-01	2.7E+02	No	3.6E+03	No		N/A	No	Max detect < resid. PRG
Indeno(1,2,3-*cd*)pyrene	1.80E+01	6.2E-01	Yes	2.6E+00	Yes		N/A	Yes	
Naphthalene	2.30E+00	5.6E+00	No	2.7E+01	No		N/A	No	Max detect < resid. PRG
Nitrobenzene	5.70E-02	2.0E+00	No	1.2E+01	No		N/A	No	Max detect < resid. PRG
Pentachlorophenol	4.02E-01	3.0E+00	No	2.9E+01	No		N/A	No	Max detect < resid. PRG
Phenanthrene	5.70E+00		N/A		N/A		N/A	Yes	
Phenol	2.30E-01	3.7E+03	No	7.2E+04	No		N/A	No	Max detect < resid. PRG
Pyrene	2.60E+01	2.3E+02	No	2.0E+03	No		N/A	No	Max detect < resid. PRG
Volatile organic compounds (mg/kg)									
1,1,1-Trichloroethane	1.08E-02	2.0E+02	No	7.6E+02	No		N/A	No	Max detect < resid. PRG
1,1,2,2-Tetrachloroethane	8.60E-04	4.1E-01	No	1.0E+00	No		N/A	No	Max detect < resid. PRG
1,2-Dimethylbenzene	3.60E-03		N/A	2.3E+05	No		N/A	Yes	
Acetone	9.78E-02	1.6E+02	No	1.2E+04	No		N/A	No	Max detect < resid. PRG
Benzene	9.20E-03	6.0E-01	No	1.6E+00	No		N/A	No	Max detect < resid. PRG
Chloroform	2.70E-04	3.6E-01	No	5.2E-01	No		N/A	No	Max detect < resid. PRG
Dimethylbenzene	2.75E-02	2.7E+01	No	2.4E+05	No		N/A	No	Max detect < resid. PRG
Ethylbenzene	5.30E-03	8.9E+00	No	2.2E+01	No		N/A	No	Max detect < resid. PRG
Methylene chloride	9.80E-03	9.1E+00	No	2.3E+01	No		N/A	No	Max detect < resid. PRG
Toluene	1.45E-02	6.6E+01	No	2.5E+02	No		N/A	No	Max detect < resid. PRG
Radionuclides (pCi/g)									
Americium-241	1.50E-01	2.2E+00	No	8.0E+00	No	0.0E+00	Yes	No	Max detect < resid. PRG
Cesium-137	4.80E+01	2.1E-02	Yes	1.0E-01	Yes	1.0E+00	Yes	Yes	
Cobalt-60	1.20E-01	4.5E-03	Yes	2.2E-02	Yes	0.0E+00	Yes	Yes	
Neptunium-237	4.26E+00	9.1E-02	Yes	4.5E-01	Yes	1.9E-01	Yes	Yes	
Plutonium-238	6.64E-01	2.7E+00	No	1.1E+01	No	1.7E-01	Yes	No	Max detect < resid. PRG
Plutonium-239	4.72E+01	2.5E+00	Yes	1.0E+01	Yes	5.1E-02	Yes	Yes	
Potassium-40	4.78E+01	7.1E-02	Yes	3.6E-01	Yes	3.4E+01	Yes	Yes	
Radium-226	2.26E+00	2.8E-03	Yes	6.7E-03	Yes	2.6E+00	No	No	Max detect < backgd.

Table A.2. Comparison of maximum detected surface soil analytes to risk-based PRGs[a] and background criteria to determine contaminants of potential concern at ETTP outside rover locations (continued)

Analyte	Max detect conc.	Resid. soil PRG[b]	Max detect > resid. PRG?	Indust. soil PRG[c]	Max detect > indust. PRG?	Backgd. conc.[d]	Max detect > backgd.?	COPC?[e]	Justification
Strontium-90	2.21E+00	1.4E+01	No	5.7E+01	No	1.1E+00	Yes	No	Max detect < resid. PRG
Technetium-99	2.09E+03	5.7E+02	Yes	2.3E+03	No	0.0E+00	Yes	Yes	
Thorium-230	2.04E+02	2.1E+01	Yes	8.1E+01	Yes	1.9E+00	Yes	Yes	
Thorium-232	2.63E+01	2.4E+01	Yes	9.3E+01	No	2.1E+00	Yes	Yes	
Uranium-234	4.90E+02	1.8E+01	Yes	7.0E+01	Yes	2.2E+00	Yes	Yes	
Uranium-235	3.20E+01	1.6E-01	Yes	8.2E-01	Yes	1.6E+00	Yes	Yes	
Uranium-236	2.31E-01	1.9E+01	No	7.4E+01	No	1.7E-01	Yes	No	Max detect < resid. PRG
Uranium-238	2.28E+02	6.3E-01	Yes	3.1E+00	Yes	2.3E+00	Yes	Yes	

Only detected data passing through the first screen (see Table A.1) are shown.

