DOE/OR/21548-910

Post-Remediation Risk Assessment for the Chemical Plant Operable Unit, Weldon Spring Site, St. Charles, Missouri

March 2002
Rev. 1

prepared by
Environmental Assessment Division, Argonne National Laboratory

prepared for
U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, under Contract W-31-109-ENG-38

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NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document. Acronyms used only in tables are defined in the respective tables.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

BEIR	Committee on the Biological Effects of Ionizing Radiation
COC	contaminant of concern
CU	confirmation unit
DA	U.S. Department of the Army
DOE	U.S. Department of Energy
EE/CA	engineering evaluation/cost assessment
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic
MDC	Missouri Department of Conservation
RFC	reference concentration
RFD	reference dose
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
UCL	upper confidence limit
VP	vicinity property
WL	working level
WLM	working level month

UNITS OF MEASURE

cm	centimeter(s)	m^2	square meter(s)
cpm	count(s) per minute	m^3	cubic meter(s)
d	day(s)	MeV	megaelectron volt(s)
dL	decaliter(s)	mg	milligram(s)
ft^2	square foot (feet)	mi	mile(s)
g	gram(s)	mrem	millirem(s)
h	hour(s)	mo	month(s)
ha	hectare(s)	pCi	picocurie(s)
in.	inch(es)	µg	microgram(s)
kg	kilogram(s)	yd^3	cubic yard(s)
km	kilometer(s)	yr	year(s)

POST-REMEDIATION RISK ASSESSMENT FOR THE CHEMICAL PLANT OPERABLE UNIT, WELDON SPRING SITE, ST. CHARLES, MISSOURI

1 INTRODUCTION

The U.S. Department of Energy (DOE) is completing the remedial action that addresses soil and structural contamination at the Weldon Spring Site Chemical Plant. A Record of Decision (ROD) stipulating the remedial action was approved in 1993 (DOE 1993). This ROD also required that a risk assessment be performed after the cleanup has been completed to identify potential residual risk levels that can be considered in upcoming decisions regarding the site. This report presents the results of the risk calculations performed in fulfillment of this requirement.

The Weldon Spring Chemical Plant is located in St. Charles County, Missouri, about 48 km (30 mi) west of St. Louis (Figure 1.1). The Weldon Spring site is composed of the Chemical Plant and a quarry. The quarry is located about 6.4 km (4 mi) south-southwest of the Chemical Plant.

Remediation of the Weldon Spring Site is being addressed through four operable units, consistent with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. The first operable unit, the Quarry Bulk Waste operable unit, was completed in 1998. The second, the Chemical Plant operable unit, which is the subject of this report, is about to be completed. The third and fourth operable units are ongoing and address the remainder of the contamination at the quarry area after bulk waste removal and remediation of the contaminated groundwater at the Chemical Plant Area, respectively.

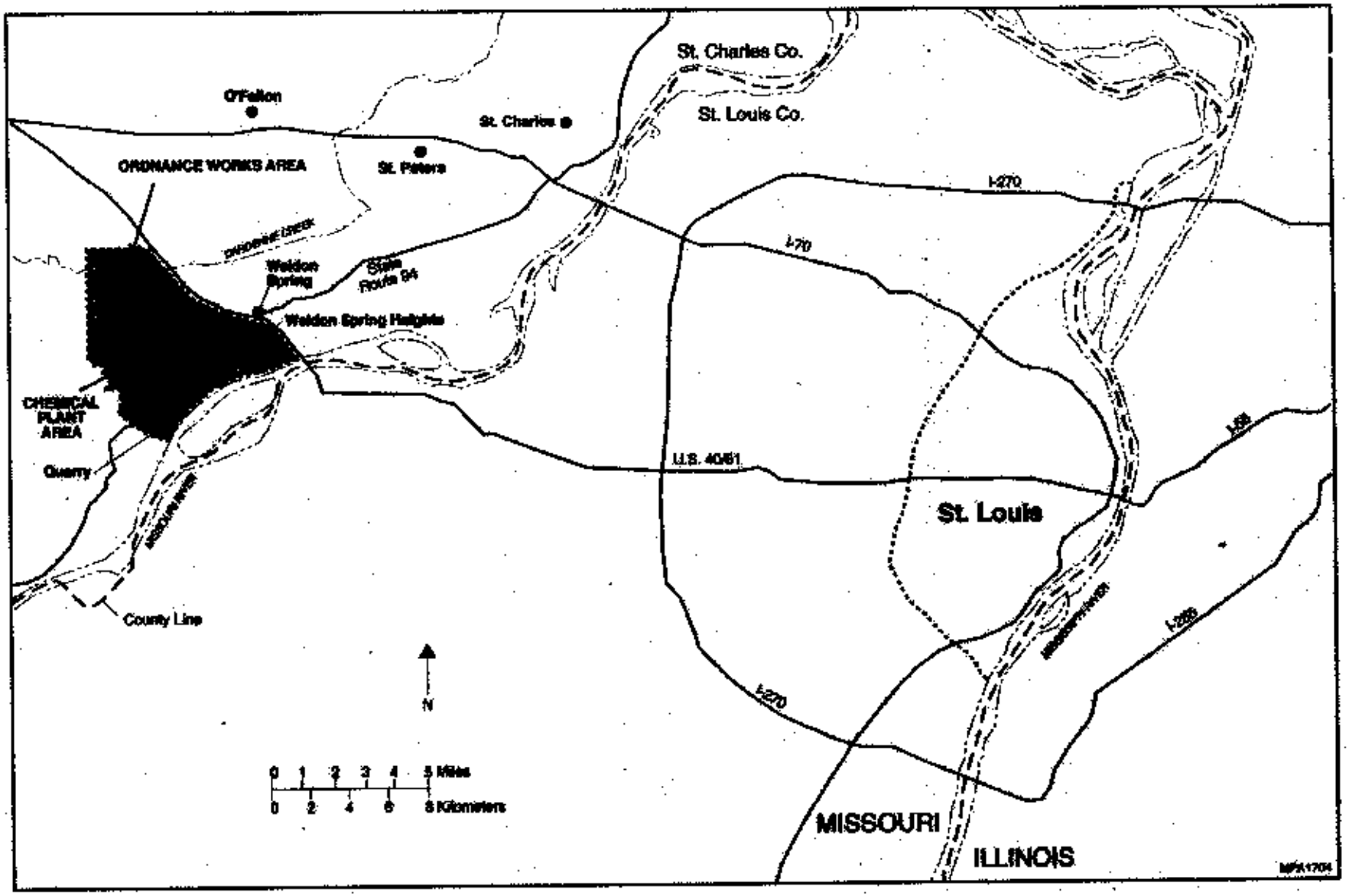

FIGURE 1.1 Location of the Weldon Spring Site

2 BACKGROUND

The Weldon Spring Chemical Plant is an 88-ha (217-acre) area that previously included 44 buildings, 4 raffinate pits, 2 ponds (Ash Pond and Frog Pond), and 2 former dump areas (north dump and south dump) (Figure 2.1). The raffinate pits covered about 10 ha (26 acres) in the southwest portion of the site. The Ash Pond, which was located in the northwestern portion of the site, covered about 4.5 ha (11 acres), and the Frog Pond, which was located in the northeastern part of the site, covered about 0.3 ha (0.7 acres). In addition to these areas, 13 vicinity properties (VPs) were also included for soil remediation. Four other VPs were remediated previous to the approval of the ROD. The VPs are located at the adjacent U.S. Department of the Army (DA) Ordnance Works Area and the Missouri Department of Conservation (MDC) areas (Figure 2.2). These VPs are listed in Table 2.1.

The remedial investigation/feasibility study (RI/FS; DOE 1992a,b,c) conducted to support the ROD of 1993 identified radiological and chemical contamination in the soil and structures at the Chemical Plant and primarily radiological contamination in soil at the VPs. Table 2.2 gives the contaminants of concern (COCs) and cleanup standards identified in the ROD (DOE 1993).

The remedial action contained in the ROD stipulated that the sludge from the raffinate pits be dredged and chemically stabilized and solidified and that contaminated soil from specific locations, including the Ash Pond; Frog Pond; the two dump areas; areas surrounding the 44 buildings, including building foundations; and at 13 VPs be excavated. This was accomplished through work packages that established various work zones such as those shown in Figure 2.3.

Two of the 13 VPs, that is, DA 4 and MDC 7, make up the Southeast Drainage. This area was addressed as a separate removal action. An engineering evaluation/cost assessment (EE/CA) (ANL 1996) was prepared to support the removal action that was completed in 1998.

The Chemical Plant ROD (DOE 1993) also stipulated that all site-generated waste materials (including the quarry bulk waste) be permanently disposed of in an on-site disposal cell. The design and construction of the on-site engineered disposal cell were primary components of the remedial action.

The raffinate pit sludge was chemically stabilized and solidified by mixing fly ash and portland cement to produce a grout that could be placed in the cell for permanent disposal. Approximately 93,000 m^3 (122,000 yd^3) of sludge was treated, and 142,000 m^3 (186,000 yd^3) of grout was produced for placement in the cell.

The intent of the soil remediation for the Chemical Plant Operable Unit is to meet the ALARA (as low as reasonably achievable) goals identified in the ROD (DOE 1993) and presented in Table 2.2. The remediation was designed to remove all soil and sludge containing contaminant concentrations greater than the ALARA goals. Contaminant concentrations

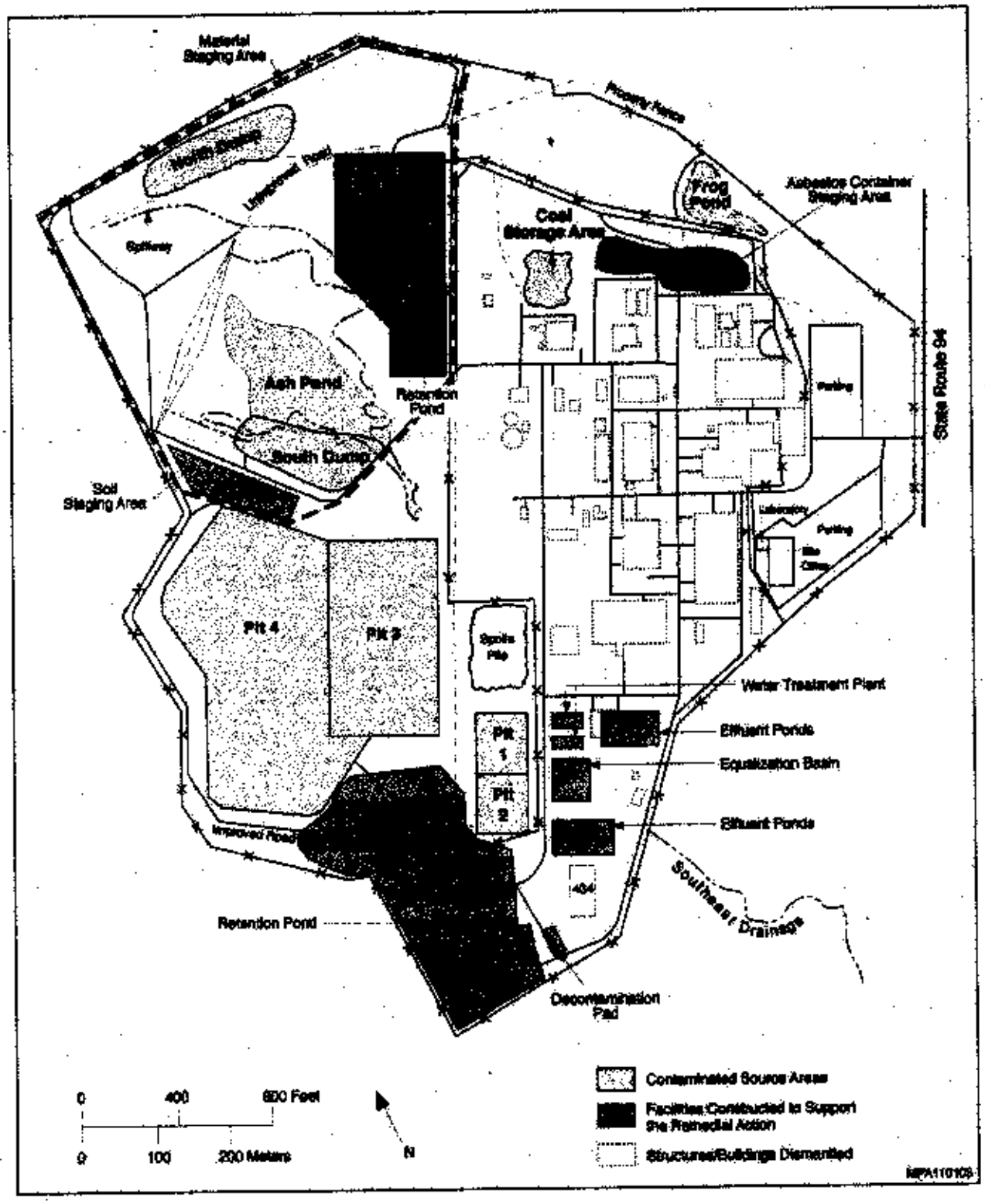

FIGURE 2.1 General Layout of the Weldon Spring Site Chemical Plant before the Remedial Action

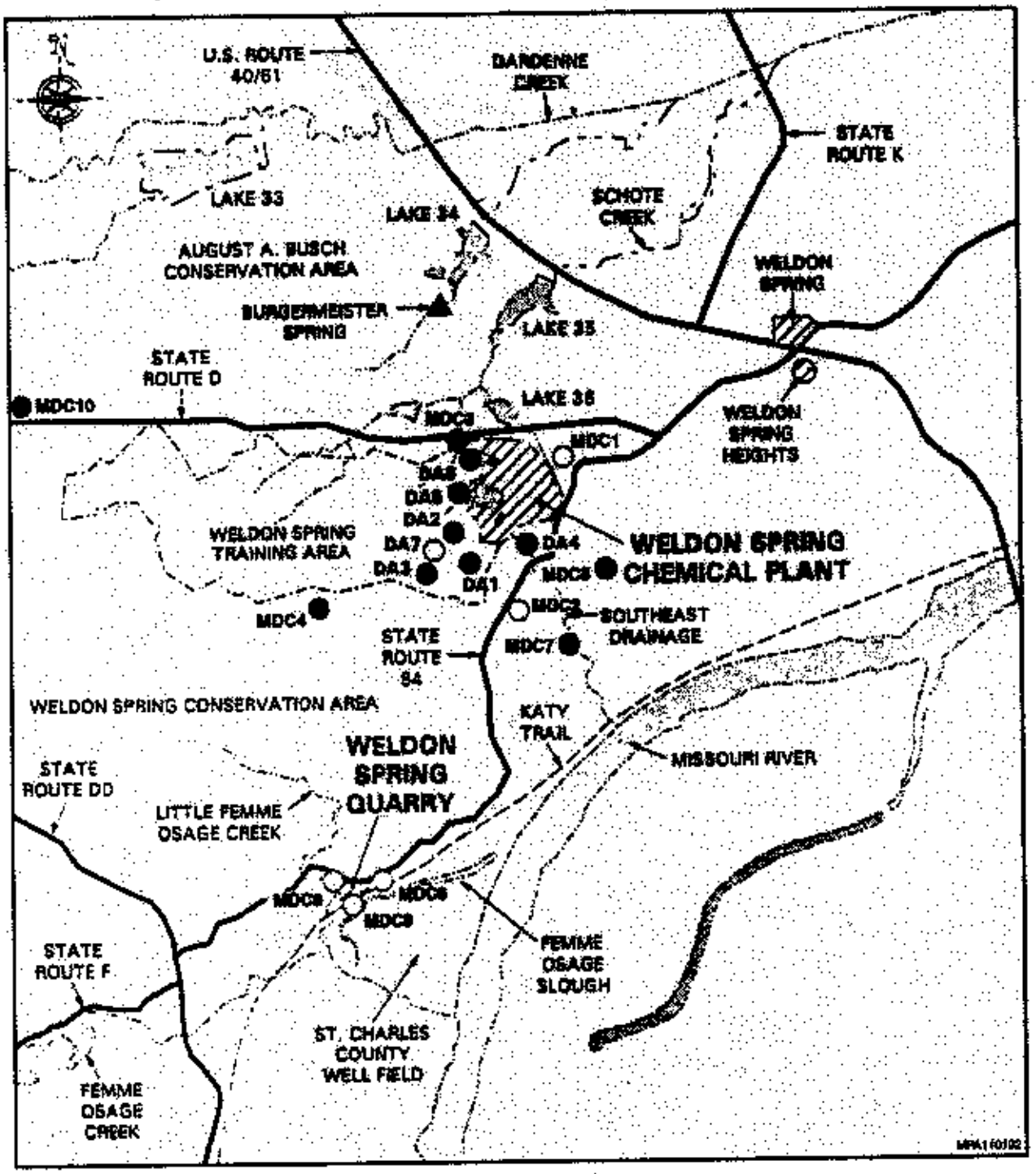

FIGURE 2.2 Locations of the Weldon Spring Site Vicinity Properties

TABLE 2.1 Vicinity Properties Associated with the Chemical Plant Operable Unit

Vicinity Property[a]	Description	Status	Reference
DA 1	Was approximately 3 ha of wooded field, consisting of a soil-covered mound and surrounding area, an approximately 1.2-m-wide ditch adjacent to a railroad track east of the wooded field, and a drainage ditch flowing northwest.	Remediation performed from December 1997 to July 1998. Confirmation data were collected as CU 162.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999c, *Close-Out Report for Vicinity Properties, DA-1, DA-2, DA-3, DA-5, and DA-7, Rev. 0*, DOE/OR/21548-778, prepared for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., May.
DA 2	Was located adjacent to a railroad track in a grass field north of the Weldon Spring Training Area entrance road. DA 2 measured about 21 m by 79 m.	Remediation performed from December 1997 to July 1998. Confirmation data were collected as CU 163.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999c, *Close-Out Report for Vicinity Properties, DA-1, DA-2, DA-3, DA-5, and DA-7, Rev. 0*, DOE/OR/21548-778, prepared for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., May.
DA 3	Consisted of a wooden loading dock south of the Weldon Spring Training Area entrance road.	Remediation performed from December 1997 to July 1998. Confirmation data were collected as CU 164.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999c, *Close-Out Report for Vicinity Properties, DA-1, DA-2, DA-3, DA-5, and DA-7, Rev. 0*, DOE/OR/21548-778, prepared for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., May.
DA 5	Was a surface drainage ditch leading west from raffinate pits across a part of the Weldon Spring Training Area.	Remediation performed from December 1997 to July 1998. Confirmation data were collected as CU 165.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999c, *Close-Out Report for Vicinity Properties, DA-1, DA-2, DA-3, DA-5, and DA-7, Rev. 0*, DOE/OR/21548-778, prepared for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., May.

TABLE 2.1 (Cont.)

Vicinity Property[a]	Description	Status	Reference
DA 6[c]	Consisted of a losing stream reach of the Ash Pond drainage extending west of the Chemical Plant fence line.	No remediation was deemed necessary based on characterization data collected subsequent to initial sampling that indicated elevated levels of uranium-238. Characterization data collected in 2000 indicated levels of uranium-238 and thorium-230 to be below 120 pCi/g and 5 pCi/g, respectively.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001a, *Analytical Data Results for Engineering Characterization of Vicinity Property DA-6: Ash Pond Drainage, Rev. 2*, DOE/OR/21548-824, prepared for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Jan.
DA 7[b]	Was a rectangular isolated area located north of the Weldon Spring Training Area entrance road. DA 7 measured about 2.1 m by 1.5 m.	Remediation was completed prior to the ROD. Post remedial action samples were taken and reported at 2.3 pCi/g, <0.5 pCi/g, and <1.9 pCi/g for radium-226, radium-228, and uranium-238, respectively.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1988, *Army Vicinity Property No.7 Post-Remedial Action Report*, DOE/OR/21548-043, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Remedial Action Project, St. Charles, Mo., Sept.; MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999c, *Close-Out Report for Vicinity Properties, DA-1, DA-2, DA-3, DA-5, and DA-7, Rev. 0*, DOE/OR/21548-778, prepared for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., May.
MDC 1[b]	Was an area of approximately 167 m^2 with radium-226 contamination on the west side of Highway 94 north of the entrance to the Missouri Highway Department property.	Remediated in 1986 according to Formerly Utilized Sites Remedial Action Program (FUSRAP) protocol prior to the ROD. Remediation was verified by Oak Ridge Associated Universities (ORAU) to meet DOE residual contamination guidelines.	Berger, J.D., 1986, *Verification of Remedial Action along Highway 94, Weldon Spring, Missouri*, Oak Ridge Associated Universities, Oak Ridge, Tenn.
MDC 2[b]	Was a small piece of pipe on the surface near Highway 94. The contaminant in the pipe was identified as radium-226 with a concentration of approximately 82 pCi/g.	Remediated by ORAU prior to the ROD. The contaminated pipe was removed.	Boerner, A.J., 1986, *Radiological Survey of the August A. Busch and Weldon Spring Wildlife Areas, Weldon Spring Site, St. Charles County, Missouri*, Oak Ridge Associated Universities, Oak Ridge, Tenn., April.

TABLE 2.1 (Cont.)

Vicinity Property[a]	Description	Status	Reference
MDC 3	Consisted of two small isolated areas of contamination south of Highway D.	Remediation performed from October 1997 to June 1998. Confirmation data were collected as CU 166.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999d, *Close-Out Report for Vicinity Properties MDC-3, MDC-4, MDC-5, and MDC-10, Rev. 1*, DOE/OR/21548-789, prepared for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., June.
MDC 4	Was an area near an access road to the radio tower (Road C) and the Department of Army (DA) property perimeter fence. Consisted of mounds of soil and miscellaneous wood, metal, and other debris.	Remediation performed from October 1997 to June 1998. Confirmation data were collected as CU 167.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999d, *Close-Out Report for Vicinity Properties MDC-3, MDC-4, MDC-5, and MDC-10, Rev. 1*, DOE/OR/21548-789, prepared for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., June.
MDC 5	Was an area located near the intersection of Highway D and Highway 94 and consisted of abandoned drums and adjacent soil.	Remediation performed from October 1997 to June 1998. Confirmation data were collected as CU 168.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999d, *Close-Out Report for Vicinity Properties MDC-3, MDC-4, MDC-5, and MDC-10, Rev. 1*, DOE/OR/21548-789, prepared for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., June.
MDC 6	Was an isolated spot of contamination adjacent to the quarry perimeter fence. Consisted of an area of soil of approximately 1 m^2.	Remediation performed in November 1993. Contaminated soil was transported with other quarry soil for permanent on-site disposal. Confirmation data were collected as CU 141.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999b, *Close-Out Report for Vicinity Properties MDC6 and MDC9, Rev. 0*, DOE/OR/21548-775, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Apr.
MDC 8[b]	Consisted of three isolated spots (measuring about 0.5 m^2 to 1 m^2) near a railroad bridge spanning the Little Femme Osage Creek.	Remediation completed in 1992, prior to the ROD.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1997b, *Vicinity Property DOC-8 Close-Out Report, Rev. 0.*, DOE/OR/21548-679, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Apr.
VP 9	Was designated as MDC 9. Located between the abandoned Missouri-Kansas-Texas Railroad and the Femme Osage Slough, south of the quarry.	Remediation was completed in 1996. Confirmation data were collected as CUs 139 and 140.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999b, *Close-Out Report for Vicinity Properties MDC6 and MDC9, Rev. 0*, DOE/OR/21548-775, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Apr.

TABLE 2.1 (Cont.)

Vicinity Property[a]	Description	Status	Reference
Southeast Drainage	Was designated as DA 4 and MDC 7. The Southeast Drainage is a natural drainage area with intermittent flow that traverses both the Army property and Weldon Spring Conservation Area from the Chemical Plant site to the Missouri River.	Remediated as a removal action in 1998 (see Appendix A for postcleanup information).	Argonne National Laboratory, 1996, *Engineering Evaluation/Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri*, DOE/OR/21548-584, prepared for U.S. Department of Energy, Weldon Spring Remedial Action Project, St. Charles, Mo., Aug.; MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999e, *Southeast Drainage Close-Out Report for Vicinity Properties DA4 and MDC7, Rev. 0*, DOE/OR/21548-772, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Sept.
Frog Pond Outlet	An area that contained contamination but was identified after the ROD of 1993. The contamination was located on the conservation area in the Frog Pond Drainage between Lake 36 and Highway D.	Remediated in September 1999 following the guidelines in the ROD for vicinity properties.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 2000c, *Post-Remedial Action Report for the Frog Pond Drainage Outlet (WP-519/505F)*, DOE/OR/21548-837, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., July.
MDC 10	Was an old Department of Army disposal area along Highway D adjacent to an access road leading to Busch Wildlife Area Lake 21. Consisted of an area of soil of approximately 0.15 m^2.	Remediation performed from October 1997 to June 1998. Confirmation data were collected as CU 169.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999d, *Close-Out Report for Vicinity Properties MDC-3, MDC-4, MDC-5, and MDC-10, Rev. 1.*, DOE/OR/21548-789, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., June.
Busch Lake 34[c,d]	A 35-acre man-made lake located on the August A. Busch Memorial Conservation Area.	Sediments were sampled in 1989. A more thorough investigation was conducted in 1998. Uranium-238 was the only contaminant detected but was below ALARA levels. No remediation was required.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999a, *Completion Report for Sediment Sampling at Busch Lakes 34 and 35, Rev. 0*, DOE/OR/21548-768, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Feb.

TABLE 2.1 (Cont.)

Vicinity Property[a]	Description	Status	Reference
Busch Lake 35[c,d]	A 60-acre man-made lake located on the August A. Busch Memorial Conservation Area.	Sediments were sampled in 1989. A more thorough investigation was conducted in 1998. Uranium-238 was the only contaminant detected but was below cleanup criteria. No remediation was required.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999a, *Completion Report for Sediment Sampling at Busch Lakes 34 and 35, Rev. 0*, DOE/OR/21548-768, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Feb.
Busch Lake 36[c,d]	A 15.5-acre man-made lake located on the August A. Busch Memorial Conservation Area.	Sediments were sampled in 1989. A more thorough investigation was conducted in 1997. Uranium-238 was the only contaminant detected but was below cleanup criteria. Although no remediation was required on the basis of the characterization data obtained, DOE agreed to remove sediments to a depth of 1 ft within an area measuring approximately 150 ft by 65 ft.	MK-Ferguson Company and Jacobs Engineering Group, Inc., 2000a, *Closure Report for the Radiological Characterization of Sediments and Soil within the Southeast Corner of Busch Lake 36 Sampling Plan, Rev.0*, DOE/OR/21548-835, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Mar.

[a] Vicinity properties that are identified with the DA prefix are located in the Weldon Spring Training Area. Those with the MDC prefix are located in the Missouri Department of Conservation Area.

[b] These VPs were remediated prior to ROD issuance in 1993.

[c] Characterization data were evaluated for these areas.

[d] The Frog Pond Outlet is designated as a VP via a nonsignificant change to the ROD of 1993. Busch Lakes 34, 35, and 36 are not VPs but are included in this table to complete the list of areas that are outside of the Chemical Plant fence line but are considered to be associated with the Chemical Plant Operable Unit.

TABLE 2.2 Radionuclide and Chemical Contaminant Cleanup Standards

		Surface[a]		Subsurface[b]	
	Background	ALARA	Criteria	ALARA	Criteria
Radionuclide (pCi/g)					
Radium-226[c,d]	1.2	5.0	6.2	5.0	16.2
Radium-228[c,d]	1.2	5.0	6.2	5.0	16.2
Throium-230[c]	1.2	5.0	6.2	5.0	16.2
Thorium-232[c]	1.2	5.0	6.2	5.0	16.2
Uranium-238	1.2	30.0	120	30	120
Chemical (mg/kg)					
Arsenic	26	45	75	75	750
Chromium (total)	36	90	110	110	1,110
Chromium VI	-[e]	90	100	100	1,000
Lead	34	240	450	450	4,500
Thallium	16	16	20	20	20
PAHs[f]	-	0.44	5.6	5.6	56
PCBs[g]	-	0.65	8	8	80
TNT	-	14	140	140	1,400

[a] Values listed for surface soils apply to contamination within the upper 15 cm (6 in.) of the soil column.

[b] Values for the subsurface apply to contamination in soils below 15 cm (6 in.) unless otherwise noted.

[c] If both thorium-230 and radium-226, or both thorium-232 and radium-228, are present and not in secular equilibrium, the cleanup criterion applies for the radionuclide with the higher concentration.

[d] At locations where both radium-226 and radium-228 are present, the cleanup criterion of 6.2 pCi/g (including background) in the top 15 cm (6 in.) of soil, and 16.2 pCi/g (including background) in each 15-cm (6-in.) layer of soil more than 15 cm (6 in.) below the surface, applies to the sum of the concentrations of these two radionuclides.

[e] A hyphen indicates that background data are not applicable.

[f] Polycylic aromatic hydrocarbons: benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and ideno(1,2,3-cd)pyrene.

[g] Polychlorinated biphenyls: Aroclor® 1248, 1254, and 1260.

Source: DOE (1993).

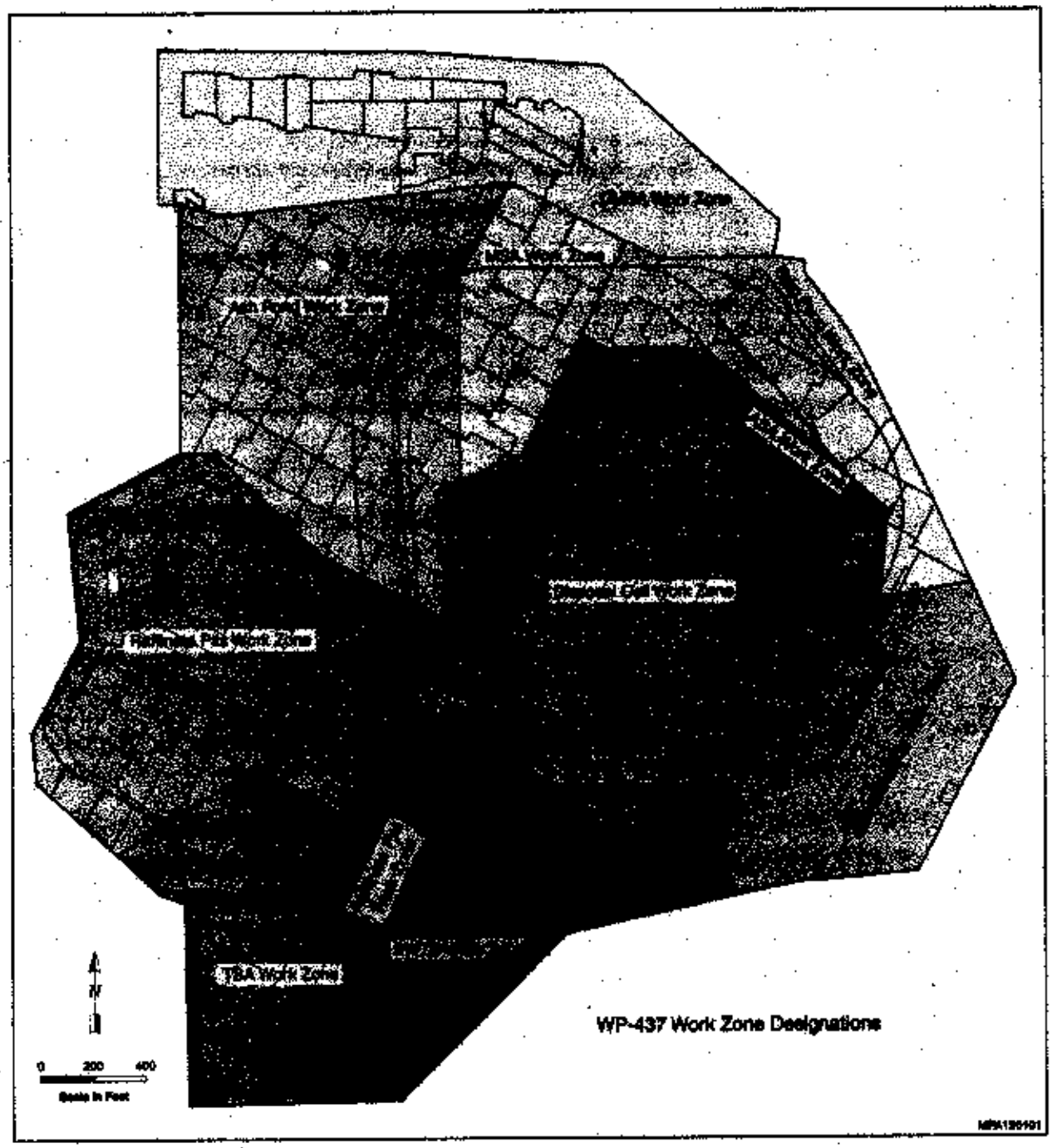

FIGURE 2.3 Work Zones at the Weldon Spring Site Chemical Plant

remaining in the final surface configuration would be expected to meet surface goals. Subsurface contaminant ALARA goals would be met for areas that would receive at least 15 cm (6 in.) of clean backfill for final grading purposes.

A gamma field scan was performed immediately following soil excavation. In general, locations with elevated direct gamma radiation exceeding 1.5 times ambient site background levels underwent further excavation. The gamma field scan was performed over each 100-m^2 (1,080-ft^2) grid within all confirmation units (CUs) after excavation had been completed. Samples were collected on a grid and analyzed for contaminants determined to be above ALARA goals during RI sampling. That is, confirmation samples were to be analyzed only for the COCs known to exist in the particular sampling area and not necessarily for the entire suite of COCs listed in Table 2.2. Over 400 CUs were sampled (see Figure 2.4); generally, about 28 confirmation samples were collected from each CU and were analyzed in a laboratory using approved analytical methods (MK-Ferguson and Jacobs Engineering Group, Inc. 1998a).

Prior to the approval of the ROD in 1993, a series of interim response actions was conducted to manage various contaminated buildings, structures, and surface water. These interim actions were supported by a series of EE/CA reports. The 44 buildings at the Chemical Plant were dismantled, and the materials generated by the dismantlement were placed in temporary storage at that time. These materials have now been placed for permanent disposal in the on-site cell.

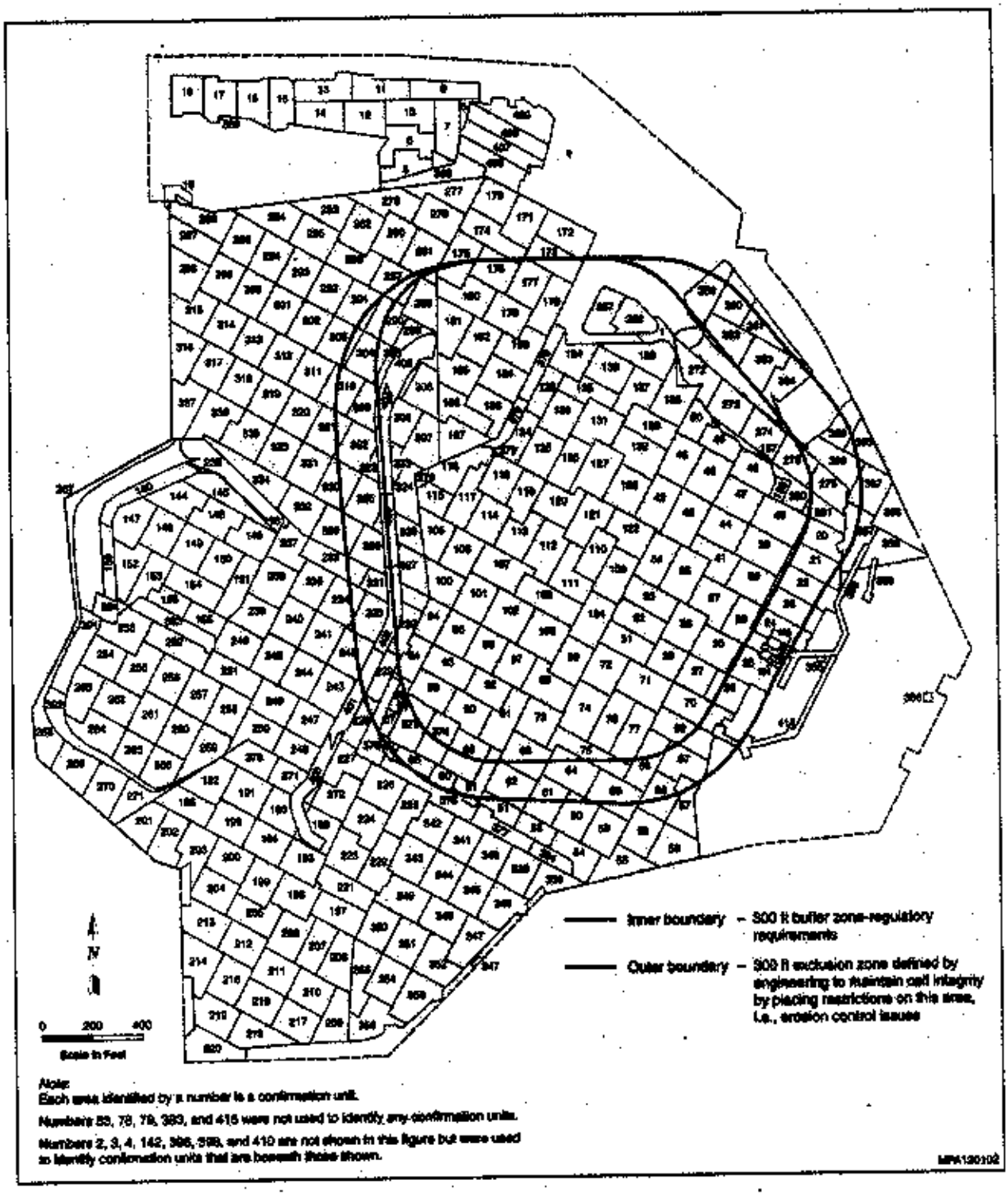

FIGURE 2.4 Confirmation Units at the Weldon Spring Site Chemical Plant

3 OBJECTIVE AND SCOPE

3.1 OBJECTIVE

The primary objective of this report is to present risk estimates for residual soil after the remedial action stipulated in the ROD of 1993 for the Chemical Plant Operable Unit is completed. These risk estimates would be used to support upcoming decisions regarding the need for institutional controls at these areas. An evaluation of whether or not cleanup standards and ALARA goals have been met by the remedial action will be evaluated and presented in a separate report.

3.2 SCOPE

Residual risk estimates are developed for all areas that are within the scope of the Chemical Plant Operable Unit remedial action. That is, residual risks are estimated for the various CUs that compose the Chemical Plant area (within the former fence line) and the 13 properties (outside of the fence line) that are designated as VPs (see Table 2.1). Two of the 13 properties (DA4 and MDC7) make up the Southeast Drainage, and postcleanup risk calculations have already been performed under a separate activity and have been reproduced as Appendix A of this report.

Residual risks are also estimated for DA6, Busch Lakes 34, 35, and 36 with characterization data obtained for these areas. DA6 was designated as a VP requiring remediation on the basis of initial sampling. However, subsequent characterization data collected indicated concentration levels that did not require remediation. Lakes 34, 35, and 36 were not designated as VPs; however, data were obtained to verify that conditions at these lakes are protective of human health and the environment. These characterization data are used in this report to develop residual risk estimates for these lakes.

Also for this report, confirmation data from the Frog Pond Outlet (i.e., CU 390) were combined with characterization data collected from an adjoining culvert to estimate residual risk for this area as a whole. A preliminary risk assessment was performed for the culvert itself at the time the characterization was completed. The results of this preliminary risk assessment completed in early 2000 (Picel 2000) indicate that the potential risk to a construction worker or a visitor scenario would be within the EPA's acceptable risk range (i.e., at 10^{-7} and 10^{-6}, respectively).

Confirmation data collected for the remediated areas are used for estimating residual risk in soil. Hence, the risk estimates in this report reflect only the potential residual risk (including inhalation of radon, see Appendix B) from the remaining soil after the completion of the remediation for the Chemical Plant Operable Unit; residual risk from groundwater is not addressed. Final decisions regarding contaminants in groundwater have not been made.

Risk estimates were performed for each CU (see Appendix C for results). Risk estimates were also developed for background concentrations of the naturally occurring COCs (see Appendix D). To facilitate the interpretation of the risk results, however, the risk estimates presented in subsequent sections of this report are shown in groupings of CUs considered to represent discrete areas within the operable unit for which decisions might be made. These groupings are shown in Table 3.1. Figures 3.1 to 3.3 denote the CUs that are included in the first three groupings presented in Table 3.1. These groupings relate to the disposal cell area within the Chemical Plant.

Finally, several small structural items such as manhole covers determined to contain radioactivity greater than background would also remain at the site. These items are referred to in this report as "Legacy" wastes because they contain radioactivity that originated from the site. Risk estimates are not derived for these items. However, a comparison to background based on surface radioactivity in counts per minute is discussed in Appendix E.

3.3 ORGANIZATION OF THE REPORT

This remainder of this report is organized as follows:

- Chapter 4 discusses the risk assessment methodology,
- Chapter 5 presents risk characterization results,
- Chapter 6 summarizes the risk results,
- Chapter 7 lists the references that support the information presented in this report,
- Appendix A reproduces the postcleanup risk assessment performed for the Southeast Drainage,
- Appendix B presents the risk associated with the inhalation of radon-222 decay products,
- Appendix C provides residual risk estimates by confirmation unit,
- Appendix D presents risk estimates considering background concentrations of the naturally occurring contaminants of concern for the Chemical Plant Operable Unit, and
- Appendix E provides a discussion regarding the legacy waste items that would remain at the Chemical Plant area.

TABLE 3.1 Confirmation Units Included for the Various Areas Associated with the Chemical Plant Operable Unit

Location	Confirmation Unit (CU)	Total Number of CUs
CUs within cell footprint and buffer/exclusion zone[a]	1-3, 20-51, 57, 60-77, 80-138, 142, 157-158, 172-188, 228-234, 242, 272-276, 281, 287-291, 303-310, 321-330, 357-367, 373-376, 378-382, 387, 389, 395-396, 398-399, 401-405, 410, 414	203
Outside of disposal cell footprint and buffer/exclusion zone (not including partial CUs)[b]	4-19, 52, 54-56, 58-59, 143-156, 159-161, 170-171, 189-227, 235-241, 243-271, 277-280, 282-286, 292-302, 311-320, 331-356, 368-372, 377, 384-386, 388, 391-394, 400, 406-409	191
Outside of disposal cell footprint and buffer/exclusion zone (including partial CUs)[c]	4-19, 21-25, 51-52, 54-62, 65-67, 80-82, 85, 143-156, 159-161, 170-177, 189-228, 232-271, 277-287, 291-303, 310-322, 329-356, 359-361, 364-372, 375-377, 384-389, 391-394, 399-401, 406-409, 414	242
Vicinity Properties[d]		
DA 1	162	1
DA 2	163	1
DA 3	164	1
DA 5	165	1
DA 6[e]	Na[f]	NA
MDC 3	166	1
MDC 4	167	1
MDC 5	168	1
MDC 6	141	1
MDC 10	169	1
VP 9	139-140	2
Frog Pond Outlet/Culvert[g]	390	1
Quarry Wastewater Treatment Plant Equalization Basin and Quarry Proper[h]	397, 411-413, 416-420	9
Busch Lake 34[i]	NA	NA
Busch Lake 35[i]	NA	NA
Busch Lake 36[i]	NA	NA

See next page for footnotes.

TABLE 3.1 (Cont.)

[a] The area considered extends to the engineering exclusion zone; includes CUs that are only partially within this zone.

[b] CUs outside the cell buffer zone but within the former fence line and not including CUs that are only partially within the zone.

[c] CUs outside the cell buffer zone but including CUs that are only partially within the zone.

[d] Only 10 of 13 VPs are included in this table. No remediation was required for DA 6 (see Table 2.1). DA 4 and MDC 7, which make up the Southeast Drainage, were addressed via a removal action. The postcleanup evaluation information is presented in Appendix A of this report.

[e] Vicinity property DA 6 did not require remediation on the basis of characterization data collected subsequent to the initial survey. Calculations presented in this report for DA 6 are based on these characterization data.

[f] NA = not applicable.

[g] The Frog Pond Outlet was designated as a VP post-ROD. Estimates for this area include characterization data collected from a culvert adjacent to the Frog Pond Outlet CU and Highway D. See also the discussion in Section 3 regarding risk calculations for the Frog Pond Culvert performed prior to this report.

[h] This group of CUs for the Quarry area is included because the confirmation process conducted is similar to that for the Chemical Plant CUs.

[i] Not designated as vicinity properties, but characterization data were used to obtain residual risk estimates.

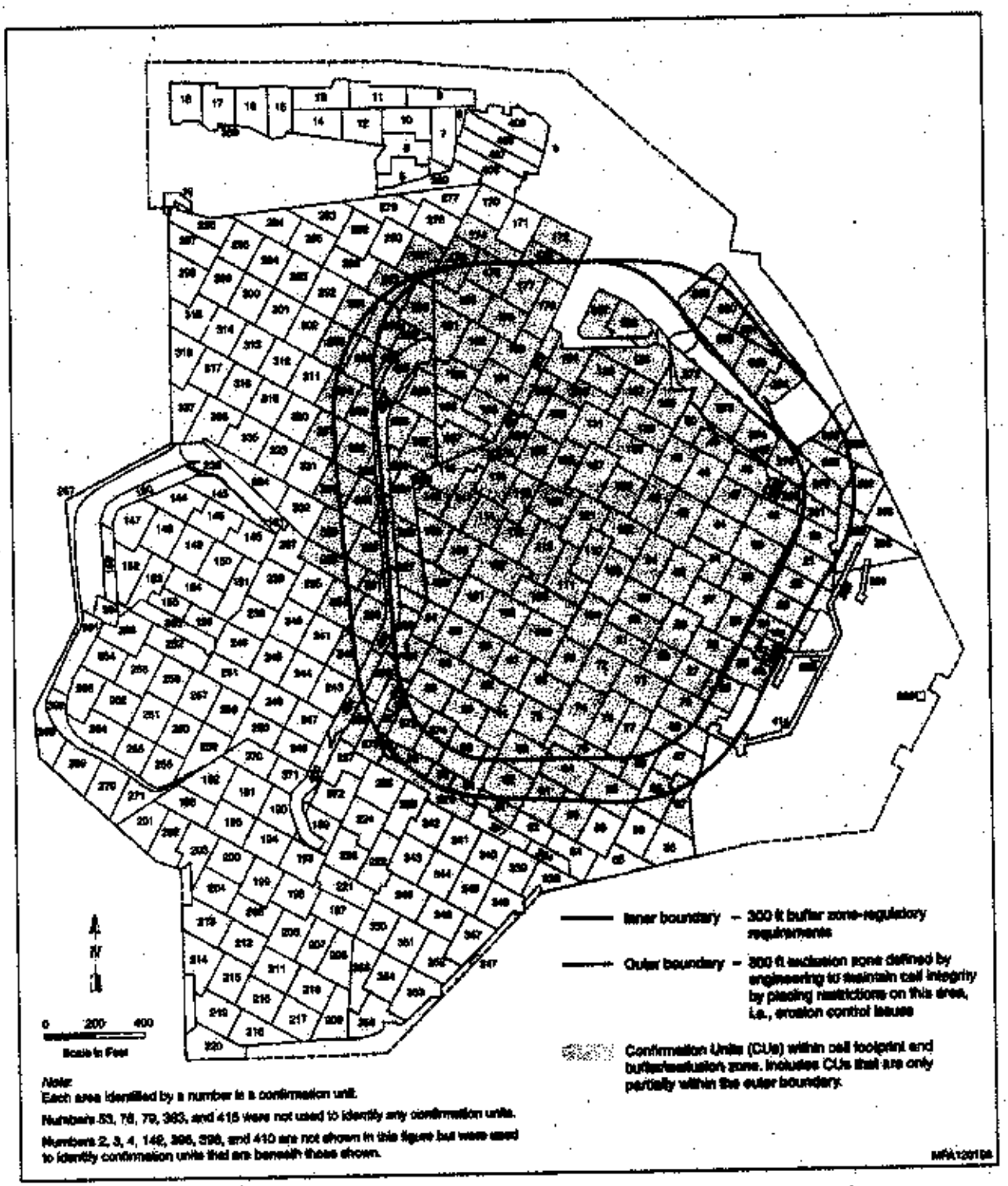

FIGURE 3.1 Confirmation Units within the Cell Footprint and Buffer/Exclusion Zone

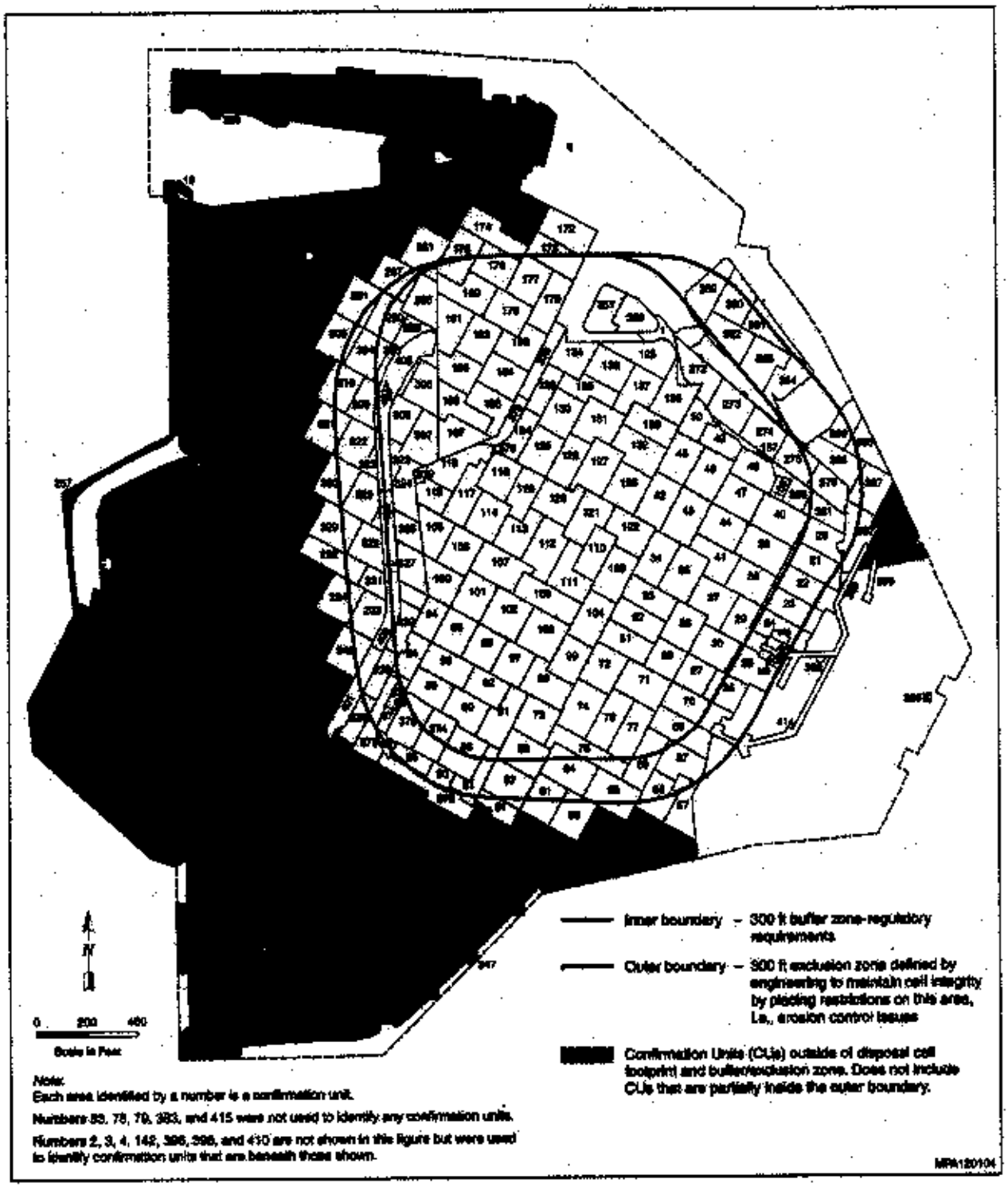

FIGURE 3.2 Confirmation Units Outside of the Disposal Cell Footprint and Buffer Zone

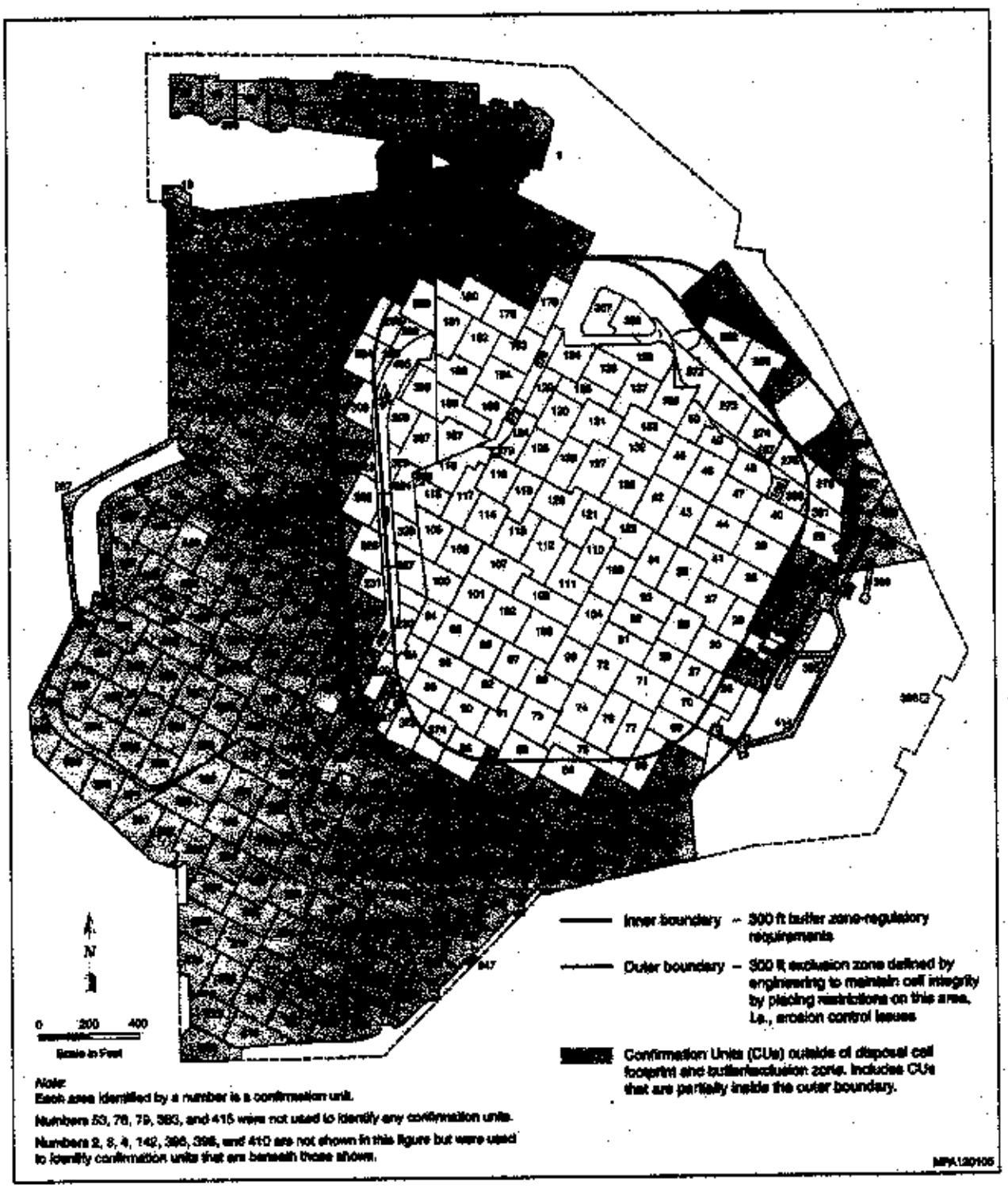

FIGURE 3.3 Confirmation Units Outside of the Disposal Cell Footprint and Buffer/Exclusion Zone (including CUs only partially within)

4 RISK ASSESSMENT

The risk methodology utilized for this assessment followed that presented in previous risk assessments performed for the Chemical Plant (DOE, 1992a). Risk estimates for a hypothetical resident and recreational visitor scenario were calculated to provide the most likely range of information that may be useful in decision making regarding future land use of the Chemical Plant and the VPs. Unforeseen land use for the Chemical Plant Area that falls outside the range of the evaluation presented in this report will be addressed in the five-year review process that will be undertaken subsequent to this report.

4.1 ESTIMATION OF EXPOSURE POINT CONCENTRATIONS

A medium-specific concentration of a contaminant at the location of exposure (i.e., exposure point concentration [EPC]) must be estimated to calculate the potential risk that might be associated with a contaminated source or medium. For these risk assessment calculations, contaminant-specific EPCs were developed for soil associated with the EPCs. EPCs were developed for DA 6 and the Busch Lakes on the basis of characterization data obtained for these areas.

The EPCs for soil were determined for each COC on the basis of data collected during confirmation. The EPCs used to calculate intakes for each location of interest (as shown in Table 3.1) are shown in Tables 4.1 and 4.2. These concentrations are the one-tailed 95% upper confidence limit (UCL) of the arithmetic average.

4.2 ESTIMATION OF CONTAMINANT INTAKE

Estimates of chemical and radioactive contaminants are based on contaminant concentrations at the exposure points and scenario-specific exposure assumptions and intake parameters. The exposure assumptions and intake parameters used to calculate intakes are listed in Table 4.3; these values are consistent with U.S. Environmental Protection Agency (EPA) recommendations and were those used in previous risk assessments performed for the Chemical Plant area (DOE 1992a). The methodologies used to calculate intakes from each route of exposure are presented in Section 4.2.1 for chemical contaminants and in Section 4.2.2 for radioactive contaminants.

To determine human health impacts from residual soil concentrations of lead, an evaluation of the potential effect on blood lead levels in children was performed consistent with EPA guidance for lead. The EPA recommends the use of the Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead. The model allows for the estimation of a plausible distribution of blood lead concentrations for a hypothetical child or population of children. From the distribution, the model then calculates the probability that children's blood lead concentrations will exceed the level of concern, which has been established to be 10 µg/dL or greater.

TABLE 4.1 Summary Statistics for the Chemical Contaminants of Concern for the Various Areas Associated with the Chemical Plant Operable Unit

	2,4,6-TNT (mg/kg)					Arsenic (mg/kg)					Chromium (mg/kg)				
Location[a]	No. of Samples	Range	Avg.	SD[b]	UCL[c]	No. of Samples	Range	Avg.	SD[b]	UCL[c]	No. of Samples	Range	Avg.	SD[b]	UCL[c]
CUs within cell footprint and buffer/exclusion zone	561	0–1,270	2.9	54	6.7	1,431	.48–123	7.7	4.7	7.9	1,840	1.4–42	17	4.6	17
Outside of disposal cell footprint and buffer/ exclusion zone (not including partial CUs)	958	0–20	.06	.76	.10	1,368	.84–32	8.6	3.3	8.7	1,238	2.5–76	18	5.0	19
Outside of disposal cell footprint and buffer/ exclusion zone (including partial CUs)	1,203	0–1,270	1.3	37	3.1	1,823	.84–123	8.6	4.4	8.8	1,653	2.5–76	18	5.1	18
Frog Pond Outlet/Culvert	-[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quarry Equalization Basin and Quarry Proper	34	0–0	0	0	0	34	5.8–22	9.6	3.2	11	34	12.7–21	17	2.4	18
Vicinity Properties															
DA 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 2	-	-	-	-	-	-	-	-	-	-	24	6.3–26	19	4.8	21
DA 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 5	25	.04–1.5	.12	.30	.22	25	4.5–21	11	4.8	13	25	10.4–40	20	7.8	23
DA 6[e]	60	.01–.12	.08	.05	.09	60	4.9–26	11	5.0	12	60	9.0–32	15	4.7	16
MDC 3	4	.12–.12	.12	.0025	.12	4	8.1–13	10	2.1	13	4	15.2–35	24	8.2	33
MDC 4	5	.05–.12	.11	.030	.12	5	3.5–11	7.3	3.5	11	5	16–18	17.6	1.0	19
MDC 5	5	.12–.12	.12	.0030	.12	-	-	-	-	-	5	18–25	21	2.8	24
MDC 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MDC 10	5	0–.07	.03	.030	.050	5	7.6–13	10	2.1	12	5	9.6–25	19	5.7	24
VP 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Busch Lake 34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Busch Lake 35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Busch Lake 36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 4.1 (Cont.)

Location[a]	Lead (mg/kg)					PAH (mg/kg)					PCB (mg/kg)				
	No. of Samples	Range	Avg.	SD[b]	UCL[c]	No. of Samples	Range	Avg.	SD[b]	UCL[c]	No. of Samples	Range	Avg.	SD[b]	UCL[c]
CUs within cell footprint and buffer/exclusion zone	1,462	1.8–817	16	23	17	1,264	0–14	.13	.60	.16	2,008	0–5.8	.034	.24	.043
Outside of disposal cell footprint and buffer/ exclusion zone (not including partial CUs)	1,235	3.3–817	21	37	23	1,467	0–4.4	.070	.30	.083	1,059	0–6.4	.074	.41	.095
Outside of disposal cell footprint and buffer/ exclusion zone (including partial CUs)	1,663	3.3–817	20	32	21	1,762	0–4.5	.071	.31	.083	1,557	0–6.4	.055	.34	.070
Frog Pond Outlet/Culvert	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quarry Equalization Basin and Quarry Proper	34	11.6–20	15	1.8	15	34	0–0	0	0	0	34	0–0	0	0	0
Vicinity Properties															
DA 1	-	-	-	-	-	-	-	-	-	-	30	0–1.1	.037	.20	.099
DA 2	-	-	-	-	-	-	-	-	-	-	24	0–.39	.035	.090	.066
DA 3	-	-	-	-	-	4	0–4.5	2.0	2.0	4.3	4	0–.069	.028	.034	.068
DA 5	25	8.7–44	21	8.2	24	25	0	0	0	0	25	0–.02	.0010	.0040	.0030
DA 6[a]	60	9.2–54	25	12	28	60	0–1.2	.057	.17	.093	60	0–.67	.049	.113	.073
MDC 3	4	14.1–158	61	66	140	4	0	0	0	0	4	0	0	0	0
MDC 4	5	8.0–22	16	5.5	21	5	0	0	0	0	5	0	0	0	0
MDC 5	5	12–71	36	29	64	5	0–.45	.089	.20	.28	5	0	0	0	0
MDC 6[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MDC 10	5	11.2–18.4	15	3.0	18	5	0	0	0	0	5	0	0	0	0
VP 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Busch Lake 34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Busch Lake 35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Busch Lake 36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 4.1 (Cont.)