COPC = contaminant of potential concern.

[a]PRG = preliminary remediation goal, at the 10^{-6} risk level or the 0.1 hazard level (whichever is smaller).

[b]Chemical (i.e., nonradiological) residential PRGs are from U. S. Environmental Protection Agency Region IX. Radiological residential PRGs are from Oak Ridge National Laboratory (ORNL).

[c]Chemical and radiological industrial PRGs are from ORNL.

[d]Contaminants never detected in background are assumed to have a background criteria of 0.0 (zero).

[e]Contaminants detected above their respective residential soil PRG and background levels are considered to be COPCs. Detected contaminants without a PRG or background screening value are retained as COPCs.

Table A.3. Type of evaluation of COPCs in surface soil at ETTP outside rover locations

Analyte	Quantitative COPC	Qualitative[a] COPC
	Metals	
Aluminum		✔
Antimony	✔	
Arsenic	✔	
Beryllium	✔	
Cadmium	✔	
Chromium	✔	
Manganese	✔	
Nickel	✔	
Thallium	✔	
Uranium	✔	
Vanadium	✔	
	PCBs	
PCB-1254	✔	
PCB-1260	✔	
	VOCs	
1,2-Dimethylbenzene	✔	
	SVOCs	
2-Methylnaphthalene		✔
3-Nitrobenzenamine		✔
4-Chloro-3-methylphenol		✔
4-Nitrobenzenamine		✔
4-Nitrophenol		✔
Acenaphthylene		✔
Benz(*a*)anthracene	✔	
Benzo(*a*)pyrene	✔	
Benzo(*b*)fluoranthene	✔	
Benzo(*g,h,i*)perylene		✔
Benzo(*k*)fluoranthene	✔	
Bis(2-chloroethoxy)methane		✔
Dibenz(*a,h*)anthracene	✔	
Indeno(1,2,3-*cd*)pyrene	✔	
Phenanthrene		✔
	Radionuclides	
Cesium-137	✔	
Cobalt-60	✔	
Neptunium-237	✔	
Plutonium-239	✔	
Potassium-40	✔	
Technetium-99	✔	
Thorium-230	✔	
Thorium-232	✔	
Uranium-234	✔	
Uranium-235	✔	
Uranium-238	✔	

[a]Based on the lack of available toxicity information, some COPCs were evaluated qualitatively.
COPC = contaminant of potential concern.
ETTP = East Tennessee Technology Park.
PCB = polychlorinated biphenyl.
SVOC = semivolatile organic compound.
VOC = volatile organic compound.

Table A.4. Parameters for evaluation of exposures to soil at ETTP outside rover locations

Pathway	EF (d/year)	ED (year)	BW (kg)	AT_{carc} (d)	AT_{nonc} (d)	CF (various)[a]	IR_{soil} (kg/d)	FI (unitless)	IR_{air} (m^3/d)	SA (m^2/d)	AF (mg/cm^2)	SE (unitless)	TE (h/h)	$EF_{ext.exp.}$ (d/d)
ETTP rover outside Main Plant fence														
Ingestion	250	5	70	25550	1825	1000.00	0.000050	1.0						
Dermal	250	5	70	25550	1825	0.01				0.316	1.0			
Inhalation	250	5	70	25550	1825	1000.00			20					
External Exposure		5										0.2	2/24	250/365

[a]Conversion factor units:
1000 g/kg for ingestion and inhalation of soil (applies to radionuclides only).
0.01 (kg-cm^2)/(mg-m^2) for dermal exposure to soil [(10^{-6} kg/mg) × (10^4 cm^2/m^2)].
Other factors used:
ABS = dermal absorption factor; value is 0.001 (0.1%) for inorganics and 0.01 (1%) for organics (unitless).
PEF = 5.38E+09 m^3/kg for the inhalation pathway.
VF in m^3/kg is analyte-specific (used for volatile organics only for the inhalation pathway).