Location[a]	Thallium (mg/kg)					Uranium[f] (mg/kg)				
	No. of Samples	Range	Avg.	SD[b]	UCL[c]	No. of Samples	Range	Avg.	SD[b]	UCL[e]
CUs within cell footprint and buffer/exclusion zone	551	.12–20	1.8	1.8	1.9	4,669	.78–684	9.4	21	9.9
Outside of disposal cell footprint and buffer/ Exclusion zone (not including partial CUs)	523	.30–12	1.8	1.4	1.9	4,518	.64–327	7.6	17	8.0
Outside of disposal cell footprint and buffer/ exclusion zone (including partial CUs)	741	.12–20	1.7	1.7	1.8	5,758	.64–684	8.2	20	8.7
Frog Pond Outlet/Culvert	-	-	-	-	-	13	3.3–930	88	260	210
Quarry Equalization Basin and Quarry Proper	-	-	-	-	-	281	.22–44	5.4	4.4	5.9
Vicinity Properties										
DA 1	-	-	-	-	-	30	4.2–196	25	42	38
DA 2	-	-	-	-	-	24	3.8–37	7.7	6.9	10
DA 3	-	-	-	-	-	4	4.5–11	8.3	2.8	12
DA 5	25	.48–5.2	2.4	1.3	2.9	-	-	-	-	-
DA 6[d]	60	.29–6.0	1.5	1.5	1.8	129	3.4–287	52	66	62
MDC 3	4	.4–1.4	.91	.42	1.4	4	5.6–38	14	16	33
MDC 4	5	.8–4.3	3.5	1.5	4.9	3	4.4–5.9	5.4	.84	6.8
MDC 5	-	-	-	-	-	-	-	-	-	-
MDC 6	-	-	-	-	-	2	4.7–5.3	5.0	.45	7.0
MDC 10	5	.76–1.6	1.3	.33	1.6	5	4.3–6.3	5.0	1.1	6.0
VP 9	-	-	-	-	-	53	3.9–243	47	44	57
Busch Lake 34	-	-	-	-	-	-	-	-	-	-
Busch Lake 35	-	-	-	-	-	-	-	-	-	-
Busch Lake 36	-	-	-	-	-	-	-	-	-	-

See next page for footnotes.

[a] CUs included for each location are presented in Table 3.1. Values for average, SD, and UCL are rounded to two significant figures.

[b] SD = standard deviation.

[c] UCL value is the upper 95% limit of the arithmetic average, which is then used as the exposure point concentration (EPC) for risk calculations.

[d] A hyphen indicates that the COC is not associated with the location.

[e] Based on characterization data collected.

[f] Data for uranium were obtained by converting the uranium-238 data in pCi/g to mg/kg. See Table 4.2 for uranium-238 data presented in pCi/g.

Sources: MK-Ferguson Company and Jacobs Engineering Group, Inc. (1997a–e; 1998 a–e; 1999a,b,e; 2000b–d; 2001a–l; 2002a–c).

TABLE 4.2 Summary Statistics for the Radiological Contaminants of Concern for the Various Areas Associated with the Chemical Plant Operable Unit

	Radium-226 (pCi/g)					Radium-228 (pCi/g)					Thorium-230 (pCi/g)				
Location[a]	No. of Samples	Range	Avg.	SD[b]	UCL[c]	No. of Samples	Range	Avg.	SD[b]	UCL[c]	No. of Samples	Range	Avg.	SD[b]	UCL[c]
CUs within cell footprint and buffer/exclusion zone	3,103	.13–17	1.2	.53	1.2	3,114	.2–6.6	1.1	.37	1.1	2,563	.09–23	1.6	1.19	1.6
Outside of disposal cell footprint and buffer/ exclusion zone (not including partial CUs)	3,802	.16–6.0	.92	.41	.93	3,611	.16–5.8	.97	.40	.98	3,632	.10–19	1.6	1.24	1.6
Outside of disposal cell footprint and buffer/ exclusion zone (including partial CUs)	4,775	.13–16.8	.97	.51	.98	4,585	.16–.8	.99	.40	1.0	4,555	.10–18.9	1.6	1.24	1.6
Frog Pond Outlet/Culvert	2	.82–1.2	1.0	.25	1.2	2	.57–1.0	.80	.32	1.0	13	.78–6.4	1.5	1.6	2.3
Quarry Equalization Basin and Quarry Proper	281	.22–7.9	1.0	.76	1.1	281	.26–9.5	1.1	.67	1.1	281	.14–78	2.7	5.7	3.3
Vicinity Properties															
DA 1	30	1.1–2.1	1.5	.22	1.6	30	.58–1.7	1.2	.25	1.3	-[d]	-	-	-	-
DA 2	24	1.2–1.9	1.5	.16	1.5	24	.51–1.4	1.0	.27	1.1	-	-	-	-	-
DA 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DA 5	25	.73–6.3	1.8	1.2	2.2	29	.48–1.6	1.1	.28	1.2	27	.81–2.3	1.1	.26	1.1
DA 6[e]	118	.26–1.3	.78	.23	.81	118	.35–1.3	.79	.30	.84	105	.60–4.3	2.1	.81	2.3
MDC 3	-	-	-	-	-	-	-	-	-	-	4	.94–1.2	1.0	.14	1.2
MDC 4	5	1.4–1.7	1.5	.14	1.7	3	.59–1.6	1.1	.51	1.9	5	.90–1.4	1.1	.19	1.2
MDC 5	5	1.4–3.2	2.0	.75	2.7	5	.61–1.2	.90	.25	1.1	5	1.0–4.0	2.3	1.2	3.4
MDC 6	2	1.1–1.3	1.2	.13	1.8	2	.42–1.1	.74	.44	2.7	2	1.1–1.8	1.4	.47	3.5
MDC 10	5	1.6–1.8	1.7	.09	1.7	5	1.0–1.6	1.3	.22	1.5	5	1.3–1.7	1.5	.22	1.7
VP 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Busch Lake 34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Busch Lake 35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Busch Lake 36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 4.2 (Cont.)

Location[a]	Uranium-238 (pCi/g)[f] No. of Samples	Range	Avg.	SD[b]	UCL[c]
CUs within cell footprint and buffer/exclusion zone	4,669	.26–228	3.1	7.1	3.3
Outside of disposal cell footprint and buffer/ exclusion zone (not including partial CUs)	4,518	.21–109	2.5	5.6	2.7
Outside of disposal cell footprint and buffer/ exclusion zone (including partial CUs)	5,758	.21–228	2.7	6.7	2.9
Frog Pond Outlet/Culvert	13	1.1–310	29	85	71
Quarry Equalization Basin and Quarry Proper	281	.07–14.5	1.8	1.5	2.0
Vicinity Properties					
DA 1	30	1.4–65	8.4	14	13
DA 2	24	1.3–12	2.6	2.3	3.4
DA 3	4	1.5–3.5	2.8	.93	3.5
DA 5	-	-	-	-	-
DA 6[e]	129	1.1–95.6	17	22	21
MDC 3	4	1.9–13	4.6	5.3	11
MDC 4	3	1.5–2.0	1.8	.28	2.3
MDC 5	-	-	-	-	-
MDC 6	2	1.6–1.8	.17	.15	2.3
MDC 10	5	1.4–2.1	1.7	.35	2.0
VP 9	53	1.3–81	16	15	19
Busch Lake 34	59	1.2–22.9	5.2	4.9	6.3
Busch Lake 35	240	1.2–44.1	6.6	6.4	7.3
Busch Lake 36	200	1.4–91	8.1	13	9.6

See next page for footnotes.

TABLE 4.2 (Cont.)

[a] CUs included under each location are presented in Table 3.1. Values for average, SD, and UCL rounded to two significant figures.

[b] SD = standard deviation.

[c] UCL value is the upper 95% limit of the arithmetic average, which is then used as the exposure point concentration (EPC) for risk calculations.

[d] A hyphen indicates that the COC is not associated with the location.

[e] Based on characterization data collected.

[f] These data for uranium-238 were converted from pCi/g to mg/kg as presented in Table 4.1 for use in determining the chemical toxicity of uranium.

Sources: MK-Ferguson Company and Jacobs Engineering Group, Inc. (1997a–e; 1998a–c; 1999a,b,e; 2000b–d; 2001a–l; 2002a–c).

TABLE 4.3 Exposure Scenario Assumptions and Intake Parameters

Intake Parameter	Unit	Exposure Scenarios[a]	
		Resident	Recreational Visitor
Exposure time (ET)	h/d		
Indoor		23	0
Outdoor		1	4
Exposure frequency (EF)	d/yr	350	20
Exposure duration (ED)	yr	30	30
Body weight (BW)	kg	70 (15)[b]	70 (15)[b]
Soil ingestion rate (IR_s)	mg/event	100 (200)[b]	100 (200)[b]
Averaging time (AT)	d		
Carcinogenic intake		365 × 70	365 × 70
Noncarcinogenic intake		365 × 30	365 × 30
Inhalation rate (IR_h)	m^3/h		
Indoor		0.84	0
Outdoor		1.6	1.6
Particulate emission factor (PEF)	m^3/kg	4.63×10^9	4.63×10^9
Shielding factor for indoor	-[c]	0.7	NA[d]
Soil fraction of indoor dust	-[c]	0.8	NA[d]

[a] The exposure assumptions included in this table are consistent with those given in EPA 1989 and 1991, and DOE 1992a.

[b] An ingestion rate of 200 mg/event and a body weight of 15 kg were assumed for the receptor as a child for the first 6 years of exposure; a rate of 100 mg/event and a body weight of 70 kg were assumed for the remaining 24 years of exposure as an adult.

[c] A hyphen indicates that the parameter is unitless.

[d] NA = not applicable.

Summary statistics of the confirmation data collected for lead at the Chemical Plant (within the former fence line) and at the VPs are presented in Table 4.1. The UCLs for lead presented in Table 4.1 were used in the model estimations to determine potential impacts from lead. The results of the model are presented in Chapter 5.

4.2.1 Chemical Intakes

Exposure to chemical contaminants is expressed in terms of intake. Intake is the amount of contaminant taken into the body per unit of body weight per unit of time (expressed as milligrams of contaminant per kilogram of body weight per day [mg/kg-d]). Intake estimates were calculated for the incidental ingestion of soil and inhalation of airborne particulates.

The intake of chemical contaminant i (I_i) from ingestion of soil was calculated as follows:

$$I_i = C_{si} \times IR_s \times CF_1 \times EF \times ED / BW \times AT \qquad (4.1)$$

where

C_{si} = concentration of contaminant i in soil or sediment (mg/kg),

IR_s = soil (or sediment) ingestion rate (mg/event),

CF_1 = conversion factor (1×10^{-6} kg/mg),

EF = exposure frequency (events/yr),

ED = exposure duration (yr),

BW = average body weight over the exposure period (kg), and

AT = averaging time (d).

Tables 4.4 and 4.5 present the chemical EPCs and estimated carcinogenic and noncarcinogenic intakes, respectively, from ingestion of soil for a resident at various locations.

The intake of chemical contaminant i (I_i) from inhalation of soil was calculated as follows:

$$I_i = C_{ai} \times IR_a \times ET \times EF \times ED / BW \times AT, \tag{4.2}$$

where

C_{ai} = concentration of contaminant i as respirable particulates (mg/m^3),

IR_a = inhalation rate (m^3/h), and

ET = exposure time (h).

The chemical EPCs and estimated intakes from inhalation of air particulates are presented in Tables 4.4 and 4.5.

4.2.2 Radiological Intakes

Intake values for radioactive contaminants were calculated with methods similar to those used to calculate intake of chemical carcinogens, except for the inclusion of body weight and averaging time, which are accounted for in the risk factor. Estimates of intakes were calculated for ingestion of soil, inhalation of airborne particulates, and gamma radiation. Radiological intake for ingestion and inhalation is the amount of contaminant taken into the body, expressed in pCi.

TABLE 4.4 Chemical Exposure Point Concentration and Carcinogenic Intake for the Hypothetical Resident and Recreational Visitor Scenarios for the Various Areas Associated with the Chemical Plant Operable Unit

			Resident Intake		Visitor Intake	
Location[a]	Contaminant[b]	EPC (mg/kg)	Ingestion (mg/kg-d)	Inhalation (mg/kg-d)	Ingestion (mg/kg-d)	Inhalation (mg/kg-d)
CUs within cell footprint and buffer/exclusion zone	2,4,6-TNT	6.7	1.044×10^{-5}	-[c]	5.967×10^{-7}	-
	Arsenic	7.9	1.243×10^{-5}	1.717×10^{-10}	7.104×10^{-7}	3.682×10^{-12}
	Chromium	17	-	3.654×10^{-10}	-	7.835×10^{-12}
	PAH	.16	2.349×10^{-7}	-	1.4567×10^{-8}	-
	PCB	.043	6.746×10^{-8}	-	3.855×10^{-9}	-
Outside of disposal cell footprint and buffer/ exclusion zone (not including partial CUs)	2,4,6-TNT	.10	1.628×10^{-7}	-	9.303×10^{-9}	-
	Arsenic	8.7	1.369×10^{-5}	1.891×10^{-10}	7.821×10^{-7}	4.054×10^{-12}
	Chromium	19	-	3.995×10^{-10}	-	8.567×10^{-12}
	PAH	.083	1.296×10^{-7}	-	7.404×10^{-9}	-
	PCB	.095	1.482×10^{-7}	-	8.470×10^{-9}	-
Outside of disposal cell footprint and buffer/exclusion zone (including partial CUs)	2,4,6-TNT	3.1	4.828×10^{-6}	-	2.759×10^{-7}	-
	Arsenic	8.8	1.373×10^{-5}	1.897×10^{-10}	7.847×10^{-7}	4.068×10^{-12}
	Chromium	18	-	3.963×10^{-10}	-	8.497×10^{-12}
	PAH	.083	1.305×10^{-7}	-	7.458×10^{-9}	-
	PCB	.070	1.091×10^{-7}	-	6.234×10^{-9}	-
Quarry Equalization Basin and Quarry Proper	2,4,6-TNT	0	0	-	0	-
	Arsenic	11	1.645×10^{-5}	2.273×10^{-10}	9.401×10^{-7}	4.873×10^{-12}
	Chromium	18	-	3.778×10^{-10}	-	8.100×10^{-12}
	PAH	0	0	-	0	-
	PCB	0	0	-	0	-

TABLE 4.4 (Cont.)

Location[a]	Contaminant[b]	EPC (mg/kg)	Resident Intake: Ingestion (mg/kg-d)	Resident Intake: Inhalation (mg/kg-d)	Visitor Intake: Ingestion (mg/kg-d)	Visitor Intake: Inhalation (mg/kg-d)
Vicinity Properties						
DA 1	2,4,6-TNT	-	-	-	-	-
	Arsenic	-	-	-	-	-
	Chromium	-	-	-	-	-
	PAH	-	-	-	-	-
	PCB	.099	1.549×10^{-7}	-	8.853×10^{-9}	-
DA 2	2,4,6-TNT	-	-	-	-	-
	Arsenic	-	-	-	-	-
	Chromium	21	-	4.440×10^{-10}	-	9.521×10^{-12}
	PAH	-	-	-	-	-
	PCB	.066	1.041×10^{-7}	-	5.948×10^{-9}	-
DA 3	2,4,6-TNT	-[c]	-	-	-	-
	Arsenic	-	-	-	-	-
	Chromium	-	-	-	-	-
	PAH	4.3	6.757×10^{-6}	-	3.861×10^{-7}	-
	PCB	.068	1.065×10^{-7}	-	6.087×10^{-9}	-
DA 5	2,4,6-TNT	.22	2.614×10^{-7}	-	1.494×10^{-8}	-
	Arsenic	13	2.027×10^{-5}	2.800×10^{-10}	1.158×10^{-6}	6.005×10^{-12}
	Chromium	23	-	4.992×10^{-10}	-	1.071×10^{-11}
	PAH	0	0	-	0	-
	PCB	.0030	4.311×10^{-9}	-	2.463×10^{-10}	-
DA 6	2,4,6-TNT	.09	1.412×10^{-7}	-	8.069×10^{-9}	-
	Arsenic	12	1.840×10^{-5}	2.542×10^{-10}	1.052×10^{-6}	5.451×10^{-12}
	Chromium	16	-	3.499×10^{-10}	-	7.503×10^{-12}
	PAH	.093	1.461×10^{-7}	-	8.346×10^{-9}	-
	PCB	.073	1.154×10^{-7}	-	6.595×10^{-9}	-

TABLE 4.4 (Cont.)

Location[a]	Contaminant[b]	EPC (mg/kg)	Resident Intake Ingestion (mg/kg-d)	Resident Intake Inhalation (mg/kg-d)	Visitor Intake Ingestion (mg/kg-d)	Visitor Intake Inhalation (mg/kg-d)
MDC 3	2,4,6-TNT	0	0	-	0	-
	Arsenic	13	2.017×10^{-5}	2.787×10^{-10}	1.153×10^{-6}	5.975×10^{-12}
	Chromium	33	-	7.227×10^{-10}	-	1.550×10^{-11}
	PAH	0	0	-	0	-
	PCB	0	0	-	0	-
MDC 4	2,4,6-TNT	0	0	-	0	-
	Arsenic	11	1.672×10^{-5}	2.310×10^{-10}	9.555×10^{-7}	4.953×10^{-12}
	Chromium	18	-	3.979×10^{-10}	-	8.533×10^{-12}
	PAH	0	0	-	0	-
	PCB	0	0	-	0	-
MDC 5	2,4,6-TNT	0	0	-	0	-
	Arsenic	-	-	-	-	-
	Chromium	24	-	5.075×10^{-10}	-	1.088×10^{-11}
	PAH	.28	4.384×10^{-7}	-	2.505×10^{-8}	-
	PCB	0	0	-	0	-
MDC 10	2,4,6-TNT	.050	8.128×10^{-8}	-	4.644×10^{-9}	-
	Arsenic	12	1.873×10^{-5}	2.588×10^{-10}	1.071×10^{-6}	5.549×10^{-12}
	Chromium	24	-	5.240×10^{-10}	-	1.124×10^{-11}
	PAH	0	0	-	0	-
	PCB	0	0	-	0	-

[a] Carcinogenic chemical COCs are not associated with MDC 6, VP 9, and the Frog Pond Outlet/Culvert. These locations are not included in this table.

[b] The contaminant list consists of the chemical COCs considered to be carcinogens. The carcinogenic effects of chromium VI are estimated. It was assumed that 10% of the total chromium determined is chromium VI.

[c] A hyphen indicates that the pathway is not applicable for the particular COC.

TABLE 4.5 Chemical Exposure Point Concentration and Noncarcinogenic Intake for the Hypothetical Resident and Recreational Visitor Scenarios for the Various Areas Associated with the Chemical Plant Operable Unit

			Resident Intake		Visitor Intake	
Location	Contaminant	EPC (mg/kg)	Ingestion (mg/kg-d)	Inhalation (mg/kg-d)	Ingestion (mg/kg-d)	Inhalation (mg/kg-d)
CUs within cell footprint and buffer/exclusion zone	2,4,6-TNT	6.7	2.437×10^{-5}	-	1.392×10^{-6}	-
	Arsenic	7.9	2.901×10^{-5}	-	1.658×10^{-6}	-
	Chromium	17	6.172×10^{-5}	8.526×10^{-10}	3.527×10^{-6}	1.828×10^{-11}
	PCB	.043	1.574×10^{-7}	-	8.995×10^{-9}	-
	Thallium	1.9	6.869×10^{-6}	-	3.925×10^{-7}	-
	Uranium	9.9	3.609×10^{-5}	-	2.062×10^{-6}	-
Outside of disposal cell footprint and buffer/ exclusion zone (not including partial CUs)	2,4,6-TNT	.10	3.799×10^{-7}	-	2.171×10^{-8}	-
	Arsenic	8.7	3.194×10^{-5}	-	1.825×10^{-6}	-
	Chromium	19	6.748×10^{-5}	9.323×10^{-10}	3.856×10^{-6}	1.999×10^{-11}
	PCB	.095	3.459×10^{-7}	-	1.976×10^{-8}	-
	Thallium	1.9	7.023×10^{-6}	-	4.013×10^{-7}	-
	Uranium	8.0	2.925×10^{-5}	-	1.671×10^{-6}	-
Outside of disposal cell footprint and buffer/ exclusion zone (including partial CUs)	2,4,6-TNT	3.1	1.127×10^{-5}	-	6.437×10^{-7}	-
	Arsenic	8.8	3.204×10^{-5}	-	1.831×10^{-6}	-
	Chromium	18	6.693×10^{-5}	9.246×10^{-10}	3.825×10^{-6}	1.983×10^{-11}
	PCB	.070	2.546×10^{-7}	-	1.455×10^{-8}	-
	Thallium	1.8	6.656×10^{-6}	-	3.803×10^{-7}	-
	Uranium	8.7	3.160×10^{-5}	-	1.806×10^{-6}	-
Frog Pond Outlet/Culvert	Uranium	210	7.829×10^{-4}	-	4.474×10^{-5}	-
Quarry Equalization Basin and Quarry Proper	2,4,6-TNT	0	0	-	0	-
	Arsenic	11	3.839×10^{-5}	-	2.194×10^{-6}	-
	Chromium	18	6.381×10^{-5}	8.815×10^{-10}	3.646×10^{-6}	1.890×10^{-11}
	PCB	0	0	-	0	-
	Uranium	5.9	2.148×10^{-5}	-	1.227×10^{-6}	-

TABLE 4.5 (Cont.)

Location	Contaminant	EPC (mg/kg)	Resident Intake Ingestion (mg/kg-d)	Resident Intake Inhalation (mg/kg-d)	Visitor Intake Ingestion (mg/kg-d)	Visitor Intake Inhalation (mg/kg-d)
Vicinity Properties						
DA 1	PCB	.099	3.615×10^{-7}	-	2.066×10^{-8}	-
	Uranium	38	1.398×10^{-4}	-	7.989×10^{-6}	-
DA 2	Chromium	21	7.500×10^{-5}	1.036×10^{-9}	4.286×10^{-6}	2.222×10^{-11}
	PCB	.066	2.429×10^{-7}	-	1.388×10^{-8}	-
	Uranium	10	3.705×10^{-5}	-	2.117×10^{-6}	-
DA 3	PCB	.068	2.485×10^{-7}	-	1.420×10^{-8}	-
	Uranium	11	3.836×10^{-5}	-	2.192×10^{-6}	-
DA 5	2,4,6-TNT	.17	6.100×10^{-7}	-	3.486×10^{-8}	-
	Arsenic	13	4.730×10^{-5}	-	2.703×10^{-6}	-
	Chromium	23	8.432×10^{-5}	1.165×10^{-9}	4.819×10^{-6}	2.498×10^{-11}
	PCB	.0027	1.006×10^{-8}	-	5.747×10^{-10}	-
	Thallium	2.9	1.043×10^{-5}	-	5.957×10^{-7}	-
DA 6	2,4,6-TNT	.090	3.295×10^{-7}	-	1.883×10^{-8}	-
	Arsenic	12	4.294×10^{-5}	-	2.454×10^{-6}	-
	Chromium	16	5.910×10^{-5}	8.165×10^{-10}	3.377×10^{-6}	1.751×10^{-11}
	PCB	.074	2.693×10^{-7}	-	1.539×10^{-8}	-
	Thallium	1.8	6.516×10^{-6}	-	3.723×10^{-7}	-
	Uranium	62	2.250×10^{-4}	-	1.286×10^{-5}	-
MDC 3	2,4,6-TNT	0	0	-	0	-
	Arsenic	13	4.707×10^{-5}	-	2.690×10^{-6}	-
	Chromium	33	1.221×10^{-4}	1.686×10^{-9}	6.975×10^{-6}	3.616×10^{-11}
	PCB	0	0	-	0	-
	Thallium	1.4	5.099×10^{-6}	-	2.914×10^{-7}	-
	Uranium	33	1.193×10^{-4}	-	6.814×10^{-6}	-

TABLE 4.5 (Cont.)

Location	Contaminant	EPC (mg/kg)	Resident Intake Ingestion (mg/kg-d)	Resident Intake Inhalation (mg/kg-d)	Visitor Intake Ingestion (mg/kg-d)	Visitor Intake Inhalation (mg/kg-d)
MDC 4	2,4,6-TNT	0	0	-	0	-
	Arsenic	11	3.902×10^{-5}	-	2.230×10^{-6}	-
	Chromium	18	6.722×10^{-5}	9.285×10^{-10}	3.841×10^{-6}	1.991×10^{-11}
	PCB	0	0	-	0	-
	Thallium	4.3	1.571×10^{-5}	-	8.976×10^{-7}	-
	Uranium	5.9	2.164×10^{-5}	-	1.237×10^{-6}	-
MDC 5	2,4,6-TNT	0	0	-	0	-
	Chromium	24	8.572×10^{-5}	1.184×10^{-9}	4.898×10^{-6}	2.539×10^{-11}
	PCB	0	0	-	0	-
MDC6	Uranium	5.3	1.929×10^{-5}	-	1.102×10^{-6}	-
MDC 10	2,4,6-TNT	.05	1.897×10^{-7}	-	1.084×10^{-8}	-
	Arsenic	12	4.371×10^{-5}	-	2.498×10^{-6}	-
	Chromium	24	8.850×10^{-5}	1.223×10^{-9}	5.057×10^{-6}	2.622×10^{-11}
	PCB	0	0	-	0	-
	Thallium	1.6	5.845×10^{-6}	-	3.340×10^{-7}	-
	Uranium	6.0	2.206×10^{-5}	-	1.261×10^{-6}	-
VP 9	Uranium	57	2.078×10^{-4}	-	1.187×10^{-5}	-
Busch Lake 34	Uranium	19	6.900×10^{-5}	-	3.943×10^{-6}	-
Busch Lake 35	Uranium	22	7.991×10^{-5}	-	4.566×10^{-6}	-
Busch Lake 36	Uranium	29	1.049×10^{-4}	-	5.99×10^{-6}	-

* A hyphen indicates that the pathway is not applicable for the particular COC.

Intakes of radioactive contaminant i (I_i) from ingestion of soil were calculated as follows:

$$I_i = R_{si} \times IR_s \times CF_2 \times EF \times ED, \tag{4.3}$$

where

R_{si} = concentration of radionuclide i in soil or sediment (pCi/g), and

CF_2 = conversion factor (1×10^{-3} g/mg).

The intake of radioactive contaminant i (I_i) from inhalation of soil was calculated as follows:

$$I_i = R_{ai} \times IR_a \times ET \times EF \times ED, \tag{4.4}$$

where

R_{ai} = concentration of contaminant i as respirable particulates (pCi/m^3).

The intake of radioactive contaminant i (I_i) from external gamma irradiation (in units of pCi-yr/g) was calculated as follows:

$$I_i = R_{si} \times ET \times EF \times ED \times CF_3, \tag{4.5}$$

where

CF_3 = conversion factor (1.14×10^{-4} yr/h).

Table 4.6 gives the EPCs and intakes for the radionuclides of concern.

Inhalation of radon by a resident in a home with a basement was also calculated. Appendix B provides details of the calculations for the radon pathway.

4.3 METHODS FOR EVALUATING RADIATION AND CHEMICAL TOXICITY TO HUMANS

4.3.1 Radiation Toxicity

The evaluation of radiological human health risks in this assessment was limited to cancer induction. This approach is consistent with EPA guidance, which notes that cancer risk is generally the limiting effect for radionuclides and suggests that radiation carcinogenesis be used as the sole basis for assessing radiation-related human health risks (EPA 1989). The EPA has developed guidance for radiological risk assessment that is consistent with the guidance for assessing chemical carcinogenic risks (EPA 1989). Carcinogenic risks are calculated for the

TABLE 4.6 Radiological Exposure Point Concentration and Intake for the Hypothetical Resident and Recreational Visitor Scenarios for the Various Areas Associated with the Chemical Plant Operable Unit

			Resident Intake			Visitor Intake		
Location	Contaminant	EPC (pCi/g)	External Gamma (yr-pCi/g)	Ingestion (pCi)	Inhalation (pCi)	External Gamma (yr-pCi/g)	Ingestion (pCi)	Inhalation (pCi)
CUs within cell footprint and buffer/exclusion zone	Radium-226	1.2	2.435×10^{1}	1.497×10^{3}	4.595×10^{-2}	3.255×10^{-1}	8.553×10^{1}	9.852×10^{-4}
	Radium-228	1.1	2.332×10^{1}	1.434×10^{3}	4.401×10^{-2}	3.117×10^{-1}	8.102×10^{1}	9.437×10^{-4}
	Thorium-230	1.6	3.304×10^{1}	2.031×10^{3}	6.235×10^{-2}	4.417×10^{-1}	1.161×10^{2}	1.337×10^{-3}
	Uranium-238	3.3	6.749×10^{1}	4.149×10^{3}	1.274×10^{-1}	9.022×10^{-1}	2.371×10^{2}	2.731×10^{-3}
Outside of disposal cell footprint and buffer/ exclusion zone (not including partial CUs)	Radium-226	.93	1.914×10^{1}	1.177×10^{3}	3.613×10^{-2}	2.559×10^{-1}	6.725×10^{1}	7.746×10^{-4}
	Radium-228	.98	2.006×10^{1}	1.233×10^{3}	3.785×10^{-2}	2.681×10^{-1}	7.045×10^{1}	8.116×10^{-4}
	Thorium-230	1.6	3.282×10^{1}	2.024×10^{3}	6.213×10^{-2}	4.401×10^{-1}	1.157×10^{2}	1.332×10^{-3}
	Uranium-238	2.7	5.471×10^{1}	3.363×10^{3}	1.032×10^{-1}	7.313×10^{-1}	1.922×10^{2}	2.214×10^{-3}
Outside of disposal cell footprint and buffer/ exclusion zone (including partial CUs)	Radium-226	.98	2.005×10^{1}	1.233×10^{3}	3.784×10^{-2}	2.680×10^{-1}	7.044×10^{1}	8.114×10^{-4}
	Radium-228	1.0	2.051×10^{1}	1.261×10^{3}	3.871×10^{-2}	2.742×10^{-1}	7.206×10^{1}	8.300×10^{-4}
	Thorium-230	1.6	3.302×10^{1}	2.030×10^{3}	6.232×10^{-2}	4.414×10^{-1}	1.160×10^{2}	1.336×10^{-3}
	Uranium-238	2.9	5.911×10^{1}	3.634×10^{3}	1.116×10^{-1}	7.901×10^{-1}	2.076×10^{2}	2.392×10^{-3}
Frog Pond Outlet/ Culvert	Radium-226	1.2	2.419×10^{1}	1.487×10^{3}	4.564×10^{-2}	3.233×10^{-1}	8.496×10^{1}	9.787×10^{-4}
	Radium-228	1.0	2.091×10^{1}	1.285×10^{3}	3.945×10^{-2}	2.795×10^{-1}	7.344×10^{1}	8.460×10^{-4}
	Thorium-230	2.3	4.774×10^{1}	2.935×10^{3}	9.008×10^{-2}	6.381×10^{-1}	1.677×10^{2}	1.932×10^{-3}
	Uranium-238	71	1.464×10^{3}	9.001×10^{4}	2.763×10^{0}	1.957×10^{1}	5.143×10^{3}	5.925×10^{-2}
Quarry Equalization Basin and Quarry Proper	Radium-226	1.1	2.270×10^{1}	1.396×10^{3}	4.284×10^{-2}	3.035×10^{-1}	7.975×10^{1}	9.186×10^{-4}
	Radium-228	1.1	2.335×10^{1}	1.436×10^{3}	4.407×10^{-2}	3.121×10^{-1}	8.203×10^{1}	9.449×10^{-4}
	Thorium-230	3.3	6.790×10^{1}	4.174×10^{3}	1.281×10^{-1}	9.076×10^{-1}	2.385×10^{2}	2.748×10^{-3}
	Uranium-238	2.0	4.017×10^{1}	2.470×10^{3}	7.581×10^{-2}	5.370×10^{-1}	1.411×10^{2}	1.626×10^{-3}

TABLE 4.6 (Cont.)

Location	Contaminant	EPC (pCi/g)	Resident Intake: External Gamma (yr-pCi/g)	Resident Intake: Ingestion (pCi)	Resident Intake: Inhalation (pCi)	Visitor Intake: External Gamma (yr-pCi/g)	Visitor Intake: Ingestion (pCi)	Visitor Intake: Inhalation (pCi)
Vicinity Properties								
DA 1	Radium-226	1.6	3.280×10^{1}	2.016×10^{3}	6.189×10^{-2}	4.384×10^{-1}	1.152×10^{2}	1.327×10^{-3}
	Radium-228	1.3	2.630×10^{1}	1.617×10^{3}	4.963×10^{-2}	3.515×10^{-1}	9.237×10^{1}	1.064×10^{-3}
	Thorium-230	-[a]	-	-	-	-	-	-
	Uranium-238	13	2.615×10^{2}	1.607×10^{4}	4.935×10^{-1}	3.495×10^{0}	9.185×10^{2}	1.058×10^{-2}
DA 2	Radium-226	1.5	3.099×10^{1}	1.905×10^{3}	5.849×10^{-2}	4.143×10^{-1}	1.089×10^{2}	1.254×10^{-3}
	Radium-228	1.1	2.313×10^{1}	1.422×10^{3}	4.364×10^{-2}	3.091×10^{-1}	8.124×10^{1}	9.358×10^{-4}
	Thorium-230	-	-	-	-	-	-	-
	Uranium-238	3.4	6.929×10^{1}	4.260×10^{3}	1.308×10^{-1}	9.262×10^{-1}	2.434×10^{2}	2.804×10^{-3}
DA 3	Radium-226	-	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-	-
	Uranium-238	3.5	7.174×10^{1}	4.410×10^{3}	1.354×10^{-1}	9.590×10^{0}	2.520×10^{2}	2.903×10^{-3}
DA 5	Radium-226	2.2	4.585×10^{1}	2.818×10^{3}	8.652×10^{-2}	6.128×10^{-1}	1.611×10^{2}	1.855×10^{-3}
	Radium-228	1.2	2.396×10^{1}	1.473×10^{3}	4.521×10^{-2}	3.202×10^{-1}	8.415×10^{1}	9.693×10^{-4}
	Thorium-230	1.1	2.343×10^{1}	1.440×10^{3}	4.421×10^{-2}	3.132×10^{-1}	8.230×10^{1}	9.480×10^{-4}
	Uranium-238	-	-	-	-	-	-	-
DA 6	Radium-226	.81	1.664×10^{1}	1.023×10^{3}	3.140×10^{-2}	2.224×10^{-1}	5.845×10^{1}	6.733×10^{-4}
	Radium-228	.84	1.723×10^{1}	1.059×10^{3}	3.251×10^{-2}	2.303×10^{-1}	6.052×10^{1}	6.971×10^{-4}
	Thorium-230	2.3	4.666×10^{1}	2.868×10^{3}	8.806×10^{-2}	6.237×10^{-1}	1.639×10^{2}	1.888×10^{-3}
	Uranium-238	21	4.208×10^{2}	2.587×10^{4}	7.941×10^{-1}	5.625×10^{0}	1.478×10^{3}	1.703×10^{-2}

TABLE 4.6 (Cont.)

Location	Contaminant	EPC (pCi/g)	Resident Intake: External Gamma (yr-pCi/g)	Resident Intake: Ingestion (pCi)	Resident Intake: Inhalation (pCi)	Visitor Intake: External Gamma (yr-pCi/g)	Visitor Intake: Ingestion (pCi)	Visitor Intake: Inhalation (pCi)
MDC 3	Radium-226	-	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-	-
	Thorium-230	1.2	2.472×10^{1}	1.520×10^{3}	4.666×10^{-2}	3.305×10^{-1}	8.685×10^{1}	1.000×10^{-3}
	Uranium-238	11	2.230×10^{2}	1.371×10^{4}	4.209×10^{-1}	2.981×10^{0}	7.835×10^{2}	9.025×10^{-3}
MDC 4	Radium-226	1.7	3.389×10^{1}	2.083×10^{3}	6.396×10^{-2}	4.530×10^{-1}	1.191×10^{2}	1.371×10^{-3}
	Radium-228	1.6	3.300×10^{1}	2.029×10^{3}	6.228×10^{-2}	4.411×10^{-1}	1.159×10^{2}	1.335×10^{-3}
	Thorium-230	1.2	2.542×10^{1}	1.562×10^{3}	4.796×10^{-2}	3.397×10^{-1}	8.928×10^{1}	1.028×10^{-3}
	Uranium-238	2.0	4.048×10^{1}	2.489×10^{3}	7.639×10^{-2}	5.411×10^{-1}	1.422×10^{2}	1.638×10^{-3}
MDC 5	Radium-226	2.7	5.491×10^{1}	3.376×10^{3}	1.036×10^{-1}	7.340×10^{-1}	1.829×10^{2}	2.222×10^{-3}
	Radium-228	1.1	2.342×10^{1}	1.440×10^{3}	4.420×10^{-2}	3.130×10^{-1}	8.227×10^{1}	9.476×10^{-4}
	Thorium-230	3.4	7.008×10^{1}	4.308×10^{3}	1.322×10^{-1}	9.367×10^{-1}	2.462×10^{2}	2.836×10^{-3}
	Uranium-238	-	-	-	-	-	-	-
MDC 6	Radium-226	1.3	2.644×10^{1}	1.625×10^{3}	4.990×10^{-2}	3.534×10^{-1}	9.288×10^{1}	1.070×10^{-3}
	Radium-228	1.1	2.152×10^{1}	1.323×10^{3}	4.061×10^{-2}	2.877×10^{-1}	7.560×10^{1}	8.708×10^{-4}
	Thorium-230	1.8	3.607×10^{1}	2.218×10^{3}	6.808×10^{-2}	4.822×10^{-1}	1.267×10^{2}	1.460×10^{-3}
	Uranium-238	1.8	3.607×10^{1}	2.218×10^{3}	6.808×10^{-2}	4.822×10^{-1}	1.267×10^{2}	1.460×10^{-3}
MDC 10	Radium-226	1.7	3.552×10^{1}	2.184×10^{3}	6.703×10^{-2}	4.748×10^{-1}	1.248×10^{2}	1.437×10^{-3}
	Radium-228	1.5	3.027×10^{1}	1.861×10^{3}	5.713×10^{-2}	4.047×10^{-1}	1.064×10^{2}	1.225×10^{-3}
	Thorium-230	1.7	3.477×10^{1}	2.137×10^{3}	6.561×10^{-2}	4.647×10^{-1}	1.221×10^{2}	1.407×10^{-3}
	Uranium-238	2.0	4.126×10^{1}	2.536×10^{3}	7.786×10^{-2}	5.515×10^{-1}	1.449×10^{2}	1.670×10^{-3}

TABLE 4.6 (Cont.)

Location	Contaminant	EPC (pCi/g)	Resident Intake: External Gamma (yr-pCi/g)	Resident Intake: Ingestion (pCi)	Resident Intake: Inhalation (pCi)	Visitor Intake: External Gamma (yr-pCi/g)	Visitor Intake: Ingestion (pCi)	Visitor Intake: Inhalation (pCi)
VP 9	Radium-226	-	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-	-
	Uranium-238	19	3.886×10^{2}	2.389×10^{4}	7.334×10^{-1}	5.194×10^{0}	1.365×10^{3}	1.573×10^{-2}
Busch Lake 34	Radium-226	-	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-	-
	Uranium-238	6.3	1.291×10^{2}	7.933×10^{3}	2.435×10^{-1}	1.725×10^{0}	4.533×10^{2}	5.222×10^{-3}
Busch Lake 35	Radium-226	-	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-	-
	Uranium-238	7.3	1.495×10^{2}	9.188×10^{3}	2.821×10^{-1}	1.998×10^{0}	5.250×10^{2}	6.048×10^{-3}
Busch Lake 36	Radium-226	-	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-	-
	Uranium-238	9.6	1.962×10^{2}	1.206×10^{4}	3.703×10^{-1}	2.623×10^{0}	6.892×10^{2}	7.939×10^{-3}

* A hyphen indicates that the radionuclide was not reported for the particular location.

radionuclides of concern in a manner similar to existing methods for chemical carcinogens by using an age-averaged lifetime excess cancer incidence per unit intake (and per unit external exposure). The EPA has developed cancer incidence factors per unit intake that are synonymous with the slope factors developed for chemical carcinogens. Table 4.7 presents the slope factors for the radionuclides of concern for the various exposure pathways considered.

4.3.2 Chemical Toxicity

The EPA has derived toxicity values for most of the chemical contaminants of human health concern. A toxicity value known as the reference dose (RfD) is used to evaluate the noncarcinogenic effects of chemicals. The chronic RfD is defined as "an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime" (EPA 1989). To derive an RfD value (expressed in mg/kg-d), the EPA reviews all toxicity studies available for a given substance and a given route of exposure, determines a no-observed-adverse-effect level (NOAEL) or lowest-observed-adverse-effect level (LOAEL) from the study most relevant to humans (the critical study), and applies uncertainty factors to these values. The RfD can be compared with estimated exposure levels to evaluate the potential for deleterious effects. Currently available RfD values are specific to either the inhalation or ingestion route of exposure because the toxic mechanism and dose required for toxicity to occur can differ for those routes of exposure. Inhalation exposures are assessed with derived reference concentrations (RfCs), which are reported in milligrams per cubic meter (mg/m^3). An RfC can be converted to the corresponding RfD (in mg/kg-d) by dividing by 70 kg (an assumed body weight) and multiplying by 20 m^3/d (an assumed inhalation rate).

Carcinogenic risks from exposure to known and potential carcinogens were evaluated separately from noncarcinogenic risks because, hypothetically, any exposure to a carcinogen increases the risk of cancer by a finite amount. Therefore, the risk from exposure to a carcinogen at a given level can be derived, but an exposure level at which no carcinogenic effect is likely to occur (as for noncarcinogenic endpoints) cannot be defined. The EPA has defined two toxicity values for evaluating the potential carcinogenic effects of a given substance: the weight-of-evidence classification and the slope factor. For substances that have weight-of-evidence classifications of A (human carcinogen), B1, or B2 (probable human carcinogens), and sometimes C (possible human carcinogens), the EPA has calculated slope factors on the basis of data from dose-response studies. The slope factor is defined as a "plausible upper-bound estimate of the probability of a response (i.e., cancer) per unit intake of a chemical over a lifetime" (EPA 1989). Generally, slope factors are derived by extrapolation from experimental high dose ranges to low doses, and they are not valid for the evaluation of high dose levels. Also, carcinogenic risks that have been calculated from slope factors are applicable to exposures that occur over a lifetime. When exposure durations are less than a lifetime, they must be converted to equivalent lifetime values (see Tables 4.8 and 4.9).

TABLE 4.7 Radiological Slope Factors

Contaminants[b]	Slope Factors[a] Ingestion (risk/pCi)	Inhalation (risk/pCi)	External Gamma Irradiation (risk/yr per pCi/g)
Lead-210+D	2.66×10^{-9}	1.39×10^{-8}	4.21×10^{-9}
Radium-226+D[c]	7.50×10^{-10}	1.16×10^{-8}	8.49×10^{-6}
Radium-228+D[c]	2.29×10^{-9}	5.23×10^{-9}	4.53×10^{-6}
Thorium-228+D[c]	8.09×10^{-10}	1.43×10^{-7}	7.76×10^{-6}
Thorium-230	2.02×10^{-10}	2.85×10^{-8}	8.19×10^{-10}
Thorium-232	2.31×10^{-10}	4.33×10^{-8}	3.42×10^{-10}
Uranium-234	1.58×10^{-10}	1.14×10^{-8}	2.52×10^{-10}
Uranium-235+D	1.63×10^{-10}	1.01×10^{-8}	5.43×10^{-7}
Uranium-238+D	2.10×10^{-10}	9.35×10^{-9}	1.14×10^{-7}

a Source: EPA (2002).

b Radionuclide marked with a "+D" indicates that the risks from associated short-lived radioactive decay products (i.e., those with half-lives less than or equal to six months) are also included.

c Concentration data are only available for four radionuclides: radium-226, radium-228, thorium-230, and uranium-238. In calculating the risks, the slope factor for uranium-238+D was adjusted to include the contributions from uranium-234+D and uranium-235+D. The slope factor for radium-226+D was adjusted to include the contribution from lead-210+D, and the slope factor for radium-228+D was adjusted to include the contributions of thorium-228+D and thorium-232. The concentrations of the contributing radionuclides, i.e., uranium-234, uranium-235+D, lead-210+D, thorium-228+D, and thorium-232 are assumed to be equal to that of the measured radionuclides in all cases except for uranium-235+D, which is taken to be 0.046 of the uranium-238+D concentration based on the naturally occurring ratio of uranium-235 to uranium-238. The thorium-232+D concentration is assumed to be equal to the radium-228+D concentration, since thorium-232 was not measured. This approach is consistent with the radionuclide source term analysis performed for the Chemical Plant Area RI report (DOE 1992c).

TABLE 4.8 Toxicity Values of the Chemical Contaminants of Concern for Ingestion and Inhalation: Potential Systemic Effects

Pathway/Parameter	Chronic RfD (mg/kg-d)	Confidence	Critical Effect	RfD Basis	RfD Source[a]	Uncertainty Factor (UF)
Ingestion						
Metals						
Arsenic	.0003	Medium	Hyperpigmentation, keritosis, and possible vascular complications	Oral, human	IRIS	3
Chromium III	1.5	Low	No adverse effects	Oral, rat	IRIS	100
Chromium VI	.003	Low	No adverse effects	Water, rat	IRIS	300
Thallium[b]	.00008	Low	No adverse effects	Oral, rat	IRIS	3,000
Uranium (soluble salts)	.003	Medium	Weight loss, moderate kidney toxicity	Oral, rabbit	IRIS	1,000
Organic compounds						
2,4,6-TNT	.0005	Medium	Liver effects	Oral, dog	IRIS	1,000
Aroclor 1254	.00002	Medium	Ocular exudate, inflamed glands	Diet, monkey	IRIS	300

Pathway/Parameter	Chronic RfD (mg/m^3)	Confidence	Critical Effect	RfD Basis	RfD Source[a]	Uncertainty Factor (UF)
Inhalation						
Metals						
Chromium VI	.0001	Medium	Lactate dehydrogenase in bronchioalveolar lavage liquid	Rat/inhalation	IRIS	300

[a] Source: IRIS = *Integrated Risk Information System* database (EPA Office of Research and Development, accessed November 2001).

[b] Values based on thallium sulfate.

TABLE 4.9 Toxicity Values of Chemical Contaminants of Concern for Ingestion and Inhalation: Potential Carcinogenic Effects

Pathway/Parameter	Slope Factor ($mg/kg\text{-}d^{-1}$)	Weight of Evidence Classification	Type of Cancer	Slope Factor Basis	Slope Factor Source[a]
Ingestion					
Metals:					
Arsenic	1.5	A: human carcinogen	Skin	Water, human	IRIS
Organic Compounds:					
2,4,6-TNT	.03	C: possible human carcinogen	Urinary bladder; transitional cell papilloma; transitional squamous carcinoma	Diet, rat	IRIS
PCBs	2.0	B2: probable human carcinogen	Liver hepatocellular adenomas, carcinomas, cholangiomas	Diet, rat	IRIS
PAHs[b]	7.3	B2: probable human carcinogen	Forestomach; larynx; esophagus	Diet, mouse, and rat	IRIS

Pathway/Parameter	Unit Risk ($\mu g/m^3$)	Weight of Evidence Classification	Type of Cancer	Slope Factor Basis	Slope Factor Source
Inhalation					
Metals					
Arsenic	.0043	A human carcinogen	Lung	Occupational, human	IRIS
Chromium VI	.012	A: human carcinogen	Lung	Occupational, human	IRIS

[a] Source: IRIS = *Integrated Risk Information System* database (EPA Office of Research and Development, accessed November 2001).

[b] The slope factor for benzo(a)pyrene was used to quantify the risk for all class B2 PAHs (i.e., benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene, and chrysene).

5 RISK CHARACTERIZATION

Potential carcinogenic health risks resulting from exposure to radioactive and chemical contamination were assessed in terms of the increased probability that an individual would develop cancer over a lifetime. The EPA has indicated that for known or suspected carcinogens, the acceptable exposure levels for members of the general public at sites on the National Priorities List (NPL) are generally concentration levels that represent an excess upperbound lifetime cancer risk to an individual of between 1×10^{-6} and 1×10^{-4} (EPA 1990).

Potential health effects other than cancer from exposure to chemical contaminants were also assessed. The quantitative measure of noncarcinogenic health effects is the hazard index (HI). The EPA has defined a HI of greater than 1 as the level of concern for noncarcinogenic health effects.

5.1 RADIOLOGICAL RISKS

Exposures to ionizing radiation can result in cancer induction, serious genetic effects, and other detrimental health effects. The predominant health concern associated with the residual radioactive contaminants at the Chemical Plant Operable Unit is the induction of cancer. The radiological health risks evaluated were limited to this concern. This approach is consistent with EPA guidance, which notes that, in general, the risk of cancer is limiting and may be used as the sole basis for assessing the radiation-related human health risks for a site contaminated with radionuclides (EPA 1989).

For this assessment, slope factors were used to estimate the potential risk from exposure to radionuclides. Intakes were estimated for each exposure pathway (see Section 4.2). Radiological risks were calculated by multiplying the intakes by the appropriate slope factor. Table 5.1 gives the radiological risk estimates for the hypothetical resident and recreational visitor scenarios from each of the radionuclides of concern at the various locations of the Chemical Plant Operable Unit. The radiological risks associated with inhalation of radon-222 and its short-lived decay products are given separately in Appendix B.

5.2 CHEMICAL RISKS AND HAZARD INDICES

5.2.1 Carcinogenic Risks

The risk to an individual resulting from exposure to chemical carcinogens is expressed as the probability of a cancer occurring over a lifetime. To calculate the excess cancer risk, the daily intake averaged over a lifetime is multiplied by a chemical-specific slope factor. The EPA has derived slope factors for a number of carcinogens, and they represent the incremental lifetime cancer risk per milligram of carcinogen per kilogram of body weight, assuming that the exposure

TABLE 5.1 Radiological Carcinogenic Risk for the Hypothetical Resident and Recreational Visitor Scenarios for the Various Areas Associated with the Chemical Plant Operable Unit

		Resident Risk			Visitor Risk		
Location	Contaminant	External	Ingestion	Inhalation	External	Ingestion	Inhalation
CUs within cell footprint and buffer/exclusion zone	Radium-226	2.1×10^{-4}	5.1×10^{-6}	1.2×10^{-9}	2.8×10^{-6}	2.9×10^{-7}	2.5×10^{-11}
	Radium-228	2.9×10^{-4}	4.8×10^{-6}	8.4×10^{-9}	3.8×10^{-6}	3.7×10^{-7}	1.8×10^{-10}
	Thorium-230	2.7×10^{-8}	4.1×10^{-7}	1.8×10^{-9}	3.6×10^{-10}	2.3×10^{-8}	3.8×10^{-11}
	Uranium-238	9.4×10^{-6}	1.6×10^{-6}	2.7×10^{-9}	1.3×10^{-7}	8.9×10^{-8}	5.8×10^{-11}
Outside of disposal cell footprint and buffer/exclusion zone (not including partial CUs)	Radium-226	1.6×10^{-4}	4.0×10^{-6}	9.2×10^{-10}	2.2×10^{-6}	2.3×10^{-7}	2.0×10^{-11}
	Radium-228	2.5×10^{-4}	4.1×10^{-6}	7.2×10^{-9}	3.3×10^{-6}	2.3×10^{-7}	1.6×10^{-10}
	Thorium-230	2.7×10^{-8}	4.1×10^{-7}	1.8×10^{-9}	3.6×10^{-10}	2.3×10^{-8}	3.8×10^{-11}
	Uranium-238	7.6×10^{-6}	1.3×10^{-6}	2.2×10^{-9}	1.0×10^{-7}	7.2×10^{-8}	4.7×10^{-11}
Outside of disposal cell footprint and buffer/exclusion zone (including partial CUs)	Radium-226	1.7×10^{-4}	4.2×10^{-6}	9.6×10^{-10}	2.3×10^{-6}	2.4×10^{-7}	2.1×10^{-11}
	Radium-228	2.5×10^{-4}	4.2×10^{-6}	7.4×10^{-9}	3.4×10^{-6}	2.4×10^{-7}	1.6×10^{-10}
	Thorium-230	3.7×10^{-8}	4.1×10^{-7}	1.8×10^{-9}	3.6×10^{-10}	2.3×10^{-8}	3.8×10^{-11}
	Uranium-238	8.2×10^{-6}	1.4×10^{-6}	2.4×10^{-9}	1.1×10^{-7}	7.8×10^{-8}	5.1×10^{-11}
Frog Pond Outlet/Culvert	Radium-226	2.1×10^{-4}	5.0×10^{-6}	1.2×10^{-9}	2.7×10^{-6}	2.9×10^{-7}	2.5×10^{-11}
	Radium-228	2.6×10^{-4}	4.3×10^{-6}	7.6×10^{-9}	3.4×10^{-6}	2.4×10^{-7}	1.6×10^{-10}
	Thorium-230	3.9×10^{-8}	5.9×10^{-7}	2.6×10^{-9}	5.2×10^{-10}	3.4×10^{-8}	5.5×10^{-11}
	Uranium-238	2.0×10^{-4}	3.4×10^{-5}	5.9×10^{-8}	2.7×10^{-6}	1.9×10^{-6}	1.3×10^{-9}
Quarry Equalization Basin and Quarry Proper	Radium-226	1.9×10^{-4}	4.7×10^{-6}	1.1×10^{-9}	2.6×10^{-6}	2.7×10^{-7}	2.3×10^{-11}
	Radium-228	2.9×10^{-4}	4.8×10^{-6}	8.4×10^{-9}	3.8×10^{-6}	2.7×10^{-7}	1.8×10^{-10}
	Thorium-230	5.6×10^{-8}	8.4×10^{-7}	3.7×10^{-9}	7.4×10^{-10}	4.8×10^{-8}	7.8×10^{-11}
	Uranium-238	5.6×10^{-6}	9.3×10^{-7}	1.6×10^{-9}	7.5×10^{-8}	5.3×10^{-8}	3.4×10^{-11}

TABLE 5.1 (Cont.)

Location	Contaminant	Resident Risk			Visitor Risk		
		External	Ingestion	Inhalation	External	Ingestion	Inhalation
Vicinity Properties							
DA 1	Radium-226	2.8×10^{-4}	6.8×10^{-6}	1.6×10^{-9}	3.7×10^{-6}	3.9×10^{-7}	3.4×10^{-11}
	Radium-228	3.2×10^{-4}	5.4×10^{-6}	9.5×10^{-9}	4.3×10^{-6}	3.1×10^{-7}	2.0×10^{-10}
	Thorium-230	-[a]	-	-	-	-	-
	Uranium-238	3.6×10^{-5}	6.6×10^{-6}	1.0×10^{-8}	4.9×10^{-7}	3.4×10^{-7}	2.2×10^{-10}
DA 2	Radium-226	2.6×10^{-4}	6.5×10^{-6}	1.5×10^{-9}	3.5×10^{-6}	3.7×10^{-7}	3.2×10^{-11}
	Radium-228	2.8×10^{-4}	4.7×10^{-6}	8.4×10^{-9}	3.8×10^{-6}	2.7×10^{-7}	1.8×10^{-10}
	Thorium-230	-	-	-	-	-	-
	Uranium-238	9.6×10^{-6}	1.6×10^{-6}	2.8×10^{-9}	1.3×10^{-8}	9.1×10^{-8}	5.9×10^{-11}
DA 3	Radium-226	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-
	Uranium-238	1.0×10^{-5}	1.7×10^{-6}	2.9×10^{-9}	1.3×10^{-7}	9.5×10^{-8}	6.2×10^{-11}
DA 5	Radium-226	3.9×10^{-4}	9.6×10^{-6}	2.2×10^{-9}	5.2×10^{-6}	5.5×10^{-7}	4.7×10^{-11}
	Radium-228	2.9×10^{-4}	4.9×10^{-6}	8.7×10^{-9}	3.9×10^{-6}	2.8×10^{-7}	1.9×10^{-10}
	Thorium-230	1.9×10^{-8}	2.9×10^{-7}	1.3×10^{-9}	2.6×10^{-10}	1.7×10^{-8}	2.7×10^{-11}
	Uranium-238	-	-	-	-	-	-
DA 6	Radium-226	1.4×10^{-4}	3.5×10^{-6}	8.0×10^{-10}	1.9×10^{-6}	2.0×10^{-7}	1.7×10^{-11}
	Radium-228	2.1×10^{-4}	3.5×10^{-6}	6.2×10^{-9}	2.8×10^{-6}	2.0×10^{-7}	1.3×10^{-10}
	Thorium-230	3.8×10^{-8}	5.8×10^{-7}	2.5×10^{-9}	5.1×10^{-10}	3.3×10^{-8}	5.4×10^{-11}
	Uranium-238	5.9×10^{-5}	9.7×10^{-6}	1.7×10^{-8}	7.8×10^{-7}	5.6×10^{-7}	3.6×10^{-10}
MDC 3	Radium-226	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-
	Thorium-230	2.0×10^{-8}	3.1×10^{-7}	1.3×10^{-9}	2.7×10^{-10}	1.8×10^{-8}	2.9×10^{-11}
	Uranium-238	3.1×10^{-5}	5.1×10^{-6}	8.9×10^{-9}	4.2×10^{-7}	2.9×10^{-7}	1.9×10^{-10}

TABLE 5.1 (Cont.)

		Resident Risk			Visitor Risk		
Location	Contaminant	External	Ingestion	Inhalation	External	Ingestion	Inhalation
MDC 4	Radium-226	2.8×10^{-4}	7.1×10^{-6}	1.6×10^{-9}	3.8×10^{-6}	4.0×10^{-7}	3.5×10^{-11}
	Radium-228	4.1×10^{-4}	6.8×10^{-6}	1.2×10^{-8}	5.4×10^{-6}	3.9×10^{-7}	2.6×10^{-10}
	Thorium-230	2.1×10^{-8}	3.2×10^{-7}	1.4×10^{-9}	2.8×10^{-10}	1.8×10^{-8}	2.9×10^{-11}
	Uranium-238	5.6×10^{-6}	9.3×10^{-7}	1.6×10^{-9}	7.5×10^{-8}	5.3×10^{-8}	3.5×10^{-11}
MDC 5	Radium-226	4.7×10^{-4}	1.1×10^{-5}	2.6×10^{-9}	6.2×10^{-6}	6.5×10^{-7}	5.7×10^{-11}
	Radium-228	2.9×10^{-4}	4.8×10^{-6}	8.5×10^{-9}	3.8×10^{-6}	2.7×10^{-7}	1.8×10^{-10}
	Thorium-230	5.7×10^{-8}	8.7×10^{-7}	3.8×10^{-9}	7.7×10^{-10}	5.0×10^{-8}	8.1×10^{-11}
	Uranium-238	-	-	-	-	-	-
MDC 6	Radium-226	2.2×10^{-4}	5.5×10^{-6}	1.3×10^{-9}	3.0×10^{-6}	3.1×10^{-7}	2.7×10^{-11}
	Radium-228	2.6×10^{-4}	4.4×10^{-6}	7.8×10^{-9}	3.5×10^{-6}	2.5×10^{-7}	1.7×10^{-10}
	Thorium-230	3.0×10^{-8}	4.5×10^{-7}	1.9×10^{-9}	3.9×10^{-10}	2.6×10^{-8}	4.2×10^{-11}
	Uranium-238	5.0×10^{-6}	8.3×10^{-7}	1.4×10^{-9}	6.7×10^{-8}	4.8×10^{-8}	3.1×10^{-11}
MDC 10	Radium-226	3.0×10^{-4}	7.4×10^{-6}	1.7×10^{-9}	4.0×10^{-6}	4.2×10^{-7}	3.7×10^{-11}
	Radium-228	3.7×10^{-4}	6.2×10^{-6}	1.1×10^{-8}	5.0×10^{-6}	3.5×10^{-7}	2.3×10^{-10}
	Thorium-230	2.8×10^{-8}	4.3×10^{-7}	1.9×10^{-9}	3.8×10^{-10}	2.5×10^{-8}	4.0×10^{-11}
	Uranium-238	5.7×10^{-6}	9.5×10^{-7}	1.7×10^{-9}	7.7×10^{-8}	5.4×10^{-8}	3.5×10^{-11}
VP 9	Radium-226	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-
	Uranium-238	5.4×10^{-5}	9.0×10^{-6}	1.6×10^{-8}	7.2×10^{-7}	5.1×10^{-7}	3.3×10^{-10}
Busch Lake 34	Radium-226	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-
	Uranium-238	1.8×10^{-5}	3.0×10^{-6}	5.2×10^{-9}	2.4×10^{-7}	1.7×10^{-7}	1.1×10^{-10}

TABLE 5.1 (Cont.)

Location	Contaminant	Resident Risk			Visitor Risk		
		External	Ingestion	Inhalation	External	Ingestion	Inhalation
Busch Lake 35	Radium-226	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-
	Uranium-238	2.1×10^{-5}	3.5×10^{-6}	6.0×10^{-9}	2.8×10^{-7}	2.0×10^{-7}	1.3×10^{-10}
Busch Lake 36	Radium-226	-	-	-	-	-	-
	Radium-228	-	-	-	-	-	-
	Thorium-230	-	-	-	-	-	-
	Uranium-238	2.7×10^{-5}	4.5×10^{-6}	7.9×10^{-9}	3.7×10^{-7}	2.6×10^{-7}	1.7×10^{-10}

* A hyphen indicates that the contaminant was not reported for the location.

occurs over a lifetime of 70 years. The estimated daily intakes (averaged over a lifetime) resulting from exposure to the chemical carcinogens in residual soil were modified by these slope factors to estimate the chemical carcinogenic risk. Table 5.2 gives the chemical risk estimates for the hypothetical resident and recreational visitor scenarios from each of the chemical COCs at the various locations associated with the Chemical Plant Operable Unit.