Table A.5. Toxicity values[a] for COPCs in surface soil at ETTP outside rover locations

		Non-carcinogenic toxicity values			Carcinogenic toxicity values				Other parameters used		
COPC	G. I. absorp. factor[b]	Oral chronic RfD[c]	Dermal chronic RfD[c]	Inhalation chronic RfD[e]	Oral slope factor[d]	Dermal slope factor[e]	Inhalation slope factor[f]	External exposure slope factor[g]	Dermal ABS factor[h]	PEF[i]	VF[j]
Non-radionuclides											
1,2-Dimethylbenzene	0.8	2.00E+00	1.60E+00						0.01	5.38E+09	6.80E+03
Antimony	0.02	4.00E-04	8.00E-06						0.001	5.38E+09	
Arsenic	0.41	3.00E-04	1.23E-04		1.50E+00	3.66E+00	1.51E+01		0.001	5.38E+09	
Benz(*a*)anthracene	0.31				7.30E-01	2.35E+00	3.10E-01		0.01	5.38E+09	1.05E+07
Benzo(*a*)pyrene	0.31				7.30E+00	2.35E+01	3.10E+00		0.01	5.38E+09	2.72E+07
Benzo(*b*)fluoranthene	0.31				7.30E-01	2.35E+00	3.10E-01		0.01	5.38E+09	5.13E+06
Benzo(*k*)fluoranthene	0.31				7.30E-02	2.35E-01	3.10E-02		0.01	5.38E+09	4.37E+07
Beryllium	0.01	2.00E-03	2.00E-05	5.71E-06			8.40E+00		0.001	5.38E+09	
Cadmium	0.01	1.00E-03	1.00E-05				6.30E+00		0.01	5.38E+09	
Chromium	0.02	3.00E-03	6.00E-05	2.86E-05			4.20E+01		0.001	5.38E+09	
Dibenz(*a,h*)anthracene	0.31				7.30E+00	2.35E+01	3.10E+00		0.01	5.38E+09	1.16E+08
Indeno(1,2,3-*cd*)pyrene	0.31				7.30E-01	2.35E+00	3.10E-01		0.01	5.38E+09	6.33E+07
Manganese	0.04	4.60E-02	1.84E-03	1.43E-05					0.001	5.38E+09	
Nickel	0.27	2.00E-02	5.40E-03						0.001	5.38E+09	
PCB-1254	0.9	2.00E-05	1.80E-05		2.00E+00	2.22E+00	2.00E+00		0.06	5.38E+09	5.89E+05
PCB-1260	0.9				2.00E+00	2.22E+00	2.00E+00		0.06	5.38E+09	4.97E+05
Thallium	0.5	8.00E-05	4.00E-05						0.01	5.38E+09	
Uranium	0.85	6.00E-04	5.10E-04						0.001	5.38E+09	
Vanadium	0.01	7.00E-03	7.00E-05						0.001	5.38E+09	
Radionuclides											
Cesium-137	1				3.17E-11		1.19E-11	2.55E-06		5.38E+09	
Cobalt-60	0.1				7.33E-12		3.58E-11	1.24E-05		5.38E+09	
Neptunium-237	0.0005				4.92E-11		1.77E-08	7.97E-07		5.38E+09	
Plutonium-239	0.0005				1.21E-10		3.33E-08	2.00E-10		5.38E+09	
Potassium-40	1				1.51E-11		1.03E-11	7.97E-07		5.38E+09	
Technetium-99	0.5				1.32E-12		1.41E-11	8.14E-11		5.38E+09	
Thorium-230	0.0005				7.73E-11		2.85E-08	8.19E-10		5.38E+09	
Thorium-232	0.0005				8.47E-11		4.33E-08	3.42E-10		5.38E+09	
Uranium-234	0.02				5.11E-11		1.14E-08	2.52E-10		5.38E+09	
Uranium-235	0.02				5.03E-11		1.01E-08	5.43E-07		5.38E+09	

Table A.5. Toxicity values[a] for COPCs in surface soil at ETTP outside rover locations (continued)

		Non-carcinogenic toxicity values			Carcinogenic toxicity values				Other parameters used		
COPC	G. I. absorp. factor[b]	Oral chronic RfD[c]	Dermal chronic RfD[c]	Inhalation chronic RfD[c]	Oral slope factor[d]	Dermal slope factor[e]	Inhalation slope factor[f]	External exposure slope factor[g]	Dermal ABS factor[h]	PEF[i]	VF[j]
Uranium-238	0.02				5.62E-11		9.35E-09	1.14E-07		5.38E+09	