5.2.2 Hazard Indices

A HI provides a measure of the potential for adverse health effects other than cancer. For an individual contaminant, the daily intake averaged over the exposure period is divided by the reference dose, or RfD, to derive the HI. The RfD is the average daily dose that can be incurred without an appreciable risk of deleterious health effects during a lifetime. The EPA has derived RfDs for exposure periods of more than seven years; only chronic RfDs were considered in this assessment.

For an individual contaminant, a HI of 1 or greater is considered to indicate a potential for adverse health effects. For multiple contaminants, the hazard quotients (HQs) for each contaminant are summed to determine a HI. Table 5.3 gives the HQs and HIs for each of the chemical COCs at the various locations associated with the Chemical Plant Operable Unit.

Estimates obtained from the IEUBK Model for lead are presented in Table 5.4. The estimates indicate that lead concentrations remaining at the Chemical Plant and the VPs are low and would not likely result in health effects of concern due to lead. A level of 10 µg/dL or greater of lead in blood in children age 1 to 7 years is considered to be of concern.

TABLE 5.2 Chemical Carcinogenic Risk for the Hypothetical Resident and Recreational Visitor Scenarios for the Various Areas Associated with the Chemical Plant Operable Unit

		Resident Risk		Visitor Risk	
Location[a]	Contaminant	Ingestion	Inhalation	Ingestion	Inhalation
CUs within cell footprint and buffer/exclusion zone	2,4,6-TNT	3.1×10^{-7}	-[b]	1.8×10^{-8}	-
	Arsenic	1.9×10^{-5}	2.6×10^{-9}	1.1×10^{-6}	5.5×10^{-11}
	Chromium VI	-	1.5×10^{-8}	-	3.3×10^{-10}
	PAH	1.9×10^{-6}	-	1.1×10^{-7}	-
	PCB	1.3×10^{-7}	-	7.7×10^{-9}	-
Outside of disposal cell footprint and buffer/exclusion zone (not including partial CUs)	2,4,6-TNT	4.9×10^{-9}	-	2.8×10^{-10}	-
	Arsenic	2.1×10^{-5}	2.8×10^{-9}	1.2×10^{-6}	6.1×10^{-11}
	Chromium VI	-	1.7×10^{-8}	-	3.6×10^{-10}
	PAH	9.5×10^{-7}	-	5.4×10^{-8}	-
	PCB	3.0×10^{-7}	-	1.7×10^{-8}	-
Outside of disposal cell footprint and buffer/exclusion zone (including partial CUs)	2,4,6-TNT	1.4×10^{-7}	-	8.3×10^{-9}	-
	Arsenic	2.1×10^{-5}	2.8×10^{-9}	1.2×10^{-6}	6.1×10^{-11}
	Chromium VI	-	1.7×10^{-8}	-	3.5×10^{-10}
	PAH	9.5×10^{-7}	-	5.4×10^{-8}	-
	PCB	2.2×10^{-7}	-	1.2×10^{-8}	-
Quarry Equalization Basin and Quarry Proper	2,4,6-TNT	0	-	0	-
	Arsenic	2.5×10^{-5}	3.4×10^{-9}	1.4×10^{-6}	7.3×10^{-11}
	Chromium VI	-	1.6×10^{-8}	-	3.4×10^{-10}
	PAH	0	-	0	-
	PCB	0	-	0	-

TABLE 5.2 (Cont.)

Location[a]	Contaminant	Resident Risk		Visitor Risk	
		Ingestion	Inhalation	Ingestion	Inhalation
Vicinity Properties:					
DA 1	2,4,6-TNT	-	-	-	-
	Arsenic	-	-	-	-
	Chromium VI	-	-	-	-
	PAH	-	-	-	-
	PCB	3.1×10^{-7}	-	1.8×10^{-8}	-
DA 2	2,4,6-TNT	-	-	-	-
	Arsenic	-	-	-	-
	Chromium VI	-	1.9×10^{-8}	-	4.0×10^{-10}
	PAH	-	-	-	-
	PCB	2.1×10^{-7}	-	1.2×10^{-8}	-
DA 3	2,4,6-TNT	-	-	-	-
	Arsenic	-	-	-	-
	Chromium VI	-	-	-	-
	PAH	4.9×10^{-5}	-	2.8×10^{-6}	-
	PCB	2.1×10^{-8}	-	1.2×10^{-8}	-
DA 5	2,4,6-TNT	7.8×10^{-9}	-	4.5×10^{-10}	-
	Arsenic	3.0×10^{-5}	4.2×10^{-9}	1.7×10^{-6}	9.0×10^{-11}
	Chromium VI	-	2.1×10^{-8}	-	4.5×10^{-10}
	PAH	0	-	0	-
	PCB	8.6×10^{-9}	-	4.9×10^{-10}	-
DA 6	2,4,6-TNT	4.2×10^{-9}	-	2.4×10^{-10}	8.1×10^{-11}
	Arsenic	2.8×10^{-5}	3.8×10^{-9}	1.6×10^{-6}	3.1×10^{-10}
	Chromium VI	-	1.5×10^{-8}	-	-
	PAH	1.1×10^{-6}	-	6.1×10^{-8}	-
	PCB	2.3×10^{-7}	-	1.3×10^{-8}	

TABLE 5.2 (Cont.)

Location[a]	Contaminant	Resident Risk		Visitor Risk	
		Ingestion	Inhalation	Ingestion	Inhalation
MDC 3	2,4,6-TNT	0	-	0	-
	Arsenic	3.0×10^{-5}	4.2×10^{-9}	1.7×10^{-6}	8.9×10^{-11}
	Chromium VI	-	3.0×10^{-8}	-	6.5×10^{-10}
	PAH	0	-	0	-
	PCB	0	-	0	-
MDC 4	2,4,6-TNT	0	-	0	-
	Arsenic	2.5×10^{-5}	3.4×10^{-9}	1.4×10^{-6}	7.4×10^{-11}
	Chromium VI	-	1.7×10^{-8}	-	3.6×10^{-10}
	PAH	0	-	0	-
	PCB	0	-	0	-
MDC 5	2,4,6-TNT	0	-	0	-
	Arsenic	-	-	-	-
	Chromium VI	-	2.1×10^{-8}	-	4.5×10^{-10}
	PAH	3.2×10^{-6}	-	1.8×10^{-7}	-
	PCB	0	-	0	-
MDC 10	2,4,6-TNT	2.4×10^{-9}	-	1.4×10^{-10}	-
	Arsenic	2.8×10^{-5}	3.9×10^{-9}	1.6×10^{-6}	8.3×10^{-11}
	Chromium VI	-	2.2×10^{-8}	-	4.7×10^{-10}
	PAH	0	-	0	-
	PCB	0	-	0	-

[a] The Frog Pond Outlet/Culvert is not shown in this table because no carcinogenic chemical COC is associated with this location.

[b] A hyphen indicates that the contaminant was not reported for the location.

TABLE 5.3 Hazard Quotient and Hazard Index for the Hypothetical Resident and Recreational Visitor Scenarios of the Various Locations of the Chemical Plant Operable Unit

		Resident HQ			Visitor HQ		
Location	Contaminant	Ingestion	Inhalation	HI[a]	Ingestion	Inhalation	HI
CUs within cell footprint and buffer/exclusion zone	2,4,6-TNT	.05	-[b]		.003	-	
	Arsenic	.1	-		.006	-	
	Chromium	<.0001	.0003		<.0001	<.0001	
	PCB	.008	-		.0004		
	Thallium	.09	-		.005		
	Uranium	.01	-		.0007		
				.3			.01
Outside of disposal cell footprint and buffer/exclusion zone (not including partial CUs)	2,4,6-TNT	.0008	-		<.0001	-	
	Arsenic	.1	-		.006	-	
	Chromium	<.0001	.0003		<.0001	<.0001	
	PCB	.02	-		.001	-	
	Thallium	.09	-		.005	-	
	Uranium	.01	-		.0006	-	
				.2			.01
Outside of disposal cell footprint and buffer/exclusion zone (including partial CUs)	2,4,6-TNT	.02	-		.0003	-	
	Arsenic	.1	-		.001	-	
	Chromium	<.0001	.0003		<.0001	<.0001	
	PCB	.01	-		.0002	-	
	Thallium	.08	-		.001	-	
	Uranium	.01	-		.0001	-	
				.2			.003
Frog Pond Outlet/Culvert	Uranium	.3	-		.01	-	
				.3			.01

TABLE 5.3 (Cont.)

Location	Contaminant	Resident HQ Ingestion	Resident HQ Inhalation	Resident HI*	Visitor HQ Ingestion	Visitor HQ Inhalation	Visitor HI
Quarry Equalization Basin and Quarry Proper	2,4,6-TNT	0	-		0	-	
	Arsenic	.1	-		.007	-	
	Chromium	<.0001	.0003		<.0001	<.0001	
	PCB	0	-		0	-	
	Thallium	-	-		-	-	
	Uranium	.007	-		<.0004	-	
				.1			.008
Vicinity Properties:							
DA 1	2,4,6-TNT	-	-		-	-	
	Arsenic	-	-		-	-	
	Chromium	-	-		-	-	
	PCB	.02	-		.001	-	
	Thallium	-	-		-	-	
	Uranium	.05	-		.003	-	
				.06			.004
DA 2	2,4,6-TNT	-	-		-	-	
	Arsenic	-	-		-	-	
	Chromium	<.0001	.0004		<.0001	<.0001	
	PCB	.01	-		.0007	-	
	Thallium	-	-		-	-	
	Uranium	.01			.0007	-	
				.02			.001
DA 3	2,4,6-TNT	-	-		-	-	
	Arsenic	-	-		-	-	
	Chromium	-	-		-	-	
	PCB	.01	-		.0007	-	
	Thallium	-	-		-	-	
	Uranium	.01	-		.0007	-	
				.03			.001

TABLE 5.3 (Cont.)

Location	Contaminant	Resident HQ			Visitor HQ		
		Ingestion	Inhalation	HI[a]	Ingestion	Inhalation	HI
DA 5	2,4,6-TNT	.001	-		<.0001	-	
	Arsenic	.2	-		.009	-	
	Chromium	<.0001	.0004		<.0001	<.0001	
	PCB	.0005	-		<.0001	-	
	Thallium	.1	-		.007	-	
	Uranium	-	-		-	-	
				.3			.02
DA 6	2,4,6-TNT	.0007	-		<.0001	-	
	Arsenic	.1	-		.008	-	
	Chromium	<.0001	.0003		<.0001	<.0001	
	PCB	.01	-		.0008	-	
	Thallium	.08	-		.005	-	
	Uranium	.07	-		.004	-	
				.3			.02
MDC 3	2,4,6-TNT	0	-		0	-	
	Arsenic	.2	-		.009	-	
	Chromium	<.0001	.0006		<.0001	<.0001	
	PCB	0	-		0	-	
	Thallium	.06	-		.004	-	
	Uranium	.04	-		.002	-	
				.3			.01
MDC 4	2,4,6-TNT	0	-		0	-	
	Arsenic	.1	-		.007	-	
	Chromium	<.0001	.0003		<.0001	<.0001	
	PCB	0	-		0	-	
	Thallium	.2	-		.01	-	
	Uranium	.007	-		.0004	-	
				.3			.02

TABLE 5.3 (Cont.)

Location	Contaminant	Resident HQ			Visitor HQ		
		Ingestion	Inhalation	HI[a]	Ingestion	Inhalation	HI
MDC 5	2,4,6-TNT	0	-		0	-	
	Arsenic	-	-		-	-	
	Chromium	<.0001	.0004		<.0001	<.0001	
	PCB	0	-		0	-	
	Thallium	-	-		-	-	
	Uranium	-	-		-	-	
				.0004			<.0001
MDC 6	Uranium	.006	-		.0004	-	
				.006			.0004
MDC 10	2,4,6-TNT	.0004	-		<.0001	-	
	Arsenic	.1	-		.008	-	
	Chromium	<.0001	.0004		<.0001	<.0001	
	PCB	0	-		0	-	
	Thallium	.07	-		.004	-	
	Uranium	.007	-		.0004	-	
				.2			.01
VP 9	Uranium	.07	-		.004	-	
				.07			.004
Busch Lake 34	Uranium	.02	-		.001	-	
				.02			.001
Busch Lake 35	Uranium	.03	-		.002	-	
				.03			.002
Busch Lake 36	Uranium	.03	-		.002	-	
				.03			.002

[a] The sum of all hazard quotients (HQs) is presented as the hazard index (HI).

[b] A hyphen indicates that the pathway is not of concern for the particular COC.

TABLE 5.4 IEUBK Model Estimates for Lead[a]

Location	UCL for Lead (mg/kg)	Range of Blood Level[b] (μg/dL)	Range of Probability[c]
CUs within cell footprint and buffer/exclusion zone	17	1.4–1.8	0–.0002
Outside of disposal cell footprint and buffer/exclusion zone (not including partial CUs)	23	1.4–1.9	0–.0002
Outside of disposal cell footprint and buffer/exclusion zone (including partial CUs)	21	1.4–1.8	0–.0002
Quarry Equalization Basin and Quarry Proper	15	1.4–1.8	0–.0001
Vicinity Properties			
DA 5	24	1.4–1.9	0–.0002
DA 6[d]	28	1.5–2.0	0–.0003
MDC 3	140	2.2–3.5	.0006–.01
MDC 4	21	1.4–1.8	0–.0002
MDC 5	64	1.7–2.5	.0001–.002
MDC 10	18	1.4–1.8	0–.0002

a The IEUBK Model (version 0.99D) developed by the EPA was used for evaluating potential health effects from lead in soil.

b The range incorporates estimates for children age 1 to 7 years. The health effect level of concern for children age 1 to 7 years is 10 μg/dL or greater.

c Probability that the blood lead concentrations could exceed 10 μg/dL or greater.

d Estimated based on characterization data.

6 SUMMARY OF RISK RESULTS

6.1 RADIOLOGICAL RISK ESTIMATES

For the hypothetical resident scenario, radiological risk estimates for the various locations evaluated as shown in Table 3.1 are slightly greater than the upper end of the EPA's acceptable risk range of 10^{-6} to 10^{-4} (see Table 6.1). The risk estimates for background concentrations of the radionuclides are also greater than 10^{-4}. Radiological risk estimates for the locations within the Chemical Plant itself (within the former fence line) are equivalent to risk estimates for background concentrations of the radionuclides of concern. That is, the estimates for the areas within the cell footprint and outside the cell footprint are 5.1×10^{-4} and 4.4×10^{-4}, respectively, as compared with 5.3×10^{-4} for background risk. For the VPs, including the Frog Pond Outlet but excluding the Southeast Drainage, the range of the radiological risk estimates is 1.2×10^{-5} at DA 3 to 7.7×10^{-4} at MDC 5. The risk estimates at VPs are at the low end of the range (e.g., at VP 9 and DA 3), where radium-226 is not a concern.

Calculations for each individual CU were also performed with risk estimates ranging from 3.7×10^{-6} to 2.1×10^{-3} for the hypothetical resident scenario and from 7.3×10^{-8} to 3.0×10^{-5} for the recreational visitor scenario. Figure 6.1 depicts the distribution of the risk estimates for the hypothetical resident scenario for the various CUs. The low end of the ranges was reported for CU 206, and the high end of the ranges was reported for CU 046. A tabulation of risk estimates for the individual CUs is presented in Appendix C.

The radiological risks for the resident scenario given in Table 6.1 do not include the contribution from inhalation of radon gas. This pathway was evaluated separately in Appendix B. The risks associated with radon are due primarily to inhalation of the short-lived decay products and are generally a concern only for indoor exposures. This risk range is from 7.3×10^{-4} at DA 6 to 2.4×10^{-3} at MDC 5 which is comparable to the background radon risk of 1.1×10^{-3} (see Table B.1). This risk is reported separately since it pertains only to indoor exposures, and specific mitigation measures are available to reduce this risk.

The estimates shown in Table 6.2 indicate that potential radiological residual risks for the recreational visitor scenario are at or lower than the lower end of the acceptable risk range. The range of risk estimates is 2.3×10^{-7} DA 3 to 1.1×10^{-5} at MDC 5 and the Frog Pond Outlet/Culvert. For comparison, the estimated risk for this scenario for background concentrations of the radionuclides of concern is 7.5×10^{-6}. Therefore, like those for the hypothetical resident scenario discussed above, the risk estimates for the recreational visitor scenario for the various locations also appear to be similar to those for background sources.

TABLE 6.1 Summary of Residual Risk for the Hypothetical Resident Scenario for the Various Locations of the Chemical Plant Operable Unit

Location[a]	Carcinogenic Risk			Hazard Index
	Radiological[b]	Chemical	Total Risk	
CUs within cell footprint and buffer/exclusion zone	5.1×10^{-4}	2.1×10^{-5}	5.3×10^{-4}	.3
Outside of disposal cell footprint and buffer/exclusion zone (not including partial CUs)	4.3×10^{-4}	2.2×10^{-5}	4.5×10^{-4}	.2
Outside of disposal cell footprint and buffer/exclusion zone (including partial CUs)	4.4×10^{-4}	2.2×10^{-5}	4.6×10^{-4}	.2
Frog Pond Outlet/Culvert	7.1×10^{-4}	-[c]	7.1×10^{-4}	.3
Quarry Equalization Basin and Quarry Proper	5.0×10^{-4}	2.5×10^{-5}	5.3×10^{-4}	.1
Vicinity Properties:				
DA 1	6.6×10^{-4}	3.1×10^{-7}	6.6×10^{-4}	.06
DA 2	5.7×10^{-4}	2.3×10^{-7}	5.7×10^{-4}	.02
DA 3	1.2×10^{-5}	5.0×10^{-5}	6.2×10^{-5}	.03
DA 5	7.0×10^{-4}	3.0×10^{-5}	7.3×10^{-4}	.3
DA 6	4.3×10^{-4}	2.9×10^{-5}	4.6×10^{-4}	.3
MDC 3	3.7×10^{-5}	3.0×10^{-5}	6.7×10^{-5}	.3
MDC 4	7.1×10^{-4}	2.5×10^{-5}	7.4×10^{-4}	.3
MDC 5	7.7×10^{-4}	3.2×10^{-6}	7.7×10^{-4}	.0005
MDC 6	5.1×10^{-4}	-	5.1×10^{-4}	.006
MDC 10	6.9×10^{-4}	2.8×10^{-5}	7.2×10^{-4}	.2
VP 9	6.3×10^{-5}	-	6.3×10^{-5}	.07
Busch Lake 34	2.1×10^{-5}	-	2.1×10^{-5}	.02
Busch Lake 35	2.4×10^{-5}	-	2.4×10^{-5}	.03
Busch Lake 36	3.2×10^{-5}	-	1.7×10^{-5}	.03

[a] The CUs that are included for each location are presented in Table 3.1.

[b] For comparison, the radiological risk for the resident scenario for background concentrations of the radionuclides (excluding radon) is 5.3×10^{-4}. The radiological risks associated with radon exposures are given in Appendix B.

[c] A hyphen indicates that there are no carcinogenic chemical contaminants of concern identified for the location.

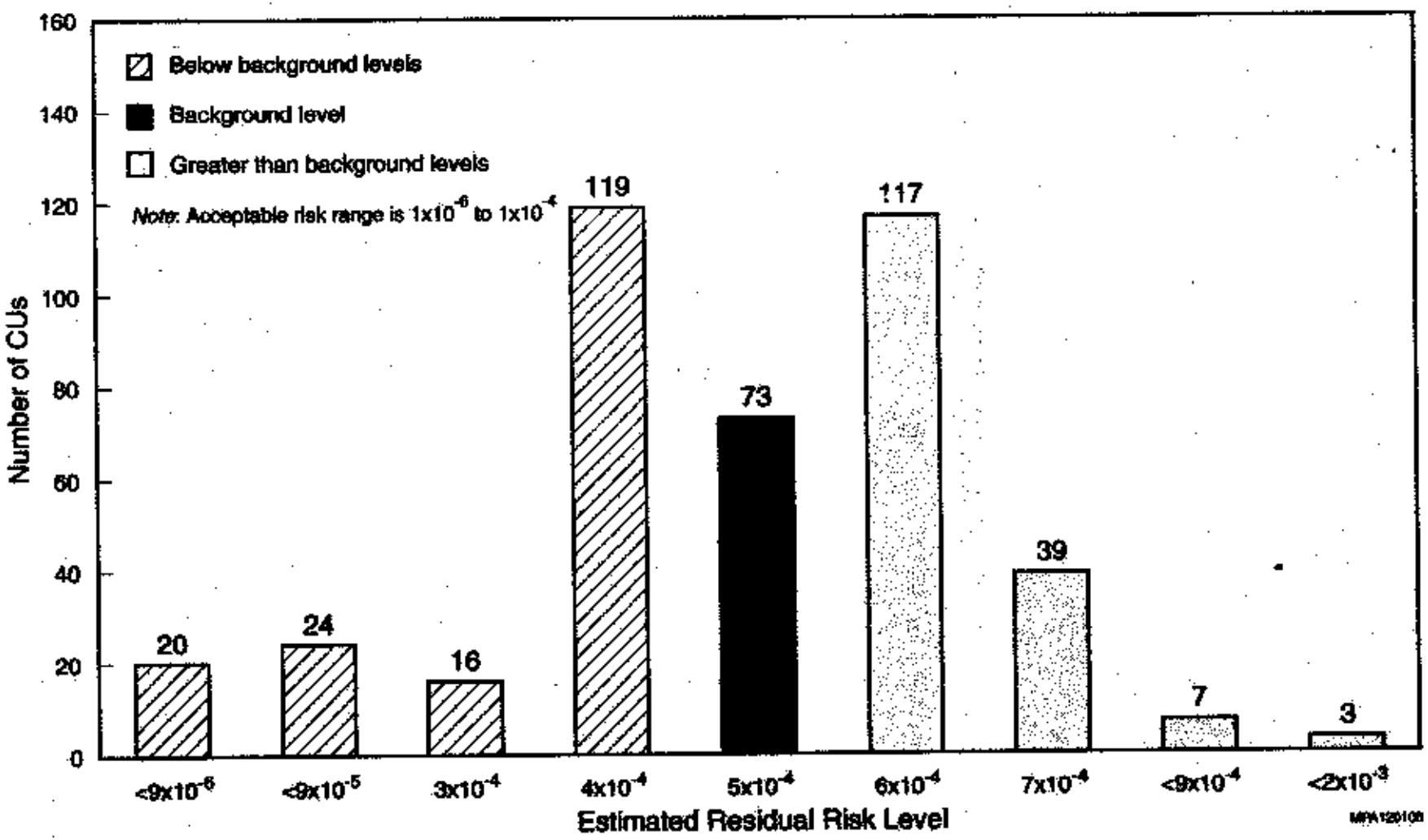

FIGURE 6.1 Distribution of Radiological Risks for the Various Confirmation Units for the Hypothetical Resident Scenario

TABLE 6.2 Summary of Residual Risk for the Recreational Visitor Scenario at Various Areas Associated with the Chemical Plant Operable Unit

Location[a]	Carcinogenic Risk[b]			Hazard Index
	Radiological	Chemical	Total Risk	
CUs within cell footprint and buffer/exclusion zone	7.4×10^{-6}	1.2×10^{-6}	8.6×10^{-6}	.01
Outside of disposal cell footprint and buffer/exclusion zone (not including partial CUs)	6.2×10^{-6}	1.2×10^{-6}	7.4×10^{-6}	.01
Outside of disposal cell footprint and buffer/exclusion zone (including partial CUs)	6.3×10^{-6}	1.3×10^{-6}	7.6×10^{-6}	.01
Frog Pond Outlet/Culvert	1.1×10^{-5}	-[c]	1.1×10^{-5}	.01
Quarry Equalization Basin and Quarry Proper	7.1×10^{-6}	1.5×10^{-6}	8.6×10^{-6}	.008
Vicinity Properties:				
DA 1	9.6×10^{-6}	1.8×10^{-8}	9.6×10^{-6}	.004
DA 2	8.2×10^{-6}	1.2×10^{-8}	8.2×10^{-6}	.001
DA 3	2.3×10^{-7}	2.8×10^{-6}	3.0×10^{-6}	.001
DA 5	1.0×10^{-5}	1.7×10^{-6}	1.2×10^{-5}	.02
DA 6	6.5×10^{-6}	1.7×10^{-6}	8.2×10^{-6}	.02
MDC 3	7.3×10^{-7}	1.7×10^{-6}	2.4×10^{-6}	.01
MDC 4	1.0×10^{-5}	1.4×10^{-6}	1.1×10^{-5}	.02
MDC 5	1.1×10^{-5}	1.8×10^{-7}	1.1×10^{-5}	<.0001
MDC 6	7.2×10^{-6}	-	7.2×10^{-6}	.0004
MDC 10	9.9×10^{-6}	1.6×10^{-6}	1.2×10^{-5}	.01
VP 9	1.2×10^{-6}	-	1.2×10^{-6}	.004
Busch Lake 34	4.1×10^{-7}	-	4.1×10^{-7}	.001
Busch Lake 35	4.8×10^{-7}	-	4.8×10^{-7}	.002
Busch Lake 36	6.2×10^{-7}	-	6.2×10^{-7}	.002

[a] The CUs that are included for each location are presented in Table 3.1.

[b] For comparison, the radiological risk from background concentrations of the radionuclides of concern is 7.5×10^{-6}.

[c] A hyphen indicates that there is no chemical risk since there were no chemical COCs identified.

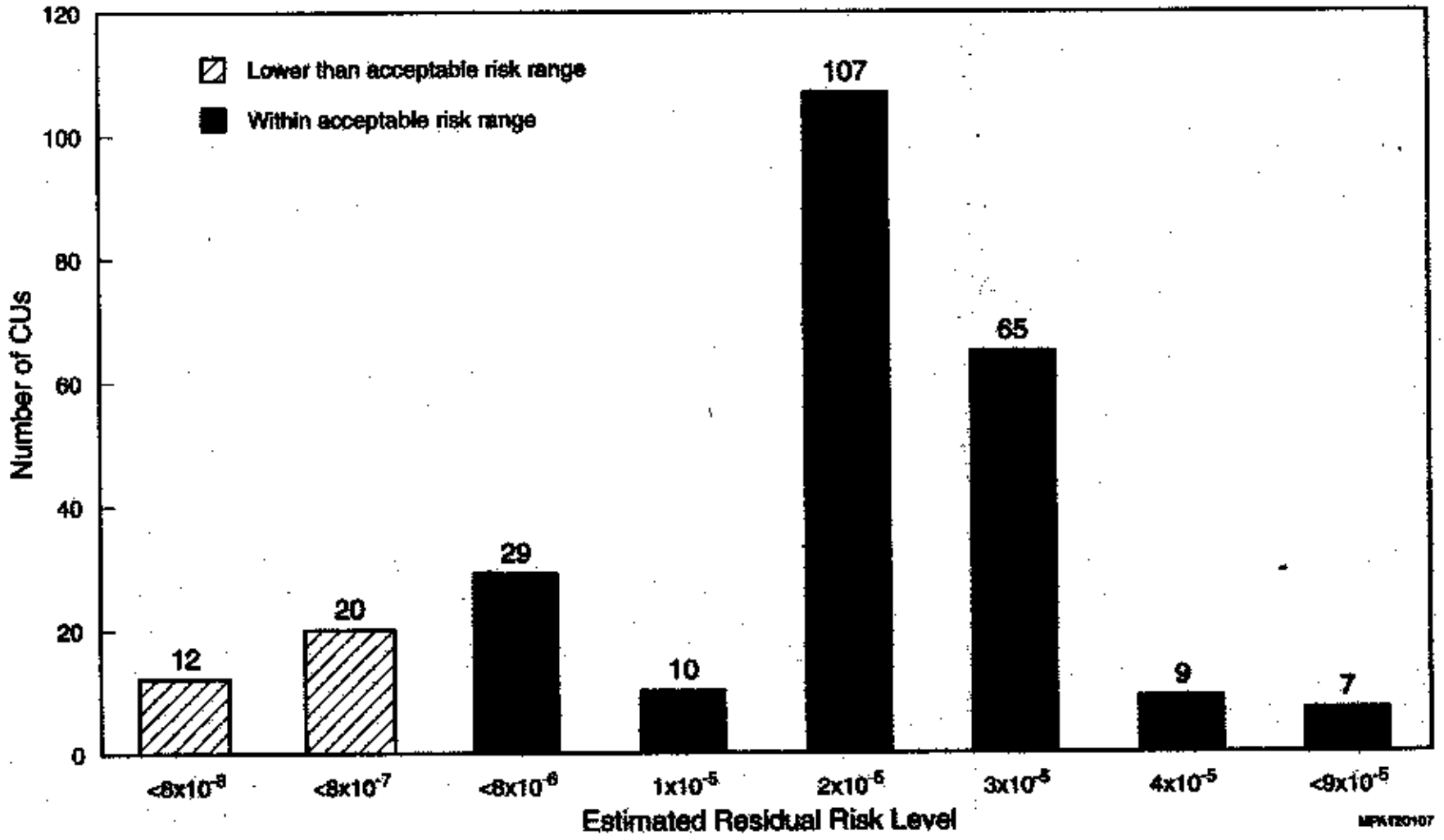

FIGURE 6.2 Distribution of Chemical Residual Risk Estimates for the Various Confirmation Units

6.2 CHEMICAL RISK ESTIMATES AND HAZARD INDICES

The chemical risk estimates for both the hypothetical resident and recreational visitor scenarios at the various locations considered in this assessment are much lower than the radiological risk estimates and are all within the acceptable risk range. For the resident scenario, the range is from 2.3×10^{-7} at DA2 to 5.0×10^{-5} at DA3. For the recreational visitor scenario, the range is from 1.2×10^{-8} at DA2 to 2.8×10^{-6} at DA3.

Figure 6.2 depicts the distribution of the risk estimates for the hypothetical resident scenario obtained for the individual CUs. These risk estimates range from 0 to 9.0×10^{-5}. The low end of this range is for those CUs where confirmation results were for the organic chemical COCs and were nondetects. The high end of the range was reported for CU 365, which is within the cell footprint.

Estimated HIs presented in Tables 6.1 and 6.2 indicate that there is a very low (if any) potential for systemic toxicity because of residual levels of contaminants to a hypothetical resident or recreational visitor at any of the various locations considered. The estimates range from .0005 to .03 and <.0001 to .02 for the resident and recreational visitor scenarios, respectively. Estimates for individual CUs are presented in Appendix C and range from .0005 to 8 and <.0001 to 0.5 for the hypothetical resident and recreational visitor scenarios, respectively. The upper end of the ranges is estimated for CU 399, which is located outside of the cell exclusion zone.

6.3 OBSERVATIONS

On the basis of the results presented in this report, the remediation performed for the Chemical Plant and its vicinity properties has resulted in residual chemical risks that are well within the acceptable risk range for both scenarios evaluated. Future use of these areas or properties in a manner similar to the scenarios assumed in this report should be protective of human health with regard to chemical risks. The hazard indices estimated also indicate that potential systemic toxicity would not be a concern at these areas. Likewise, the IEUBK model estimates for lead did not indicate residual concentrations of lead to be of concern.

The risk estimates for radiological residual risk are at the 10^{-4} level, which is the higher end of the acceptable risk range. However, estimated radiological risks from background concentrations of the radionuclides of concern are also at similar levels, which indicates that remediation was accomplished to levels that are generally equivalent or similar to background.

Appendix D presents risk estimates for background concentrations of the naturally occurring COCs. It also presents the excess residual radiological and chemical risks and HIs at the various CUs after background is subtracted.

7 REFERENCES

Argonne National Laboratory, 1996, *Engineering Evaluation/Cost Analysis for the Proposed Removal at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri*, DOE/OR/21548-584, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Aug.

Berger, J.D., 1986, *Verification of Remedial Action along Highway 94, Weldon Spring, Missouri*, Oak Ridge Associated Universities, Oak Ridge, Tenn.

Boerner, A.J., 1986, *Radiological Survey of the August A. Busch and Weldon Spring Wildlife Areas, Weldon Spring Site, St. Charles County, Missouri*, Oak Ridge Associated Universities, Oak Ridge, Tenn., April.

DOE (U.S. Department of Energy), 1992a, *Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site*, DOE/OR/21548-091, prepared by Argonne National Laboratory, Argonne, Ill., for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Nov.

DOE, 1992b, *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site*, DOE/EIS-0185D (DOE/OR/21548-148, Vol. I), prepared by Argonne National Laboratory, Argonne, Ill., for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Nov.

DOE, 1992c, *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site*, DOE/EIS-0185D (DOE/OR/21548-074, Vol. I), prepared by MK-Ferguson Company and Jacobs Engineering Group, Inc., Weldon Spring, Mo., for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Nov.

DOE, 1993, *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site*, DOE/OR/21548-376, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Sept.

EPA (U.S. Environmental Protection Agency), 1989, *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, (Part A)*, EPA/540/1-89/002, Interim Final, Office of Emergency and Remedial Response, Washington, D.C., Dec.

EPA, 1990, "National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule (40 CFR Part 300)," *Federal Register* 55(35):6154-6176, Feb. 21.

EPA, 1991, "Human Health Evaluation Manual, Supplemental Guidance: 'Standard Default Exposure Factors,'" Office of Solid Waste and Emergency Response Directive 9285.6-03, Washington, D.C.

EPA, 2001, *Integrated Risk Information System (IRIS)*, Office of Research and Development, Washington, D.C. [URL: http//www.epa.gov/iris.htm] Accessed in Nov..

EPA, 2002, "Radionuclide Carcinogenicity Slope Factors," Radiation Protection Programs, Health Effects Assessment Summary Tables for Radionuclides [URL http://www.epa.gov/radiation/health/index.html].

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1988, *Army Vicinity Property No. 7 Post-Remedial Action Report*, DOE/OR/21548-043, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Sept.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1997a, *Post-Remedial Action Report for WP-399 Chemical Plant Drainage Control Facilities*, DOE/OR/21548-630, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Feb.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1997b, *Vicinity Property DOC-8 Close-Out Report, Rev. 0*, DOE/OR/21548-679, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Apr.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1997c, *Post-Remediation Sampling Plan for the Southeast Drainage, Rev. 0*, DOE/OR/21548-616, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., July.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1997d, *Post-Remedial Action Report for Work Package420: Remedial Unit 6, Chemical Plant Area Foundations and Contaminated Soil Removal*, DOE/OR/21548-666, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Sept.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1997e, *Post-Remedial Action Report for Work Package 420: Chemical Plant Area Foundations and Contaminated Soil Removal, Remedial Unit 7*, DOE/OR/21548-667, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Sept.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1998a,. *Confirmation Sampling Plan Details for the Disposal Cell Facility (WP-437)*, DOE/OR/21548-706, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Jan.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1998b, *Post-Remedial Action Report for the Chemical Plant Construction Materials Staging Area (WP-253)*, DOE/OR/21548-714, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Jan.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1998c, *Post Remedial Action Report for Work Package 420, Chemical Plant Area Foundations and Contaminated Soil Removal, Remedial Unit 9*, DOE/OR/21548-704, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Jan.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1998d, *Post-Remedial Action Report for Work Package 420, Chemical Plant Area Foundations and Contaminated Soil Removal, Remedial Unit 10*, DOE/OR/21548-705, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Jan.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1998e, *Post-Remedial Action Report for Work Package 420, Chemical Plant Area Foundations and Contaminated Soil Removal, Remedial Unit 8*, DOE/OR/21548-684, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Feb.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999a, *Completion Report for Sediment Sampling at Busch Lakes 34 and 35, Rev. 0.*, DOE/OR/21548-768, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Feb.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999b, *Close-Out Report for Vicinity Properties MDC6 and MDC9, Rev. 0*, DOE/OR/21548-775, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Apr.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999c, *Close-Out Report for Vicinity Properties, DA-1, DA-2, DA-3, DA-5, and DA-7, Rev. 0*, DOE/OR/21548-778, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., May.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999d, *Close-Out Report for Vicinity Properties MDC-3, MDC-4, MDC-5, and MDC-10, Rev. 1*, DOE/OR/21548-789, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., June.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999e, *Southeast Drainage Close-Out Report Vicinity Properties DA4 and MDC7, Rev. 0*, DOE/OR/21548-772, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Sept.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2000a, *Closure Report for the Radiological Characterization of Sediments and Soil within the Southeast Corner of Busch Lake 36 Sampling Plan, Rev. 0*, DOE/OR/21548-835, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Mar.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2000b, *Post Remedial Action Report for WP-471*, DOE/OR/21548-765, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Mar.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2000c, *Post-Remedial Action Report for the Frog Pond Drainage Outlet (WP-519/505F)*, DOE/OR/21548-837, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., July.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2000d, *Post-Remedial Action Report for Vicinity Properties (WP-458)*, DOE/OR/21548-767, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Nov.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001a, *Analytical Data Results for Engineering Characterization of Vicinity Property DA-6: Ash Pond Drainage, Rev. 2.*, DOE/OR/21548-824, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Jan.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001b, *Post-Remedial Action Report for the Asbestos Storage Area (WP-437/RU017)*, DOE/OR/21548-877), prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Mar.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001c, *Post-Remedial Action Report for the Material Staging Area Work Zone (WP-437/RU018)*, DOE/OR/21548-874, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Mar.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001d, *Post-Remedial Action Report for the Frog Pond Work Zone (WP-437/RU016)*, DOE/OR/21548-883, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., July.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001e, *Post-Remedial Action Report for the Quarry Water Treatment Plant Equalization Basin (RU026)*, DOE/OR/21548-890, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., July.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001f, *Post-Remedial Action Report for the Chemical Stabilization and Solidification (CSS) Work Zone (WP-437/RU023)*, DOE/OR/21548-898, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Sept.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001g, *Post-Remedial Action Report for the Construction Materials Staging Area Work Zone (WP-437/RU019)*, DOE/OR/21548-892, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Oct.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001h, *Draft Post-Remedial Action Report for the Ash Pond Work Zone (WP437/RU020)*, DOE/OR/21548-888, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Dec.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001i, *Draft Post-Remedial Action Report for the Raffinate Pits Work Zone (WP437/RU021)*, DOE/OR/21548-907, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Dec.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001j, *Draft Post-Remedial Action Report for the Site Water Treatment Plant Work Zone (WP437/RU024)*, DOE/OR/21548-xxx, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., (in progress).

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001k, *Draft Post-Remedial Action Report for the TSA Work Zone (WP437/RU022)*, DOE/OR/21548-xxx, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., (in progress).

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2001l, *Post-Remedial Action Report for the Ash Pond Work Zone (WP-437/RU010)*, DOE/OR/21548-888, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Dec.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2002a, *Post-Remedial Action Report for the Administration Work Zone (WP-437/RU015)*, DOE/OR/21548-906, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Jan.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2002b, *Post-Remedial Action Report for the Disposal Cell Work Zone (WP-437/RU025), Rev. 0*, DOE/OR/21548-911, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Feb.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 2002c, *Post-Remedial Action Report for the Raffinate Pit Work Zone (WP-437-RU021), Rev. A*, DOE/OR/21548-907, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Feb.

Picel, M., 2000, letter from Picel (Argonne National Laboratory, Argonne, Ill.) to T. Pauling (U.S. Department of Energy, Weldon Spring Remedial Action Project, St. Charles, Mo.) March 9.

APPENDIX A:

POSTCLEANUP RISK ASSESSMENT FOR THE SOUTHEAST DRAINAGE

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POSTCLEANUP RISK ASSESSMENT FOR THE SOUTHEAST DRAINAGE

This appendix presents the results of the postcleanup risk assessment performed for the Southeast Drainage. The purpose of the assessment was to determine the amount of risk reduction achieved by the removal action. Figure A.1 depicts specific locations in the drainage that were remediated.

Postcleanup risk estimates for each segment are presented in Table A.1. Risk calculations were performed using the same methodology and scenario assumptions (i.e., hypothetical child and recreational visitor/hunter scenarios) presented in the engineering evaluation/cost analysis (EE/CA) (ANL 1996). The exposure routes evaluated include external gamma irradiation and incidental ingestion of sediment. Exposure point concentrations for sediment were calculated for each exposure unit (i.e., segment) by using the one-tailed 95% upper confidence limit (UCL) of the arithmetic average for each radionuclide. The summary statistics for each segment are based on location-specific data as presented in Table A.2. Risk calculations for each segment were based on postremediation data from locations that were remediated, in combination with data from locations that were not remediated in the segment. (Note that some locations were not targeted for cleanup because they are not accessible and have contaminant concentrations that exceed risk-based cleanup criteria.) At locations where more than one sample was collected, the data were averaged to obtain a representative concentration for that location prior to aggregating the data for each segment. Additional volumes were removed from Location 60 in Segment D and Locations 101 and 132 in Segment B. For these locations, data collected after removal of the additional volumes were used in the calculations.

Estimated residual risk or postcleanup risk estimates for the hypothetical child scenario for Segments A through D are 2×10^{-5}, 2×10^{-5}, 1×10^{-5}, and 8×10^{-6}, respectively. These results indicate that the risk reductions achieved are equal to or greater than those projected in the EE/CA. Additional risk reduction was achieved in Segments C and D because of removal of 17 additional locations not planned for in the EE/CA because they were originally thought to be inaccessible. These additional locations were determined to be accessible during the field planning stage and were remediated.

Location-specific baseline (precleanup) and postcleanup risk estimates for the hypothetical child are also presented in Table A.2. Of the 55 locations that were remediated, postcleanup risk estimates at 48 locations are at or below 1×10^{-5}, and 7 locations are near 1×10^{-5} (i.e., 2×10^{-5} at 5 locations and 3×10^{-5} at 2 locations) for the hypothetical child scenario. These results indicate that the removal action accomplished the goals presented in the Decision Document for the Southeast Drainage (DOE 1996).

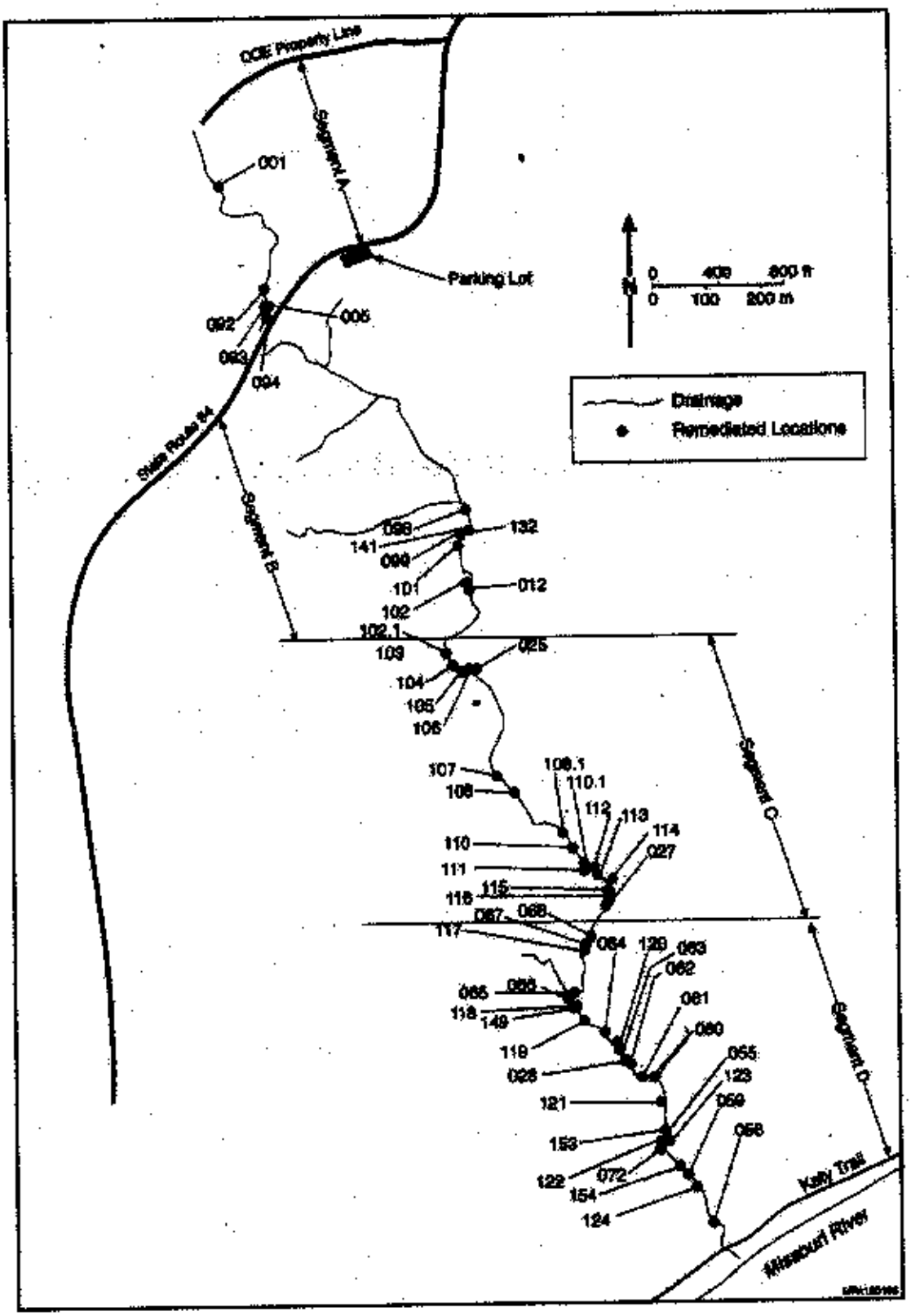

FIGURE A.1 Remediated Locations in the Southeast Drainage

TABLE A.1 Postcleanup Risk Estimates for the Southeast Drainage[a]

Segment		Summary Statistics[b]				Postcleanup	
		Ra-226	Ra-228	Th-230	U-238	Hypothetical[c] Child	Recreational Visitor/ Hunter[d]
A	Max. conc. (pCi/g)	39.0	5.0	38.0	200.0	2×10^{-5}	5×10^{-5}
	Min. conc. (pCi/g)	1.3	0.6	0.2	10.9		
	Avg. conc. (pCi/g)	15.8	1.8	12.4	52.4		
	Standard deviation	13.0	1.1	10.6	49.0		
	T-statistic	1.753	1.753	1.753	1.753		
	Count	16	16	16	16		
	UCL[e] (pCi/g)	22	2.3	17	74		
B	Max. conc. (pCi/g)	110.0	4.0	39.0	59.0	2×10^{-5}	5×10^{-6}
	Min. conc. (pCi/g)	1.2	0.5	0.3	2.0		
	Avg. conc. (pCi/g)	14.7	1.4	11.1	16.6		
	Standard deviation	25.7	0.9	10.4	18.9		
	T-statistic	1.740	1.740	1.740	1.740		
	Count	18	18	18	18		
	UCL[e] (pCi/g	25	1.8	15	24		
C	Max. conc. (pCi/g)	36.0	6.6	45.0	74.0	1×10^{-5}	3×10^{-6}
	Min. conc. (pCi/g)	1.1	0.8	1.3	1.3		
	Avg. conc. (pCi/g)	8.2	1.6	7.8	14.8		
	Standard deviation	10.2	1.2	10.1	17.1		
	T-statistic	1.717	1.717	1.717	1.717		
	Count	23	23	23	23		
	UCL[e] (pCi/g	12	2.0	11	21		
D	Max. conc. (pCi/g)	27.0	6.7	120.0	70.0	8×10^{-6}	2×10^{-6}
	Min. conc. (pCi/g)	1.1	0.6	0.7	2.0		
	Avg. conc. (pCi/g)	6.2	1.6	16	12		
	Standard deviation	5.4	1.0	25.7	15		
	T-statistic	1.684	1.684	1.684	1.684		
	Count	44	44	44	44		
	UCL[e] (pCi/g	7.6	1.9	23	16		

[a] Postcleanup risk estimates for each segment were calculated by using the UCLs derived from all postcleanup data for remediated locations, combined with data from remaining locations in the segments that were not remediated.

[b] Summary statistics presented for each segment were developed from the location-specific data that constitute each segment, as shown in Table A.2.

[c] The postcleanup risk estimates for the hypothetical child scenario were calculated using the same methodology and scenario assumptions presented in the EE/CA (ANL 1996). In the EE/CA, baseline (before cleanup) risk estimates and projected postcleanup risk estimates for this scenario were presented for each segment as follows:

Segment	Baseline Risk	EE/CA-Projected Postcleanup Risk
A	5×10^{-5}	2×10^{-5}
B	1×10^{-4}	3×10^{-5}
C	9×10^{-5}	4×10^{-5}
D	5×10^{-5}	2×10^{-5}

TABLE A.1 (Cont.)

Postcleanup risk estimates for the hypothetical child scenario indicate that the removal action performed at the Southeast Drainage attained the projected postcleanup risks presented for Alternative 2.1 in Table A.4, page 57, of the EE/CA (ANL 1996).

[d] The postcleanup risk estimates for the recreational visitor/hunter scenario were calculated using the same methodology and scenario assumptions presented in the EE/CA (ANL 1996). In the EE/CA, baseline (before cleanup) risk estimates and projected postcleanup risks for this scenario were presented for each segment as follows:

Segment	Baseline Risk	EE/CA-Projected Postcleanup Risk
A	1×10^{-5}	5×10^{-6}
B	2×10^{-5}	6×10^{-6}
C	2×10^{-5}	9×10^{-6}
D	1×10^{-5}	5×10^{-6}

Postcleanup risk estimates for the recreational visitor/hunter scenario indicate that the removal action performed at the Southeast Drainage attained the projected postcleanup risks presented for Alternative 2.1 in Table A.3, page 57, of the EE/CA (ANL 1996).

[e] UCL = upper confidence limit.

TABLE A.2 Location-Specific Data Summary and Risk Estimates for the Southeast Drainage

Segment	Location	Concentration (pCi/g)[a]				Risk Estimates	
		RA-226	Ra-228	Th-230	U-238	Baseline Hypothetical Child	Postcleanup Hypothetical Child
A	001[b]	12.3	1.6	4.7	37.8	9×10^{-5}	1×10^{-5}
	092[b]	5.4	1.5	38.0	80.0	2×10^{-6}	9×10^{-6}
	093[b]	1.9	1.2	0.8	76.0	2×10^{-5}	5×10^{-6}
	094[b]	3.8	1.2	8.9	17.0	1×10^{-5}	5×10^{-6}
	005[b]	4.7	2.9	22.9	10.9	2×10^{-4}	7×10^{-6}
	002	39.0	5.0	15.0	120.0	4×10^{-5}	-[c]
	003	39.0	1.4	31.0	200.0	4×10^{-5}	-
	004	17.0	2.7	11.0	50.0	2×10^{-5}	-
	016	7.0	1.5	14.0	17.0	8×10^{-5}	-
	017	11.0	1.4	1.4	15.0	1×10^{-5}	-
	018	1.3	0.8	0.2	16.0	2×10^{-6}	-
	087	15.0	0.6	6.8	47.0	1×10^{-5}	-
	088	30.0	2.8	11.0	43.0	3×10^{-5}	-
	089	11.0	1.3	5.1	31.0	1×10^{-5}	-
	090	33.0	1.3	14.0	48.0	3×10^{-5}	-
	091	22.0	1.2	14.0	29.0	2×10^{-5}	-
B	012[b]	1.7	1.1	10.0	2.0	4×10^{-5}	2×10^{-6}
	098[b]	2.5	1.1	3.7	2.5	3×10^{-4}	3×10^{-6}
	099[b]	2.5	1.2	2.5	3.0	5×10^{-5}	3×10^{-6}
	101[b]	5.9	0.7	34.2	2.8	2×10^{-4}	6×10^{-6}
	102[b]	2.8	1.3	6.4	9.9	2×10^{-5}	4×10^{-6}
	132[b]	5.3	0.5	39.0	8.4	1×10^{-4}	6×10^{-6}
	141[b]	2.1	0.9	4.9	2.9	5×10^{-5}	2×10^{-6}
	006	25.0	2.8	18.0	56.0	3×10^{-5}	-
	007	12.0	4.0	11.0	49.0	2×10^{-5}	-
	008	36.0	1.5	12.0	17.0	3×10^{-5}	-
	009	110.0	1.7	13.0	59.0	9×10^{-5}	-
	010	21.0	2.2	13.0	17.0	2×10^{-5}	-
	011	1.3	0.7	0.3	2.6	2×10^{-5}	-
	019	18.0	1.1	7.5	7.8	2×10^{-5}	-
	020	1.2	0.9	3.0	2.6	2×10^{-5}	-
	021	2.2	1.0	2.8	14.0	3×10^{-6}	-
	095	4.6	1.5	6.8	16.0	6×10^{-6}	-
	096	11.0	1.7	12.0	27.0	1×10^{-5}	-
C	025[b]	15.0	1.3	21.0	74.0	3×10^{-4}	2×10^{-5}
	027[b,d]	23.0	6.6	15.0	27.0	2×10^{-5}	2×10^{-5}
	102.1[b]	1.4	1.4	1.6	2.0	9×10^{-5}	2×10^{-6}
	107[b,d]	34.0	1.8	45.0	40.0	4×10^{-5}	3×10^{-5}
	108[b,d]	5.3	1.1	4.7	11.0	2×10^{-5}	5×10^{-6}
	108.1[b,d]	7.1	1.0	3.3	9.6	3×10^{-5}	6×10^{-6}
	110[b,d]	4.3	1.1	2.9	24.0	3×10^{-5}	5×10^{-6}
	110.1[b,d]	1.8	2.0	2.1	5.6	1×10^{-5}	3×10^{-6}
	111[b,d]	4.6	1.2	22.0	29.0	4×10^{-5}	6×10^{-6}
	112[b,d]	11.0	2.0	10.0	9.1	1×10^{-5}	1×10^{-6}
	113[b,d]	36.0	1.0	11.0	11.0	6×10^{-5}	3×10^{-5}
	114[b,d]	2.7	1.0	2.0	6.1	2×10^{-5}	3×10^{-6}
	115[b,d]	4.6	0.9	7.3	7.3	5×10^{-5}	5×10^{-6}
	116[b,d]	2.2	1.4	1.8	5.3	2×10^{-5}	3×10^{-6}
	103[b]	1.3	0.8	1.5	2.0	4×10^{-5}	2×10^{-6}
	104[b]	4.1	1.1	9.4	11.0	1×10^{-4}	4×10^{-5}
	105[b]	16.0	0.8	3.4	29.0	3×10^{-5}	1×10^{-5}
	106[b]	1.3	1.3	1.3	2.0	6×10^{-6}	2×10^{-6}
	049	6.5	1.7	1.3	26.0	8×10^{-6}	-
	143	1.8	1.6	4.6	3.7	3×10^{-6}	-
	144	1.1	1.5	2.4	1.4	2×10^{-6}	-
	145	1.3	0.9	4.6	2.3	2×10^{-6}	-
	146	1.4	2.6	1.7	1.3	3×10^{-6}	-

TABLE A.2 (Cont.)

Segment	Location	Concentration (pCi/g)[a]				Risk Estimates	
		RA-226	Ra-228	Th-230	U-238	Baseline Hypothetical Child	Postcleanup Hypothetical Child
D	117[b,d]	9.4	1.6	12.0	10.0	9×10^{-5}	9×10^{-6}
	118[b,d]	17.1	6.7	60.0	69.5	2×10^{-5}	2×10^{-5}
	119	1.5	1.0	0.7	10.6	2×10^{-5}	2×10^{-6}
	120[b]	8.8	0.6	2.4	2.0	1×10^{-4}	8×10^{-6}
	121[b]	14.9	1.1	7.8	10.6	2×10^{-5}	1×10^{-6}
	122[b]	1.7	1.4	1.1	2.7	3×10^{-5}	2×10^{-6}
	123[b]	5.0	1.1	7.1	3.8	5×10^{-5}	5×10^{-6}
	124[b]	6.7	1.6	12.4	9.4	1×10^{-4}	7×10^{-6}
	149[b]	10.4	1.4	18.2	34.2	2×10^{-5}	1×10^{-5}
	153[b]	7.3	1.2	3.5	6.4	9×10^{-6}	7×10^{-6}
	154[b]	5.1	1.5	8.6	8.3	5×10^{-6}	5×10^{-6}
	028[b]	11.0	2.0	3.2	3.7	3×10^{-6}	1×10^{-5}
	055[b]	4.3	1.0	5.6	8.8	2×10^{-5}	5×10^{-6}
	058[b]	5.0	1.2	2.9	5.0	5×10^{-5}	5×10^{-6}
	059[b]	4.9	2.0	46.0	10.0	5×10^{-5}	7×10^{-6}
	060[b]	16.8	1.0	49.7	12.1	5×10^{-5}	2×10^{-5}
	061[b]	27.0	1.0	18.0	70.0	8×10^{-5}	2×10^{-5}
	062[b]	1.3	1.1	1.3	2.0	1×10^{-5}	2×10^{-6}
	063[b]	11.0	2.0	3.2	6.1	5×10^{-5}	1×10^{-5}
	064[b]	2.9	1.3	4.7	10.0	2×10^{-5}	4×10^{-6}
	065	12.0	2.6	29.0	30.0	6×10^{-5}	1×10^{-5}
	066[b,d]	10.1	1.5	70.4	16.0	5×10^{-5}	1×10^{-5}
	067[b,d]	1.5	1.2	1.3	2.0	3×10^{-6}	2×10^{-6}
	068[b,d]	1.5	1.2	1.3	2.1	9×10^{-6}	2×10^{-6}
	072[b]	11.0	1.8	16.0	18/0	1×10^{-6}	1×10^{-5}
	026	3.6	1.4	95.0	10.2	7×10^{-6}	-
	030	2.4	1.4	6.5	2.9	3×10^{-6}	-
	050	9.3	1.0	6.8	7.7	9×10^{-6}	-
	051	8.2	3.2	120.0	33.0	1×10^{-6}	-
	052	1.9	1.3	4.3	5.7	3×10^{-6}	-
	053	5.6	1.2	8.9	23.0	7×10^{-6}	-
	054	2.1	1.2	4.1	3.3	3×10^{-6}	-
	056	3.9	1.3	11.0	16.0	5×10^{-6}	-
	057	2.7	1.3	3.8	3.6	3×10^{-6}	-
	069	1.5	1.3	2.9	4.1	2×10^{-6}	-
	070	3.6	1.3	15.0	6.4	5×10^{-6}	-
	071	1.6	1.1	3.6	5.5	2×10^{-6}	-
	073	1.5	1.0	3.3	3.8	2×10^{-6}	-
	074	1.5	1.1	2.7	4.2	2×10^{-6}	-
	147	1.6	3.3	4.0	2.9	4×10^{-6}	-
	148	1.1	2.6	3.2	2.2	3×10^{-6}	-
	150	3.3	1.9	9.1	11.0	5×10^{-6}	-
	151	5.3	2.9	12.0	14.0	7×10^{-6}	-
	152	3.8	2.6	3.1	6.2	5×10^{-6}	-

[a] Radionuclide concentrations for each location represent postcleanup concentrations as presented in the *Closure Report for the Post-Remedial Sampling Plan of the Southeast Drainage* (MK-Ferguson and Jacobs Engineering Group, Inc. 1999) for those locations that were remediated, and precleanup concentrations (as presented in the EE/CA [ANL 1996]) for those locations that were not remediated.

[b] Remediated locations.

[c] A hyphen designates that the location was not remediated because it was inaccessible; therefore, the postcleanup risk would be the same as the baseline risk.

[d] The location was remediated but not originally identified for remediation in the EE/CA (ANL 1996). Access to these locations was determined during the field planning phase.

APPENDIX A REFERENCES

ANL (Argonne National Laboratory), 1996, *Engineering Evaluation/Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri*, DOE/OR/21548-584, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Aug.

MK-Ferguson Company and Jacobs Engineering Group, Inc., 1999, *Closure Report for the Post-Remedial Sampling Plan of the Southeast Drainage*, DOE/OR/21548-794, Rev. 0, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., July.

U.S. Department of Energy, 1996, *Decision Document: Engineering Evaluation/Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Missouri*, DOE/OR/21548-584, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, Weldon Spring, Mo., Nov.

APPENDIX B:

RISKS ASSOCIATED WITH INHALATION OF RADON-222 DECAY PRODUCTS

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RISKS ASSOCIATED WITH INHALATION OF RADON-222 DECAY PRODUCTS

Radon-222 is a decay product of radium-226, and elevated levels of radon-222 can be expected to occur in areas of the site having elevated concentrations of radium-226. The risk associated with radon-222 is due primarily to inhalation of its short-lived decay products and is generally a concern only for indoor exposures. For this reason, this exposure route was only addressed for the resident scenario. Since the radon-222 risk is due primarily to its decay products, the concentration of radon by itself is not a good measure of the hazard associated with this radionuclide. A more appropriate measure is an estimate of the potential alpha energy associated with its short-lived decay products, for example, as expressed in the working level (WL) unit of measure. One working level corresponds to 100 pCi/L of radon-222 in equilibrium with its short-lived decay products.

The radon-222 decay product concentration in the resident's house was estimated using the following correlation

$$C_{Rn} = C_{Ra} \times CR, \tag{B.1}$$

where

C_{Rn} = concentration of radon-222 decay products in air (WL);

C_{Ra} = radium-226 concentration in soil (pCi/g); and

CR = concentration ratio (0.0041 WL per pCi/g), the ratio of the radon-222 concentration in indoor air to the average concentration of radium-226 in soil (Gilbert et al. 1983).

The concentration ratio of 0.0041 WL per pCi/g of radium-226 was developed for a home with a basement and takes into consideration the time one spends on different floors in the home (Gilbert et al. 1983). The value is based on the average indoor radon concentration measured in homes in the New Jersey and New York area and is considered reasonable for use in this assessment.