[a]Toxicity data are from http://risk.lsd.ornl.gov/tox/tox_values.html.
[b]Gastrointestinal absorption factor; unitless.
[c]Units for reference doses (RfDs) are mg/kg-d.
[d]Units for oral slope factors are $(mg/kg\text{-}d)^{-1}$ for chemicals and risk/pCi for radionuclides.
[e]Units for dermal slope factors are $(mg/kg\text{-}d)^{-1}$ (for chemicals only).
[f]Units for inhalation slope factors are $(mg/kg\text{-}d)^{-1}$ for chemicals and risk/pCi for radionuclides.
[g]Units for external exposure slope factors are (risk/year per pCi/g) [for radionuclides only].
[h]Dermal absorption factor; unitless (for chemicals only).
[i]Particulate Emission Factor, in m^3/kg.
[j]Volatilization Factor, in m^3/kg (only used for VOCs).
COPC = contaminant of potential concern.
ETTP = East Tennessee Technology Park.

Table A.6. Cancer risks from exposure to surface soil at ETTP outside rover locations

COPC	EPC[a]	Cancer intakes[b]				Cancer risks					COC?[c]
		Ingestion	Dermal	Inhalation	External exposure	Ingestion	Dermal	Inhalation	External exposure	Total	
ETTP rover outside Main Plant fence											
Arsenic	1.66E+01	5.8E-07	3.7E-08	4.3E-11		8.7E-07	1.3E-07	6.5E-10		1.0E-06	
Beryllium	4.61E+00	1.6E-07	1.0E-08	1.2E-11				1.0E-10		1.0E-10	
Cadmium	1.31E+00	4.6E-08	2.9E-08	3.4E-12				2.1E-11		2.1E-11	
Chromium	2.86E+01	1.0E-06	6.3E-08	7.4E-11				3.1E-09		3.1E-09	
Inorganics pathway total						8.7E-07	1.3E-07	7.7E-10		1.0E-06	
Benz(*a*)anthracene	1.44E+00	5.0E-08	3.2E-08	3.7E-12		3.7E-08	7.5E-08	1.2E-12		1.1E-07	
Benzo(*a*)pyrene	1.86E+00	6.5E-08	4.1E-08	4.8E-12		4.7E-07	9.7E-07	1.5E-11		1.4E-06	
Benzo(*b*)fluoranthene	2.00E+00	7.0E-08	4.4E-08	5.2E-12		5.1E-08	1.0E-07	1.6E-12		1.6E-07	
Benzo(*k*)fluoranthene	1.79E+00	6.3E-08	4.0E-08	4.7E-12		4.6E-09	9.3E-09	1.4E-13		1.4E-08	
Dibenz(*a,h*)anthracene	8.75E-01	3.1E-08	1.9E-08	2.3E-12		2.2E-07	4.6E-07	7.0E-12		6.8E-07	
Indeno(1,2,3-*cd*)pyrene	1.57E+00	5.5E-08	3.5E-08	4.1E-12		4.0E-08	8.2E-08	1.3E-12		1.2E-07	
PCB-1254	9.49E-02	3.3E-09	1.3E-08	2.5E-13		6.6E-09	2.8E-08	4.9E-13		3.5E-08	
PCB-1260	8.21E-02	2.9E-09	1.1E-08	2.1E-13		5.7E-09	2.4E-08	4.3E-13		3.0E-08	
Organics pathway total						8.4E-07	1.7E-06	2.7E-11		2.6E-06	
Chemicals pathway total						1.7E-06	1.9E-06	3.9E-09		3.6E-06	
Cesium-137	1.07E+00	6.7E+01		5.0E-03	2.4E-01	2.1E-09		5.9E-14	6.2E-07	6.2E-07	
Cobalt-60	1.91E-02	1.2E+00		8.9E-05	4.4E-03	8.8E-12		3.2E-15	5.4E-08	5.4E-08	
Neptunium-237	2.99E-01	1.9E+01		1.4E-03	6.8E-02	9.2E-10		2.5E-11	5.4E-08	5.5E-08	
Plutonium-239	1.58E+00	9.9E+01		7.3E-03	3.6E-01	1.2E-08		2.4E-10	7.2E-11	1.2E-08	
Potassium-40	1.55E+01	9.7E+02		7.2E-02	3.5E+00	1.5E-08		7.4E-13	2.8E-06	2.8E-06	
Technetium-99	4.52E+01	2.8E+03		2.1E-01	1.0E+01	3.7E-09		3.0E-12	8.4E-10	4.6E-09	
Thorium-230	7.95E+00	5.0E+02		3.7E-02	1.8E+00	3.8E-08		1.1E-09	1.5E-09	4.1E-08	
Thorium-232	1.15E+00	7.2E+01		5.3E-03	2.6E-01	6.1E-09		2.3E-10	8.9E-11	6.4E-09	
Uranium-234	2.13E+01	1.3E+03		9.9E-02	4.9E+00	6.8E-08		1.1E-09	1.2E-09	7.1E-08	
Uranium-235	1.41E+00	8.8E+01		6.5E-03	3.2E-01	4.4E-09		6.6E-11	1.7E-07	1.8E-07	
Uranium-238	1.30E+01	8.1E+02		6.0E-02	3.0E+00	4.6E-08		5.7E-10	3.4E-07	3.9E-07	

Table A.6. Cancer risks from exposure to surface soil at ETTP outside rover locations (continued)

		Cancer intakes[b]				Cancer risks					
COPC	EPC[a]	Ingestion	Dermal	Inhalation	External exposure	Ingestion	Dermal	Inhalation	External exposure	Total	COC?[c]
Radionuclides pathway total						2.0E-07		3.3E-09	4.1E-06	4.3E-06	

[a]EPC = exposure point concentration, defined as the smaller value between the maximum detected concentration and the UCL95; units are mg/kg for chemicals and pCi/g for radionuclides.

[b]Units for cancer intakes are (mg/kg-d) for chemicals; pCi for radiological ingestion and inhalation; and pCi-year/g for external exposure.

[c]COC = contaminant of concern. When the total risk > 10^{-4}, then any individual contaminant with risk > 10^{-6} is a COA. As seen there are no carcinogenic COCs for either receptor.

COPC = contaminant of potential concern.

ETTP = East Tennessee Technology Park.

Table A.7. Non-carcinogenic hazards from exposure to surface soil at ETTP outside rover locations

COPC	EPC[a]	Non-carcinogenic intakes[b]			Hazard quotients				COC?[c]
		Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation	Total	
ETTP rover outside Main Plant fence									
Antimony	4.09E+00	2.0E-06	1.3E-07	1.5E-10	5.0E-03	1.6E-02		2.1E-02	
Arsenic	1.66E+01	8.1E-06	5.1E-07	6.0E-10	2.7E-02	4.2E-03		3.1E-02	
Beryllium	4.61E+00	2.3E-06	1.4E-07	1.7E-10	1.1E-03	7.1E-03	2.9E-05	8.3E-03	
Cadmium	1.31E+00	6.4E-07	4.1E-07	4.8E-11	6.4E-04	4.1E-02		4.1E-02	
Chromium	2.86E+01	1.4E-05	8.9E-07	1.0E-09	4.7E-03	1.5E-02	3.6E-05	1.9E-02	
Manganese	1.35E+03	6.6E-04	4.2E-05	4.9E-08	1.4E-02	2.3E-02	3.4E-03	4.0E-02	
Nickel	3.73E+01	1.8E-05	1.2E-06	1.4E-09	9.1E-04	2.1E-04		1.1E-03	
Thallium	5.59E+00	2.7E-06	1.7E-06	2.0E-10	3.4E-02	4.3E-02		7.7E-02	
Uranium	5.19E+00	2.5E-06	1.6E-07	1.9E-10	4.2E-03	3.1E-04		4.5E-03	
Vanadium	4.27E+01	2.1E-05	1.3E-06	1.6E-09	3.0E-03	1.9E-02		2.2E-02	
Inorganics pathway total					9.5E-02	1.7E-01	3.5E-03	2.7E-01	
1,2-Dimethylbenzene	3.60E-03	1.8E-09	1.1E-09	1.0E-07	8.8E-10	7.0E-10		1.6E-09	
PCB-1254	9.49E-02	4.6E-08	1.8E-07	3.5E-12	2.3E-03	9.8E-03		1.2E-02	
Organics pathway total					2.3E-03	9.8E-03		1.2E-02	
Chemicals pathway total					9.7E-02	1.8E-01	3.5E-03	2.8E-01	

[a]EPC = exposure point concentration, defined as the smaller value between the maximum detected concentration and the 95% upper confidence limit (UCL95); units are in mg/kg.

[b]Units for non-carcinogenic intakes are mg/kg-d.

[c]COC = Contaminant of Concern. When the total hazard $\geq$ 1.0, then any individual contaminant with a hazard $\geq$ 0.1 is a COA. As seen there are no non-carcinogenic COCs for either receptor.

COPC = contaminant of potential concern.

ETTP = East Tennessee Technology Park.

PCB = polychlorinated biphenyl.

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