Exposure to radon-222 and its short-lived decay products can be expressed in the unit of working level month (WLM). When originally proposed, 1 WL was considered to be an acceptable maximum concentration for uranium miners working a 40-hour week (or 170 hours per month). Thus, exposure of a worker to a radon-222 decay product concentration of 1 WL for 170 hours, with an inhalation rate of 1.2 m^3/h, would result in an exposure of 1 WLM. The

exposure (E) to radon-222 decay products in WLM can be calculated using the parameters for the residential scenario given in Table 4.2:

$$E = \frac{C_{Rn} \times IR \times ET \times EF \times ED}{CF} , \qquad \text{(B.2)}$$

where

E = radon-222 decay product exposure (WLM);

C_{Rn} = concentration of radon-222 decay products (WL);

IR = inhalation rate (0.8 m^3/h);

ET = exposure time (23 h/d);

EF = exposure frequency (365 d/yr);

ED = exposure duration (30 yr); and

CF = conversion factor, 204 m^3/mo (CF is the product of the inhalation rate for a worker [1.2 m^3/h] and the number of working hours in 1 month [170 h/mo]).

The WLM unit was used here because the risk of inhalation of radon decay products is typically expressed in this unit (1 WLM is equivalent to 1,000 mrem [ICRP 1981]).

The risk of fatal cancer from inhalation of radon-222 decay products was estimated using the risk factor of 2.2×10^{-4}/WLM recommended by the U.S Environmental Protection Agency (EPA 1992; Puskin 1992). This value is based on recommendations given in the BEIR IV study of the Committee on Biological Effects of Ionizing Radiation (BEIR; National Research Council 1988), with adjustments to more accurately represent residential exposures to radon-222 decay products. The dose to the bronchial epithelium portion of the lung per WLM of radon decay products is about 30% lower for residential exposures than for exposures received in underground mines, which formed the basis of the risk model developed in the BEIR IV study. The results of the BEIR IV report were adjusted by this factor in developing the risk factor given here, as identified in EPA (1992) and Puskin (1992). Because most lung cancers are fatal, this estimator can also be used to estimate the rate of cancer induction. This risk factor is believed to be an accurate representation of the health risks associated with exposure to radon-222 decay products at the Weldon Spring Site.

The results of these calculations are presented in Table B.1 and include the contribution of the background concentrations of radium-226.

TABLE B.1 Data Summary for the Inhalation of Radon Pathway for the Hypothetical Resident Scenario[a]

Location	Radium-226 UCL (pCi/g)	WL	WLM	Inhalation Risk
CUs within cell footprint and buffer/exclusion zone	1.2	.0049	4.8	1.1×10^{-3}
Outside of disposal cell footprint and buffer/exclusion zone (not including partial CUs)	.93	.0038	3.8	8.4×10^{-4}
Outside of disposal cell footprint and buffer/exclusion zone (including partial CUs)	.98	.0040	4.0	8.8×10^{-4}
Frog Pond Outlet	1.2	.0048	4.8	1.1×10^{-3}
Quarry Equalization Basin and Quarry Proper	1.1	.0045	4.5	9.9×10^{-4}
Vicinity Properties:				
DA 1	1.6	.0066	6.5	1.4×10^{-3}
DA 2	1.5	.0062	6.2	1.4×10^{-3}
DA 5	2.2	.0092	9.1	2.0×10^{-3}
DA 6	.81	.0033	3.3	7.3×10^{-4}
MDC 4	1.7	.0068	6.7	1.5×10^{-3}
MDC 5	2.7	.011	11	2.4×10^{-3}
MDC 6	1.3	.0053	5.3	1.2×10^{-3}
MDC 10	1.7	.0071	7.1	1.6×10^{-3}

[a] This table only includes those locations where confirmation data for radium-226 have been reported. Values have been rounded to two significant figures. A WL is any combination of short-lived radon-222 decay products in one liter of air without regard to the degree of equilibrium that will result in the ultimate emission of 1.3×10^5 MeV of alpha energy. One WL corresponds to 100 pCi/L of radon-222 in equilibrium with its short-lived decay products. The radon risk from the background concentration of 1.2 pCi/g of radium-226 is estimated to be 1.1×10^{-3}.

APPENDIX B REFERENCES

Gilbert, T.L., et al., 1983, *Pathways Analysis and Radiation Dose Estimates for Radioactive Residues at Formerly Utilized MED/AEC Sites*, ORO-832 (Rev.), prepared by Argonne National Laboratory, Division of Environmental Impact Studies, Argonne, Ill., for U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, Tenn., March (reprinted with corrections: Jan. 1984).

International Commission on Radiological Protection, 1981, *Limits for Inhalation of Radon Daughters by Workers* (Adopted March 1981), ICRP Publication 32, Annals of the ICRP, Vol. 6, No. 1, Pergamon Press, New York, N.Y.

National Research Council, 1988, *Health Risks of Radon and Other Internally Deposited Alpha Emitters*, BEIR IV Report, report of the Committee on the Biological Effects of Ionizing Radiation, Washington, D.C.

Puskin, J.S., 1992, "An Analysis of the Uncertainties in Estimates of Radon-Induced Lung Cancer," *Risk Analysis* 12:277–285.

U.S. Environmental Protection Agency, 1992, *Technical Support Document for the 1992 Citizen's Guide to Radon*, EPA-400-R-92-011, Washington, D.C.

APPENDIX C:

RISK ESTIMATES BY CONFIRMATION UNIT

TABLE C.1 Total Radiological Risk Ordered by Descending Risk

Confirmation Unit	Adult Resident	Adult Visitor
046	2.1029E-03	2.9822E-05
067	1.0394E-03	1.4946E-05
411	9.9157E-04	1.4281E-05
329	8.9414E-04	1.2864E-05
014	8.0187E-04	1.1863E-05
168	7.7144E-04	1.1061E-05
080	7.6840E-04	1.1078E-05
096	7.6062E-04	1.0879E-05
102	7.5178E-04	1.0743E-05
144	7.5042E-04	1.0776E-05
412	7.4132E-04	1.0724E-05
281	7.3578E-04	1.0553E-05
365	7.3406E-04	1.0777E-05
310	7.2858E-04	1.0534E-05
015	7.2489E-04	1.0937E-05
167	7.1418E-04	1.0206E-05
111	7.1278E-04	1.0244E-05
090	7.1068E-04	1.0221E-05
390	7.1007E-04	1.1405E-05
058	7.0633E-04	1.0382E-05
013	7.0576E-04	1.0422E-05
038	7.0399E-04	1.0136E-05
108	7.0359E-04	1.0077E-05
069	7.0284E-04	1.0239E-05
165	6.9863E-04	9.9842E-06
380	6.9759E-04	1.0105E-05
169	6.9458E-04	9.9403E-06
160	6.9340E-04	9.9243E-06
275	6.9314E-04	1.0220E-05
309	6.9268E-04	1.0115E-05
092	6.9212E-04	9.9477E-06
032	6.7410E-04	9.9939E-06
095	6.7322E-04	9.6366E-06
089	6.7296E-04	9.6651E-06
065	6.7105E-04	9.9285E-06
143	6.7000E-04	9.5997E-06
084	6.6985E-04	9.6208E-06
017	6.6564E-04	9.6715E-06
086	6.6524E-04	9.6530E-06
028	6.6472E-04	9.5343E-06
036	6.6382E-04	9.5537E-06
050	6.6188E-04	9.4832E-06
034	6.6019E-04	9.4577E-06

TABLE C.1 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
297	6.5734E-04	9.4119E-06
162	6.5644E-04	9.5737E-06
062	6.5522E-04	9.4836E-06
060	6.5410E-04	9.3668E-06
332	6.5385E-04	9.3908E-06
304	6.5166E-04	9.3817E-06
044	6.4714E-04	9.3099E-06
041	6.4704E-04	9.3266E-06
059	6.4585E-04	9.4027E-06
031	6.4556E-04	9.2758E-06
051	6.4544E-04	9.3442E-06
073	6.4371E-04	9.3441E-06
120	6.4142E-04	9.1730E-06
208	6.4067E-04	9.1744E-06
021	6.4035E-04	9.4631E-06
027	6.3943E-04	9.3091E-06
029	6.3893E-04	9.1929E-06
103	6.3845E-04	9.1652E-06
030	6.3758E-04	9.1888E-06
052	6.3725E-04	9.1588E-06
378	6.3672E-04	9.1108E-06
161	6.3660E-04	9.1295E-06
129	6.3511E-04	9.0772E-06
016	6.3241E-04	9.2056E-06
110	6.3199E-04	9.1099E-06
057	6.3197E-04	9.0784E-06
130	6.3122E-04	9.0295E-06
047	6.2990E-04	9.0491E-06
142	6.2913E-04	9.0270E-06
040	6.2850E-04	9.0235E-06
006	6.2765E-04	8.9729E-06
109	6.2654E-04	9.0165E-06
104	6.2248E-04	8.9276E-06
063	6.2192E-04	9.0216E-06
033	6.2082E-04	8.8944E-06
148	6.2055E-04	8.8897E-06
054	6.2012E-04	8.9198E-06
379	6.1988E-04	8.8937E-06
026	6.1784E-04	8.8440E-06
070	6.1755E-04	8.8856E-06
061	6.1659E-04	8.8698E-06
039	6.1568E-04	8.9078E-06
135	6.1559E-04	8.7967E-06
124	6.1550E-04	8.8161E-06
071	6.1499E-04	8.8324E-06

TABLE C.1 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
042	6.1352E-04	8.7792E-06
035	6.1337E-04	8.8020E-06
056	6.1073E-04	8.7838E-06
098	6.1041E-04	8.7528E-06
381	6.1008E-04	8.7717E-06
153	6.0927E-04	8.7376E-06
176	6.0875E-04	8.7018E-06
174	6.0822E-04	8.6896E-06
099	6.0807E-04	8.7051E-06
134	6.0720E-04	8.6735E-06
334	6.0714E-04	8.7967E-06
307	6.0681E-04	8.7447E-06
146	6.0618E-04	8.6812E-06
020	6.0537E-04	8.6946E-06
170	6.0438E-04	8.6329E-06
399	6.0425E-04	8.6644E-06
025	6.0321E-04	8.6396E-06
023	6.0289E-04	8.6604E-06
125	6.0240E-04	8.6073E-06
075	6.0136E-04	8.6390E-06
367	6.0114E-04	8.6715E-06
037	5.9927E-04	8.6486E-06
064	5.9868E-04	8.5941E-06
074	5.9848E-04	8.8059E-06
175	5.9809E-04	8.5531E-06
185	5.9801E-04	8.5494E-06
133	5.9718E-04	8.5361E-06
022	5.9593E-04	8.5719E-06
043	5.9575E-04	8.5926E-06
066	5.9456E-04	8.5451E-06
187	5.9318E-04	8.4793E-06
121	5.9226E-04	8.4577E-06
389	5.9079E-04	8.5414E-06
173	5.9061E-04	8.4280E-06
137	5.9046E-04	8.4360E-06
131	5.8967E-04	8.4474E-06
115	5.8861E-04	8.4246E-06
072	5.8832E-04	8.4467E-06
077	5.8814E-04	8.4697E-06
156	5.8800E-04	8.4153E-06
123	5.8729E-04	8.3958E-06
127	5.8623E-04	8.3863E-06
171	5.8580E-04	8.3663E-06
324	5.8282E-04	8.4053E-06
138	5.8255E-04	8.3286E-06

TABLE C.1 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
186	5.8164E-04	8.3098E-06
136	5.8117E-04	8.3118E-06
274	5.8008E-04	8.3294E-06
112	5.7929E-04	8.2854E-06
126	5.7908E-04	8.2829E-06
076	5.7727E-04	8.2678E-06
024	5.7665E-04	8.2592E-06
177	5.7644E-04	8.2265E-06
273	5.7471E-04	8.2403E-06
182	5.7390E-04	8.1970E-06
308	5.7093E-04	8.2580E-06
068	5.7000E-04	8.2218E-06
163	5.6994E-04	8.1784E-06
180	5.6994E-04	8.1696E-06
149	5.6861E-04	8.1419E-06
188	5.6825E-04	8.1237E-06
179	5.6768E-04	8.1075E-06
147	5.6681E-04	8.1123E-06
178	5.6461E-04	8.0533E-06
145	5.6344E-04	8.1631E-06
172	5.6301E-04	8.0431E-06
366	5.6241E-04	8.1969E-06
018	5.6240E-04	8.0870E-06
325	5.6229E-04	8.1338E-06
122	5.6137E-04	8.0235E-06
368	5.6032E-04	8.0427E-06
388	5.6026E-04	8.0797E-06
184	5.6009E-04	8.0088E-06
272	5.5929E-04	8.0288E-06
151	5.5868E-04	7.9901E-06
183	5.5735E-04	7.9622E-06
132	5.5535E-04	7.9483E-06
101	5.5519E-04	7.9643E-06
128	5.4977E-04	7.8461E-06
321	5.4812E-04	7.9767E-06
211	5.4783E-04	7.8536E-06
387	5.4645E-04	7.8868E-06
335	5.4462E-04	7.9527E-06
159	5.4370E-04	7.7757E-06
152	5.4203E-04	7.7616E-06
210	5.3752E-04	7.6989E-06
154	5.3718E-04	7.6728E-06
336	5.3523E-04	7.7682E-06
150	5.3231E-04	7.6135E-06
306	5.3002E-04	7.6259E-06

TABLE C.1 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
216	5.2998E-04	7.6071E-06
237	5.2687E-04	7.5461E-06
BKG	5.2571E-04	7.5101E-06
217	5.2159E-04	7.4865E-06
305	5.2037E-04	7.4817E-06
228	5.1938E-04	7.4478E-06
323	5.1704E-04	7.5059E-06
181	5.1651E-04	7.3982E-06
218	5.1376E-04	7.3565E-06
141	5.0536E-04	7.2452E-06
257	5.0447E-04	7.3250E-06
397	5.0408E-04	7.2047E-06
193	5.0211E-04	7.1983E-06
155	5.0094E-04	7.1576E-06
312	5.0020E-04	7.4436E-06
240	4.9990E-04	7.1671E-06
242	4.9477E-04	7.1112E-06
330	4.9393E-04	7.2099E-06
276	4.9353E-04	7.1112E-06
289	4.9333E-04	7.0705E-06
248	4.8932E-04	7.0006E-06
416	4.8903E-04	6.9983E-06
302	4.8856E-04	7.2848E-06
319	4.8837E-04	7.0511E-06
418	4.8560E-04	6.9466E-06
220	4.8173E-04	6.9530E-06
253	4.8121E-04	6.8868E-06
238	4.8031E-04	6.8798E-06
303	4.7870E-04	6.9303E-06
376	4.7789E-04	6.8245E-06
205	4.7590E-04	6.8036E-06
241	4.7266E-04	6.7888E-06
233	4.7251E-04	6.7791E-06
419	4.7169E-04	6.7513E-06
223	4.7106E-04	6.7485E-06
229	4.7083E-04	6.7534E-06
322	4.6909E-04	6.8490E-06
301	4.6869E-04	7.0899E-06
371	4.6775E-04	6.6975E-06
249	4.6770E-04	6.6979E-06
234	4.6744E-04	6.7076E-06
219	4.6581E-04	6.6959E-06
333	4.6414E-04	6.7092E-06
285	4.6410E-04	6.7585E-06
246	4.6298E-04	6.6473E-06

TABLE C.1 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
236	4.6293E-04	6.6695E-06
250	4.6161E-04	6.6127E-06
396	4.6158E-04	6.6070E-06
337	4.6065E-04	6.6283E-06
196	4.5989E-04	6.5991E-06
247	4.5849E-04	6.5591E-06
254	4.5844E-04	6.5559E-06
224	4.5674E-04	6.5349E-06
227	4.5558E-04	6.5320E-06
372	4.5516E-04	6.5165E-06
191	4.5437E-04	6.5242E-06
353	4.5401E-04	6.4843E-06
280	4.5248E-04	6.5340E-06
263	4.5230E-04	6.4667E-06
358	4.5168E-04	6.4784E-06
266	4.5159E-04	6.4599E-06
192	4.4906E-04	6.4341E-06
315	4.4899E-04	6.4211E-06
214	4.4783E-04	6.4018E-06
231	4.4778E-04	6.4186E-06
377	4.4770E-04	6.3847E-06
230	4.4769E-04	6.4220E-06
260	4.4755E-04	6.5072E-06
313	4.4696E-04	6.5928E-06
292	4.4664E-04	6.4566E-06
081	4.4416E-04	6.5368E-06
190	4.4284E-04	6.3563E-06
243	4.4281E-04	6.3434E-06
212	4.4215E-04	6.3327E-06
403	4.4146E-04	6.3181E-06
320	4.4071E-04	6.5308E-06
215	4.4013E-04	6.3068E-06
318	4.4009E-04	6.3513E-06
235	4.3846E-04	6.2815E-06
400	4.3844E-04	6.2690E-06
364	4.3716E-04	6.2818E-06
414	4.3676E-04	6.2444E-06
311	4.3629E-04	6.4358E-06
352	4.3617E-04	6.2239E-06
232	4.3605E-04	6.3001E-06
370	4.3536E-04	6.2367E-06
197	4.3382E-04	6.1910E-06
264	4.3378E-04	6.2117E-06
404	4.3314E-04	6.1819E-06
198	4.3280E-04	6.2007E-06

TABLE C.1 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
356	4.3193E-04	6.1643E-06
420	4.3013E-04	6.1826E-06
293	4.2981E-04	6.2768E-06
317	4.2961E-04	6.2054E-06
316	4.2946E-04	6.1620E-06
DA6	4.2901E-04	6.4915E-06
373	4.2881E-04	6.1471E-06
279	4.2779E-04	6.1318E-06
085	4.2738E-04	6.1750E-06
409	4.2735E-04	6.1197E-06
398	4.2597E-04	6.0861E-06
207	4.2551E-04	6.0758E-06
265	4.2548E-04	6.1003E-06
395	4.2539E-04	6.0744E-06
200	4.2530E-04	6.1045E-06
204	4.2528E-04	6.0919E-06
251	4.2513E-04	6.0905E-06
331	4.2486E-04	6.1159E-06
194	4.2460E-04	6.0855E-06
402	4.2169E-04	6.0179E-06
291	4.2144E-04	6.0619E-06
287	4.2129E-04	6.0814E-06
338	4.2102E-04	6.0327E-06
213	4.2033E-04	6.0412E-06
349	4.2031E-04	6.0074E-06
346	4.2020E-04	6.0057E-06
226	4.1848E-04	5.9822E-06
374	4.1848E-04	5.9996E-06
355	4.1723E-04	5.9605E-06
360	4.1677E-04	5.9775E-06
300	4.1306E-04	5.9175E-06
392	4.1265E-04	5.9029E-06
382	4.1240E-04	5.8882E-06
405	4.1161E-04	5.8769E-06
195	4.1104E-04	5.8935E-06
401	4.1096E-04	5.8641E-06
209	4.1053E-04	5.8654E-06
221	4.1035E-04	5.8845E-06
239	4.0997E-04	5.8886E-06
417	4.0970E-04	5.8819E-06
354	4.0750E-04	5.8218E-06
348	4.0639E-04	5.8020E-06
407	4.0633E-04	5.8022E-06
299	4.0632E-04	5.8177E-06
394	4.0607E-04	5.7942E-06

TABLE C.1 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
269	4.0567E-04	5.8151E-06
199	4.0532E-04	5.8086E-06
369	4.0524E-04	5.7931E-06
244	4.0478E-04	5.7939E-06
314	4.0376E-04	5.7962E-06
189	4.0291E-04	5.7767E-06
259	4.0219E-04	5.7603E-06
258	4.0123E-04	5.7481E-06
286	4.0072E-04	5.8000E-06
345	4.0043E-04	5.7582E-06
343	3.9933E-04	5.7288E-06
408	3.9748E-04	5.6861E-06
290	3.9728E-04	5.7024E-06
359	3.9591E-04	5.6791E-06
282	3.9537E-04	5.7580E-06
344	3.9489E-04	5.6637E-06
271	3.9261E-04	5.6350E-06
225	3.9165E-04	5.6050E-06
362	3.9126E-04	5.6025E-06
283	3.9051E-04	5.6408E-06
406	3.8987E-04	5.5716E-06
361	3.8986E-04	5.5958E-06
339	3.8790E-04	5.5572E-06
288	3.8727E-04	5.5547E-06
410	3.8717E-04	5.5298E-06
391	3.8667E-04	5.5464E-06
393	3.8543E-04	5.5163E-06
203	3.8493E-04	5.5300E-06
350	3.8465E-04	5.4957E-06
284	3.8460E-04	5.4993E-06
357	3.8312E-04	5.4948E-06
201	3.8154E-04	5.4734E-06
296	3.8105E-04	5.4649E-06
298	3.7876E-04	5.4496E-06
245	3.7786E-04	5.4081E-06
294	3.7636E-04	5.4005E-06
202	3.7534E-04	5.3869E-06
351	3.7193E-04	5.3114E-06
222	3.7033E-04	5.3071E-06
342	3.6946E-04	5.2972E-06
262	3.6776E-04	5.3044E-06
270	3.6678E-04	5.2682E-06
256	3.6329E-04	5.2806E-06
261	3.5600E-04	5.1359E-06
363	3.5582E-04	5.0903E-06

TABLE C.1 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
295	3.4918E-04	4.9970E-06
340	3.4706E-04	4.9857E-06
255	3.4316E-04	4.9608E-06
341	3.4020E-04	4.8688E-06
252	3.3868E-04	4.8634E-06
267	3.3855E-04	4.8519E-06
268	3.3054E-04	4.7409E-06
413	3.2250E-04	4.6523E-06
012	3.0645E-04	4.5608E-06
005	2.9013E-04	4.1822E-06
010	2.7987E-04	4.0717E-06
009	2.7977E-04	4.0711E-06
011	2.7797E-04	4.1472E-06
007	2.6190E-04	3.7753E-06
347	2.5169E-04	3.5816E-06
008	2.5147E-04	3.6250E-06
140	8.7912E-05	1.7224E-06
139	3.8767E-05	7.5955E-07
055	3.8217E-05	7.7503E-07
166	3.6539E-05	7.2731E-07
091	3.5701E-05	6.9948E-07
L36	3.1853E-05	6.2409E-07
L35	2.4265E-05	4.7543E-07
326	2.1878E-05	4.5041E-07
002	2.1549E-05	4.2220E-07
328	2.1224E-05	4.4452E-07
L34	2.0952E-05	4.1051E-07
001	1.7296E-05	3.3888E-07
094	1.7072E-05	3.3449E-07
100	1.6566E-05	3.2457E-07
045	1.6470E-05	3.2269E-07
083	1.2485E-05	2.6495E-07
164	1.1647E-05	2.2820E-07
048	1.1399E-05	2.2333E-07
107	1.0062E-05	1.9715E-07
004	9.9452E-06	1.9485E-07
116	9.9423E-06	1.9480E-07
049	9.8085E-06	1.9218E-07
003	9.7073E-06	1.9019E-07
088	9.5543E-06	1.8720E-07
375	9.4795E-06	2.1125E-07
113	9.4509E-06	1.8517E-07
087	9.2671E-06	1.8157E-07
097	9.2509E-06	1.9219E-07
093	9.1473E-06	1.7922E-07

TABLE C.1 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
119	8.9116E-06	1.7460E-07
082	8.8332E-06	1.7307E-07
327	8.7987E-06	1.9573E-07
158	8.7347E-06	1.7114E-07
105	8.6415E-06	1.6931E-07
114	8.5730E-06	1.6797E-07
118	8.1273E-06	1.5924E-07
117	7.9383E-06	1.5553E-07
106	7.2764E-06	1.4256E-07
157	6.3392E-06	1.2420E-07
019	6.0385E-06	1.1831E-07
278	5.7660E-06	1.1297E-07
277	4.9205E-06	9.6407E-08
384	4.8872E-06	1.0546E-07
206	3.7029E-06	7.2549E-08

TABLE C.2 Total Chemical Risk
Ordered by Descending Risk

Confirmation Unit	Adult Resident	Adult Visitor
365	8.9943E-05	5.1392E-06
080	8.0969E-05	4.6258E-06
399	7.1692E-05	4.0960E-06
086	5.4794E-05	3.1303E-06
251	5.1560E-05	2.9455E-06
164	4.9540E-05	2.8309E-06
038	4.5962E-05	2.6257E-06
299	4.4071E-05	2.5169E-06
297	4.3097E-05	2.4614E-06
022	4.0899E-05	2.3362E-06
296	4.0817E-05	2.3313E-06
295	3.8960E-05	2.2251E-06
092	3.7130E-05	2.1209E-06
334	3.6141E-05	2.0645E-06
281	3.6046E-05	2.0591E-06
290	3.5526E-05	2.0294E-06
021	3.4919E-05	1.9946E-06
090	3.4907E-05	1.9939E-06
362	3.3933E-05	1.9383E-06
039	3.2929E-05	1.8810E-06
332	3.1815E-05	1.8173E-06
058	3.1343E-05	1.7904E-06
387	3.1002E-05	1.7714E-06
307	3.0803E-05	1.7595E-06
044	3.0713E-05	1.7543E-06
372	3.0666E-05	1.7515E-06
366	3.0661E-05	1.7519E-06
276	3.0660E-05	1.7514E-06
165	3.0450E-05	1.7391E-06
166	3.0292E-05	1.7297E-06
062	3.0126E-05	1.7208E-06
191	2.9656E-05	1.6938E-06
219	2.9644E-05	1.6931E-06
153	2.9451E-05	1.6828E-06
301	2.9426E-05	1.6808E-06
309	2.9216E-05	1.6687E-06
069	2.9127E-05	1.6637E-06
DA6	2.8925E-05	1.6522E-06
292	2.8754E-05	1.6423E-06
285	2.8730E-05	1.6410E-06
060	2.8481E-05	1.6269E-06
370	2.8328E-05	1.6179E-06

TABLE C.2 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
169	2.8129E-05	1.6065E-06
291	2.8116E-05	1.6058E-06
275	2.8010E-05	1.5999E-06
284	2.7993E-05	1.5987E-06
059	2.7988E-05	1.5987E-06
320	2.7920E-05	1.5945E-06
280	2.7899E-05	1.5935E-06
283	2.7791E-05	1.5873E-06
067	2.7766E-05	1.5860E-06
066	2.7564E-05	1.5745E-06
190	2.7511E-05	1.5713E-06
298	2.7463E-05	1.5685E-06
068	2.7251E-05	1.5565E-06
303	2.7193E-05	1.5532E-06
367	2.7132E-05	1.5498E-06
287	2.7026E-05	1.5437E-06
003	2.6900E-05	1.5370E-06
213	2.6889E-05	1.5359E-06
328	2.6877E-05	1.5352E-06
192	2.6861E-05	1.5341E-06
002	2.6857E-05	1.5347E-06
040	2.6711E-05	1.5257E-06
360	2.6450E-05	1.5107E-06
302	2.6432E-05	1.5097E-06
189	2.6101E-05	1.4907E-06
252	2.6044E-05	1.4875E-06
317	2.5947E-05	1.4819E-06
253	2.5894E-05	1.4789E-06
329	2.5647E-05	1.4649E-06
319	2.5413E-05	1.4514E-06
379	2.5396E-05	1.4503E-06
316	2.5349E-05	1.4477E-06
371	2.5314E-05	1.4458E-06
110	2.5225E-05	1.4408E-06
029	2.5222E-05	1.4403E-06
300	2.5210E-05	1.4399E-06
077	2.5140E-05	1.4359E-06
196	2.5119E-05	1.4346E-06
167	2.5103E-05	1.4337E-06
304	2.4999E-05	1.4278E-06
065	2.4976E-05	1.4266E-06
335	2.4948E-05	1.4249E-06
282	2.4797E-05	1.4163E-06
397	2.4697E-05	1.4106E-06
236	2.4645E-05	1.4076E-06

TABLE C.2 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
359	2.4603E-05	1.4052E-06
389	2.4457E-05	1.3974E-06
286	2.4320E-05	1.3890E-06
063	2.4260E-05	1.3856E-06
051	2.4259E-05	1.3855E-06
218	2.4209E-05	1.3826E-06
311	2.4044E-05	1.3731E-06
355	2.4032E-05	1.3727E-06
321	2.3937E-05	1.3671E-06
333	2.3798E-05	1.3592E-06
348	2.3792E-05	1.3588E-06
202	2.3702E-05	1.3535E-06
337	2.3549E-05	1.3449E-06
313	2.3128E-05	1.3208E-06
336	2.3104E-05	1.3195E-06
323	2.3017E-05	1.3146E-06
279	2.3003E-05	1.3137E-06
393	2.2912E-05	1.3086E-06
203	2.2832E-05	1.3039E-06
306	2.2823E-05	1.3035E-06
293	2.2774E-05	1.3006E-06
358	2.2403E-05	1.2794E-06
064	2.2370E-05	1.2776E-06
037	2.2222E-05	1.2693E-06
057	2.2091E-05	1.2618E-06
318	2.1933E-05	1.2526E-06
061	2.1901E-05	1.2508E-06
310	2.1774E-05	1.2435E-06
314	2.1723E-05	1.2406E-06
201	2.1692E-05	1.2394E-06
305	2.1663E-05	1.2373E-06
357	2.1506E-05	1.2283E-06
325	2.1444E-05	1.2247E-06
349	2.1406E-05	1.2225E-06
071	2.1342E-05	1.2189E-06
312	2.1278E-05	1.2152E-06
111	2.1270E-05	1.2147E-06
214	2.1231E-05	1.2125E-06
308	2.1217E-05	1.2118E-06
327	2.1140E-05	1.2074E-06
205	2.1090E-05	1.2045E-06
395	2.1082E-05	1.2039E-06
152	2.1081E-05	1.2045E-06
200	2.0924E-05	1.1949E-06
344	2.0708E-05	1.1826E-06

TABLE C.2 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
073	2.0686E-05	1.1814E-06
343	2.0674E-05	1.1807E-06
147	2.0586E-05	1.1762E-06
215	2.0475E-05	1.1693E-06
212	2.0353E-05	1.1624E-06
216	2.0263E-05	1.1572E-06
294	2.0122E-05	1.1490E-06
208	2.0105E-05	1.1488E-06
195	1.9939E-05	1.1386E-06
193	1.9840E-05	1.1330E-06
324	1.9806E-05	1.1311E-06
020	1.9748E-05	1.1275E-06
109	1.9735E-05	1.1272E-06
209	1.9564E-05	1.1172E-06
075	1.9532E-05	1.1154E-06
346	1.9509E-05	1.1142E-06
024	1.9411E-05	1.1083E-06
330	1.9319E-05	1.1033E-06
373	1.9083E-05	1.0899E-06
041	1.9031E-05	1.0869E-06
054	1.8959E-05	1.0828E-06
217	1.8958E-05	1.0827E-06
381	1.8926E-05	1.0810E-06
023	1.8847E-05	1.0760E-06
028	1.8803E-05	1.0739E-06
047	1.8762E-05	1.0715E-06
198	1.8758E-05	1.0711E-06
350	1.8754E-05	1.0710E-06
288	1.8662E-05	1.0658E-06
034	1.8588E-05	1.0616E-06
076	1.8544E-05	1.0590E-06
374	1.8523E-05	1.0579E-06
052	1.8436E-05	1.0529E-06
072	1.8367E-05	1.0489E-06
238	1.8343E-05	1.0472E-06
194	1.8201E-05	1.0394E-06
070	1.8194E-05	1.0391E-06
326	1.8175E-05	1.0380E-06
204	1.8009E-05	1.0284E-06
237	1.7873E-05	1.0204E-06
338	1.7479E-05	9.9810E-07
315	1.7471E-05	9.9780E-07
382	1.7398E-05	9.9345E-07
159	1.7082E-05	9.7602E-07
331	1.6879E-05	9.6376E-07

TABLE C.2 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
035	1.6843E-05	9.6187E-07
036	1.6634E-05	9.5000E-07
211	1.6125E-05	9.2083E-07
289	1.6097E-05	9.1925E-07
207	1.6089E-05	9.1867E-07
032	1.6082E-05	9.1844E-07
322	1.6034E-05	9.1564E-07
074	1.5968E-05	9.1184E-07
199	1.5692E-05	8.9594E-07
001	1.5607E-05	8.9183E-07
210	1.5551E-05	8.8798E-07
043	1.4073E-05	8.0336E-07
031	1.4034E-05	8.0138E-07
033	1.3959E-05	7.9713E-07
267	1.3714E-05	7.8367E-07
085	1.2696E-05	7.2495E-07
121	1.2655E-05	7.2259E-07
042	1.2625E-05	7.2072E-07
122	1.1916E-05	6.8028E-07
386	1.1039E-05	6.3073E-07
274	1.1027E-05	6.3011E-07
133	7.9369E-06	4.5288E-07
112	6.8209E-06	3.8938E-07
137	6.6257E-06	3.7796E-07
391	6.0903E-06	3.4802E-07
132	5.9120E-06	3.3729E-07
135	5.1354E-06	2.9283E-07
131	5.0823E-06	2.8978E-07
254	4.9229E-06	2.8131E-07
263	4.7160E-06	2.6948E-07
136	4.6999E-06	2.6803E-07
268	4.6841E-06	2.6766E-07
138	4.3038E-06	2.4531E-07
380	4.0936E-06	2.3392E-07
266	3.8920E-06	2.2240E-07
168	3.2212E-06	1.8331E-07
129	3.1471E-06	1.7914E-07
171	2.9894E-06	1.7082E-07
055	2.9523E-06	1.6870E-07
130	2.5363E-06	1.4422E-07
353	2.4686E-06	1.4106E-07
134	2.4224E-06	1.3773E-07
265	2.2865E-06	1.3066E-07
354	2.2802E-06	1.3030E-07
128	2.0712E-06	1.1798E-07

TABLE C.2 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
123	1.9665E-06	1.1176E-07
124	1.9349E-06	1.0987E-07
106	1.4537E-06	8.2498E-08
260	1.4173E-06	8.0989E-08
103	1.0638E-06	6.0087E-08
347	8.2035E-07	4.6877E-08
101	7.6571E-07	4.3106E-08
227	6.9301E-07	3.9601E-08
125	5.6207E-07	3.1446E-08
098	5.1712E-07	2.8887E-08
096	4.9639E-07	2.8365E-08
127	4.7998E-07	2.6868E-08
104	4.6307E-07	2.5776E-08
273	3.9220E-07	2.2412E-08
102	3.6491E-07	2.0412E-08
181	3.4992E-07	1.9995E-08
097	3.1521E-07	1.8012E-08
162	3.0987E-07	1.7707E-08
126	2.3726E-07	1.2966E-08
197	2.3525E-07	1.3443E-08
163	2.2668E-07	1.2293E-08
364	2.0444E-07	1.1682E-08
099	1.9178E-07	1.0399E-08
392	1.6510E-07	9.4344E-09
233	1.6438E-07	9.3933E-09
100	8.2055E-08	3.9392E-09
143	6.4369E-08	3.6782E-09
232	6.3027E-08	3.6016E-09
222	5.8039E-08	3.3165E-09
146	5.3146E-08	3.0369E-09
182	2.9921E-08	1.7098E-09
172	2.8815E-08	1.6466E-09
025	2.3264E-08	1.3294E-09
030	1.6996E-08	9.7118E-10
107	1.6857E-08	3.6146E-10
027	1.0551E-08	6.0290E-10
145	1.0802E-09	6.1728E-11
179	0.0000E+00	0.0000E+00
356	0.0000E+00	0.0000E+00
235	0.0000E+00	0.0000E+00
026	0.0000E+00	0.0000E+00
259	0.0000E+00	0.0000E+00
361	0.0000E+00	0.0000E+00
363	0.0000E+00	0.0000E+00
117	0.0000E+00	0.0000E+00

TABLE C.2 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
180	0.0000E+00	0.0000E+00
264	0.0000E+00	0.0000E+00
018	0.0000E+00	0.0000E+00
015	0.0000E+00	0.0000E+00
014	0.0000E+00	0.0000E+00
011	0.0000E+00	0.0000E+00
239	0.0000E+00	0.0000E+00
170	0.0000E+00	0.0000E+00
158	0.0000E+00	0.0000E+00
185	0.0000E+00	0.0000E+00
223	0.0000E+00	0.0000E+00
270	0.0000E+00	0.0000E+00
271	0.0000E+00	0.0000E+00
225	0.0000E+00	0.0000E+00
206	0.0000E+00	0.0000E+00
272	0.0000E+00	0.0000E+00
157	0.0000E+00	0.0000E+00
108	0.0000E+00	0.0000E+00
234	0.0000E+00	0.0000E+00
116	0.0000E+00	0.0000E+00
342	0.0000E+00	0.0000E+00
246	0.0000E+00	0.0000E+00
228	0.0000E+00	0.0000E+00
221	0.0000E+00	0.0000E+00
183	0.0000E+00	0.0000E+00
224	0.0000E+00	0.0000E+00
226	0.0000E+00	0.0000E+00

TABLE C.3 Chemical Hazard Index
Ordered by Descending Hazard Risk

Confirmation Unit	Adult Resident	Adult Visitor
399	8.0666E+00	4.6094E-01
365	7.9423E-01	4.5384E-02
086	6.5257E-01	3.7279E-02
080	4.9469E-01	2.8257E-02
317	4.7148E-01	2.6929E-02
335	4.2908E-01	2.4507E-02
307	4.1999E-01	2.3989E-02
321	4.1027E-01	2.3432E-02
308	4.0884E-01	2.3352E-02
236	4.0429E-01	2.3091E-02
381	3.7864E-01	2.1628E-02
320	3.7789E-01	2.1579E-02
319	3.7134E-01	2.1206E-02
333	3.5555E-01	2.0304E-02
306	3.4627E-01	1.9777E-02
283	3.4004E-01	1.9419E-02
251	3.3991E-01	1.9412E-02
314	3.3899E-01	1.9359E-02
059	3.3464E-01	1.9112E-02
167	3.3399E-01	1.9074E-02
291	3.2682E-01	1.8662E-02
292	3.2637E-01	1.8637E-02
287	3.1904E-01	1.8220E-02
299	3.1784E-01	1.8138E-02
DA6	3.1403E-01	1.7935E-02
309	3.0883E-01	1.7636E-02
313	3.0479E-01	1.7404E-02
301	3.0282E-01	1.7294E-02
366	3.0164E-01	1.7236E-02
296	2.9386E-01	1.6773E-02
297	2.9315E-01	1.6730E-02
295	2.9145E-01	1.6634E-02
331	2.9088E-01	1.6609E-02
165	2.9017E-01	1.6567E-02
311	2.9007E-01	1.6561E-02
362	2.8947E-01	1.6530E-02
389	2.8449E-01	1.6257E-02
302	2.8305E-01	1.6164E-02
253	2.7974E-01	1.5972E-02
370	2.7746E-01	1.5841E-02
037	2.7291E-01	1.5586E-02
SDA	2.6967E-01	1.5410E-02

TABLE C.3 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
367	2.6767E-01	1.5287E-02
288	2.6184E-01	1.4952E-02
166	2.6106E-01	1.4897E-02
390	2.6095E-01	1.4912E-02
312	2.5734E-01	1.4693E-02
393	2.5594E-01	1.4614E-02
303	2.5538E-01	1.4581E-02
374	2.5532E-01	1.4581E-02
282	2.5295E-01	1.4443E-02
285	2.5185E-01	1.4379E-02
280	2.4661E-01	1.4080E-02
284	2.4539E-01	1.4009E-02
293	2.4245E-01	1.3842E-02
275	2.4042E-01	1.3727E-02
286	2.3886E-01	1.3637E-02
065	2.3694E-01	1.3529E-02
304	2.3610E-01	1.3480E-02
373	2.3484E-01	1.3409E-02
310	2.3475E-01	1.3402E-02
110	2.3324E-01	1.3318E-02
318	2.3306E-01	1.3305E-02
106	2.3199E-01	1.3246E-02
305	2.2955E-01	1.3107E-02
038	2.2894E-01	1.3070E-02
169	2.2699E-01	1.2956E-02
279	2.2462E-01	1.2822E-02
281	2.2277E-01	1.2718E-02
325	2.2197E-01	1.2674E-02
041	2.2194E-01	1.2672E-02
323	2.2162E-01	1.2654E-02
371	2.1886E-01	1.2494E-02
330	2.1784E-01	1.2436E-02
289	2.1758E-01	1.2424E-02
298	2.1552E-01	1.2303E-02
372	2.1536E-01	1.2294E-02
062	2.1535E-01	1.2295E-02
336	2.1368E-01	1.2199E-02
300	2.1137E-01	1.2068E-02
092	2.1128E-01	1.2061E-02
252	2.1093E-01	1.2042E-02
138	2.1016E-01	1.1997E-02
294	2.0910E-01	1.1935E-02
135	2.0582E-01	1.1749E-02
358	2.0276E-01	1.1574E-02
090	2.0219E-01	1.1541E-02

TABLE C.3 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
029	1.9921E-01	1.1367E-02
063	1.9613E-01	1.1197E-02
360	1.9384E-01	1.1065E-02
035	1.9334E-01	1.1039E-02
021	1.9201E-01	1.0959E-02
322	1.9010E-01	1.0854E-02
054	1.8860E-01	1.0768E-02
334	1.8799E-01	1.0731E-02
137	1.8758E-01	1.0706E-02
077	1.8634E-01	1.0637E-02
069	1.8599E-01	1.0617E-02
359	1.8546E-01	1.0587E-02
395	1.8267E-01	1.0425E-02
171	1.8086E-01	1.0335E-02
058	1.8076E-01	1.0319E-02
387	1.8072E-01	1.0327E-02
276	1.7565E-01	1.0028E-02
357	1.7261E-01	9.8528E-03
036	1.7171E-01	9.8036E-03
219	1.7057E-01	9.7329E-03
064	1.6917E-01	9.6554E-03
073	1.6781E-01	9.5779E-03
133	1.6652E-01	9.5029E-03
028	1.6623E-01	9.4897E-03
191	1.6415E-01	9.3661E-03
068	1.6407E-01	9.3650E-03
032	1.6340E-01	9.3286E-03
338	1.6295E-01	9.2998E-03
131	1.6225E-01	9.2591E-03
067	1.5989E-01	9.1272E-03
039	1.5950E-01	9.1048E-03
153	1.5926E-01	9.1005E-03
044	1.5829E-01	9.0332E-03
051	1.5826E-01	9.0327E-03
136	1.5713E-01	8.9686E-03
379	1.5436E-01	8.8059E-03
040	1.5425E-01	8.8033E-03
328	1.5299E-01	8.7326E-03
075	1.5258E-01	8.7074E-03
190	1.5156E-01	8.6477E-03
332	1.5143E-01	8.6407E-03
071	1.5142E-01	8.6426E-03
003	1.5012E-01	8.5781E-03
346	1.4896E-01	8.5016E-03
213	1.4880E-01	8.4932E-03

TABLE C.3 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
329	1.4745E-01	8.4146E-03
074	1.4698E-01	8.3879E-03
192	1.4682E-01	8.3770E-03
076	1.4650E-01	8.3610E-03
072	1.4617E-01	8.3414E-03
047	1.4501E-01	8.2763E-03
060	1.4222E-01	8.1170E-03
337	1.4220E-01	8.1134E-03
189	1.4046E-01	8.0137E-03
196	1.3851E-01	7.9038E-03
316	1.3814E-01	7.8802E-03
022	1.3579E-01	7.7440E-03
208	1.3453E-01	7.6877E-03
109	1.3436E-01	7.6684E-03
061	1.3337E-01	7.6110E-03
397	1.3306E-01	7.5926E-03
207	1.3183E-01	7.5211E-03
218	1.3068E-01	7.4553E-03
202	1.3037E-01	7.4354E-03
052	1.2922E-01	7.3738E-03
348	1.2767E-01	7.2832E-03
023	1.2719E-01	7.2509E-03
057	1.2701E-01	7.2479E-03
015	1.2646E-01	7.2264E-03
034	1.2590E-01	7.1845E-03
209	1.2510E-01	7.1363E-03
324	1.2405E-01	7.0770E-03
066	1.2301E-01	7.0190E-03
203	1.2291E-01	7.0113E-03
327	1.2234E-01	6.9806E-03
111	1.2189E-01	6.9521E-03
020	1.2155E-01	6.9302E-03
201	1.1995E-01	6.8542E-03
024	1.1954E-01	6.8149E-03
326	1.1863E-01	6.7690E-03
152	1.1677E-01	6.6724E-03
349	1.1557E-01	6.5926E-03
214	1.1476E-01	6.5477E-03
343	1.1470E-01	6.5436E-03
147	1.1397E-01	6.5128E-03
200	1.1378E-01	6.4888E-03
344	1.1364E-01	6.4818E-03
290	1.1331E-01	6.4640E-03
215	1.1264E-01	6.4251E-03
205	1.1244E-01	6.4134E-03

TABLE C.3 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
216	1.1209E-01	6.3941E-03
260	1.1064E-01	6.3224E-03
212	1.1025E-01	6.2903E-03
195	1.0933E-01	6.2352E-03
193	1.0873E-01	6.2008E-03
217	1.0515E-01	5.9980E-03
033	1.0483E-01	5.9815E-03
198	1.0226E-01	5.8297E-03
355	1.0200E-01	5.8200E-03
350	1.0162E-01	5.7961E-03
238	1.0045E-01	5.7241E-03
382	1.0044E-01	5.7269E-03
194	1.0042E-01	5.7267E-03
237	1.0008E-01	5.7028E-03
204	9.8559E-02	5.6206E-03
140	9.6505E-02	5.5146E-03
055	9.5089E-02	5.4337E-03
159	9.4939E-02	5.4251E-03
043	9.4899E-02	5.4086E-03
315	9.2631E-02	5.2837E-03
031	9.1538E-02	5.2213E-03
070	9.1336E-02	5.2094E-03
211	9.1231E-02	5.2028E-03
SDB	8.9095E-02	5.0912E-03
210	8.8230E-02	5.0304E-03
014	8.8150E-02	5.0371E-03
199	8.6693E-02	4.9405E-03
085	7.9292E-02	4.5218E-03
013	7.7359E-02	4.4205E-03
SDC	7.6336E-02	4.3621E-03
103	7.5565E-02	4.3044E-03
042	7.3699E-02	4.1984E-03
121	7.3566E-02	4.1940E-03
122	7.1189E-02	4.0572E-03
385	6.8493E-02	3.9139E-03
162	6.4678E-02	3.6959E-03
132	6.4672E-02	3.6852E-03
101	6.0949E-02	3.4702E-03
SDD	5.7811E-02	3.3035E-03
386	5.7230E-02	3.2703E-03
347	5.1986E-02	2.9706E-03
098	4.5328E-02	2.5773E-03
112	4.4525E-02	2.5375E-03
139	4.2556E-02	2.4318E-03
016	4.1838E-02	2.3907E-03

TABLE C.3 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
017	4.0605E-02	2.3203E-03
104	4.0055E-02	2.2755E-03
081	3.9680E-02	2.2674E-03
027	3.9434E-02	2.2534E-03
091	3.9191E-02	2.2395E-03
096	3.8642E-02	2.2081E-03
L36	3.4967E-02	1.9981E-03
233	3.2242E-02	1.8424E-03
257	3.1959E-02	1.8262E-03
012	3.0392E-02	1.7367E-03
102	3.0265E-02	1.7209E-03
128	2.9938E-02	1.7035E-03
011	2.9723E-02	1.6985E-03
380	2.8784E-02	1.6448E-03
097	2.8196E-02	1.6112E-03
100	2.8154E-02	1.5942E-03
145	2.7310E-02	1.5606E-03
L35	2.6637E-02	1.5221E-03
164	2.5212E-02	1.4407E-03
163	2.4909E-02	1.4105E-03
002	2.3655E-02	1.3517E-03
232	2.3069E-02	1.3182E-03
L34	2.3000E-02	1.3143E-03
256	2.2250E-02	1.2715E-03
099	2.1999E-02	1.2462E-03
030	2.0503E-02	1.1716E-03
388	1.9716E-02	1.1266E-03
124	1.9314E-02	1.0903E-03
001	1.8987E-02	1.0850E-03
094	1.8741E-02	1.0709E-03
143	1.8702E-02	1.0687E-03
197	1.8553E-02	1.0601E-03
045	1.8080E-02	1.0331E-03
412	1.7520E-02	1.0011E-03
018	1.6260E-02	9.2915E-04
127	1.6107E-02	9.0952E-04
134	1.5945E-02	8.9758E-04
220	1.5931E-02	9.1034E-04
142	1.5594E-02	8.9111E-04
056	1.5540E-02	8.8802E-04
089	1.5427E-02	8.8154E-04
146	1.5412E-02	8.8071E-04
255	1.5370E-02	8.7830E-04
108	1.5307E-02	8.7469E-04
261	1.5291E-02	8.7375E-04

TABLE C.3 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
129	1.5082E-02	8.4825E-04
272	1.4973E-02	8.5562E-04
262	1.4732E-02	8.4181E-04
274	1.4629E-02	8.3592E-04
046	1.4303E-02	8.1734E-04
144	1.4217E-02	8.1243E-04
050	1.3978E-02	7.9874E-04
273	1.3672E-02	7.8127E-04
083	1.3063E-02	7.4644E-04
180	1.2770E-02	7.2974E-04
084	1.2721E-02	7.2692E-04
048	1.2513E-02	7.1503E-04
368	1.2322E-02	7.0411E-04
420	1.1840E-02	6.7656E-04
181	1.1799E-02	6.7421E-04
182	1.1490E-02	6.5656E-04
107	1.1424E-02	6.4110E-04
364	1.1124E-02	6.3569E-04
115	1.1099E-02	6.3425E-04
095	1.1064E-02	6.3225E-04
004	1.0917E-02	6.2385E-04
116	1.0914E-02	6.2366E-04
049	1.0767E-02	6.1528E-04
088	1.0488E-02	5.9933E-04
113	1.0375E-02	5.9284E-04
087	1.0173E-02	5.8131E-04
161	1.0094E-02	5.7682E-04
093	1.0041E-02	5.7380E-04
119	9.7828E-03	5.5901E-04
082	9.6967E-03	5.5409E-04
375	9.5991E-03	5.4852E-04
158	9.5885E-03	5.4792E-04
105	9.4862E-03	5.4207E-04
114	9.4111E-03	5.3778E-04
175	9.0703E-03	5.1830E-04
118	8.9217E-03	5.0981E-04
188	8.9079E-03	5.0902E-04
123	8.7330E-03	4.8718E-04
117	8.7143E-03	4.9796E-04
187	8.6475E-03	4.9414E-04
025	8.6237E-03	4.9279E-04
148	8.5643E-03	4.8939E-04
120	8.5551E-03	4.8886E-04
172	8.3965E-03	4.7980E-04
340	8.1357E-03	4.6490E-04

TABLE C.3 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
176	8.0959E-03	4.6262E-04
009	8.0731E-03	4.6132E-04
010	7.9142E-03	4.5224E-04
130	7.9008E-03	4.3773E-04
185	7.7917E-03	4.4524E-04
265	7.7083E-03	4.4047E-04
378	7.6944E-03	4.3968E-04
006	7.6895E-03	4.3940E-04
026	7.6522E-03	4.3727E-04
419	7.5986E-03	4.3420E-04
160	7.5226E-03	4.2986E-04
361	7.5084E-03	4.2905E-04
125	7.4830E-03	4.1454E-04
222	7.4321E-03	4.2469E-04
264	7.4255E-03	4.2431E-04
417	7.3898E-03	4.2227E-04
184	7.2716E-03	4.1552E-04
242	7.1403E-03	4.0802E-04
418	7.1324E-03	4.0757E-04
126	7.1251E-03	3.9564E-04
411	7.1154E-03	4.0660E-04
156	7.1056E-03	4.0603E-04
183	7.0894E-03	4.0511E-04
186	7.0870E-03	4.0497E-04
221	7.0733E-03	4.0419E-04
157	6.9589E-03	3.9765E-04
170	6.9071E-03	3.9469E-04
174	6.9019E-03	3.9440E-04
239	6.7777E-03	3.8730E-04
151	6.6976E-03	3.8272E-04
019	6.6287E-03	3.7878E-04
178	6.5084E-03	3.7191E-04
339	6.5035E-03	3.7163E-04
396	6.4460E-03	3.6834E-04
141	6.4292E-03	3.6738E-04
230	6.3841E-03	3.6480E-04
231	6.3485E-03	3.6277E-04
179	6.3477E-03	3.6273E-04
278	6.3296E-03	3.6169E-04
154	6.3185E-03	3.6106E-04
155	6.3002E-03	3.6001E-04
269	6.2952E-03	3.5973E-04
149	6.2845E-03	3.5911E-04
173	6.2803E-03	3.5887E-04
150	6.2526E-03	3.5729E-04

TABLE C.3 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
223	6.1890E-03	3.5366E-04
246	6.1546E-03	3.5169E-04
414	6.1348E-03	3.5056E-04
177	6.0724E-03	3.4699E-04
376	5.8786E-03	3.3592E-04
254	5.8607E-03	3.3490E-04
229	5.8073E-03	3.3185E-04
258	5.6778E-03	3.2444E-04
228	5.5869E-03	3.1925E-04
416	5.5458E-03	3.1691E-04
263	5.5156E-03	3.1518E-04
271	5.4431E-03	3.1103E-04
277	5.4015E-03	3.0866E-04
227	5.3951E-03	3.0829E-04
235	5.3867E-03	3.0781E-04
247	5.3738E-03	3.0707E-04
363	5.2464E-03	2.9979E-04
353	5.2319E-03	2.9897E-04
403	5.2229E-03	2.9845E-04
250	5.1827E-03	2.9616E-04
243	5.1705E-03	2.9546E-04
240	5.1520E-03	2.9440E-04
268	5.1393E-03	2.9367E-04
409	5.1369E-03	2.9354E-04
392	5.1336E-03	2.9335E-04
249	5.1194E-03	2.9253E-04
241	5.1160E-03	2.9234E-04
248	5.0778E-03	2.9016E-04
270	5.0746E-03	2.8998E-04
384	5.0581E-03	2.8903E-04
225	5.0371E-03	2.8783E-04
259	4.9911E-03	2.8521E-04
266	4.9104E-03	2.8059E-04
391	4.8830E-03	2.7903E-04
234	4.8385E-03	2.7649E-04
406	4.8276E-03	2.7586E-04
224	4.7596E-03	2.7198E-04
244	4.6608E-03	2.6633E-04
400	4.6601E-03	2.6629E-04
245	4.6345E-03	2.6483E-04
394	4.6010E-03	2.6292E-04
405	4.5476E-03	2.5986E-04
226	4.4958E-03	2.5690E-04
377	4.4790E-03	2.5595E-04
267	4.4777E-03	2.5587E-04

TABLE C.3 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
369	4.3952E-03	2.5116E-04
BKG	4.3836E-03	2.5049E-04
356	4.3345E-03	2.4768E-04
354	4.3054E-03	2.4602E-04
342	4.2930E-03	2.4532E-04
398	4.2740E-03	2.4423E-04
341	4.1963E-03	2.3979E-04
407	4.1897E-03	2.3941E-04
408	4.1888E-03	2.3936E-04
404	4.1734E-03	2.3848E-04
345	4.1541E-03	2.3738E-04
410	4.0980E-03	2.3417E-04
402	4.0944E-03	2.3397E-04
401	4.0677E-03	2.3244E-04
206	4.0648E-03	2.3227E-04
352	4.0290E-03	2.3023E-04
351	4.0244E-03	2.2997E-04
413	3.9588E-03	2.2622E-04
168	4.7463E-04	1.2443E-05

TABLE C.4 Total Radon Risk Ordered by Descending Risk

Confirmation Unit	Adult Resident	Adult Visitor
067	3.5679E-03	NA[a]
168	2.4030E-03	NA
412	2.1415E-03	NA
310	2.0631E-03	NA
046	2.0092E-03	NA
165	2.0063E-03	NA
411	1.9350E-03	NA
329	1.8123E-03	NA
380	1.6729E-03	NA
304	1.6687E-03	NA
014	1.6427E-03	NA
281	1.5888E-03	NA
309	1.5727E-03	NA
275	1.5682E-03	NA
399	1.5671E-03	NA
169	1.5544E-03	NA
096	1.5532E-03	NA
058	1.5407E-03	NA
160	1.5299E-03	NA
095	1.5094E-03	NA
167	1.4831E-03	NA
057	1.4826E-03	NA
080	1.4768E-03	NA
005	1.4589E-03	NA
028	1.4513E-03	NA
092	1.4496E-03	NA
089	1.4441E-03	NA
162	1.4352E-03	NA
006	1.4338E-03	NA
013	1.4302E-03	NA
090	1.4269E-03	NA
084	1.4262E-03	NA
069	1.4229E-03	NA
102	1.4172E-03	NA
015	1.4111E-03	NA
017	1.4097E-03	NA
012	1.4018E-03	NA
144	1.4007E-03	NA
129	1.3918E-03	NA
066	1.3875E-03	NA
041	1.3870E-03	NA

TABLE C.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
050	1.3840E-03	NA
124	1.3835E-03	NA
086	1.3831E-03	NA
038	1.3821E-03	NA
133	1.3808E-03	NA
135	1.3786E-03	NA
051	1.3750E-03	NA
068	1.3723E-03	NA
010	1.3711E-03	NA
009	1.3699E-03	NA
029	1.3689E-03	NA
130	1.3682E-03	NA
030	1.3646E-03	NA
101	1.3634E-03	NA
070	1.3626E-03	NA
163	1.3563E-03	NA
027	1.3545E-03	NA
044	1.3544E-03	NA
103	1.3502E-03	NA
016	1.3479E-03	NA
174	1.3475E-03	NA
161	1.3389E-03	NA
134	1.3382E-03	NA
228	1.3365E-03	NA
056	1.3365E-03	NA
142	1.3361E-03	NA
111	1.3361E-03	NA
185	1.3336E-03	NA
125	1.3319E-03	NA
059	1.3302E-03	NA
176	1.3283E-03	NA
025	1.3258E-03	NA
023	1.3241E-03	NA
060	1.3223E-03	NA
138	1.3195E-03	NA
307	1.3190E-03	NA
378	1.3185E-03	NA
007	1.3170E-03	NA
047	1.3161E-03	NA
026	1.3156E-03	NA
379	1.3099E-03	NA
274	1.3079E-03	NA
170	1.3076E-03	NA
136	1.3075E-03	NA
061	1.3065E-03	NA

TABLE C.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
040	1.3062E-03	NA
131	1.3026E-03	NA
039	1.3026E-03	NA
062	1.3018E-03	NA
306	1.3011E-03	NA
143	1.2952E-03	NA
120	1.2916E-03	NA
024	1.2890E-03	NA
018	1.2854E-03	NA
022	1.2848E-03	NA
043	1.2824E-03	NA
037	1.2815E-03	NA
042	1.2794E-03	NA
175	1.2770E-03	NA
184	1.2755E-03	NA
137	1.2731E-03	NA
332	1.2716E-03	NA
052	1.2708E-03	NA
305	1.2704E-03	NA
036	1.2693E-03	NA
171	1.2662E-03	NA
008	1.2645E-03	NA
031	1.2638E-03	NA
011	1.2616E-03	NA
064	1.2611E-03	NA
073	1.2575E-03	NA
065	1.2558E-03	NA
334	1.2540E-03	NA
123	1.2525E-03	NA
126	1.2502E-03	NA
186	1.2498E-03	NA
081	1.2468E-03	NA
032	1.2400E-03	NA
381	1.2378E-03	NA
187	1.2377E-03	NA
021	1.2356E-03	NA
063	1.2339E-03	NA
071	1.2329E-03	NA
108	1.2288E-03	NA
216	1.2257E-03	NA
104	1.2248E-03	NA
324	1.2223E-03	NA
179	1.2215E-03	NA
193	1.2168E-03	NA
132	1.2165E-03	NA

TABLE C.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
172	1.2135E-03	NA
182	1.2117E-03	NA
153	1.2043E-03	NA
115	1.1983E-03	NA
076	1.1933E-03	NA
035	1.1925E-03	NA
180	1.1914E-03	NA
173	1.1891E-03	NA
289	1.1846E-03	NA
075	1.1790E-03	NA
273	1.1774E-03	NA
177	1.1750E-03	NA
321	1.1701E-03	NA
127	1.1700E-03	NA
387	1.1680E-03	NA
183	1.1672E-03	NA
146	1.1671E-03	NA
085	1.1660E-03	NA
054	1.1642E-03	NA
272	1.1639E-03	NA
336	1.1636E-03	NA
077	1.1619E-03	NA
335	1.1613E-03	NA
020	1.1608E-03	NA
388	1.1603E-03	NA
368	1.1574E-03	NA
141	1.1571E-03	NA
217	1.1551E-03	NA
218	1.1516E-03	NA
110	1.1515E-03	NA
188	1.1493E-03	NA
365	1.1374E-03	NA
147	1.1374E-03	NA
181	1.1364E-03	NA
220	1.1181E-03	NA
148	1.1165E-03	NA
367	1.1131E-03	NA
325	1.1126E-03	NA
308	1.1121E-03	NA
099	1.1103E-03	NA
074	1.1095E-03	NA
152	1.1077E-03	NA
109	1.1046E-03	NA
210	1.1045E-03	NA
072	1.1027E-03	NA

TABLE C.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
033	1.1002E-03	NA
389	1.0861E-03	NA
237	1.0856E-03	NA
229	1.0809E-03	NA
211	1.0803E-03	NA
034	1.0802E-03	NA
240	1.0777E-03	NA
BKG	1.0764E-03	NA
219	1.0679E-03	NA
337	1.0677E-03	NA
112	1.0674E-03	NA
323	1.0650E-03	NA
390	1.0584E-03	NA
149	1.0476E-03	NA
242	1.0445E-03	NA
178	1.0412E-03	NA
128	1.0399E-03	NA
246	1.0375E-03	NA
248	1.0305E-03	NA
121	1.0300E-03	NA
319	1.0250E-03	NA
303	1.0220E-03	NA
227	1.0209E-03	NA
215	1.0203E-03	NA
223	1.0186E-03	NA
236	1.0150E-03	NA
122	1.0121E-03	NA
159	1.0109E-03	NA
151	1.0095E-03	NA
233	1.0041E-03	NA
249	9.9029E-04	NA
253	9.8717E-04	NA
098	9.8645E-04	NA
145	9.8261E-04	NA
318	9.8047E-04	NA
234	9.7993E-04	NA
397	9.7761E-04	NA
312	9.7733E-04	NA
316	9.7571E-04	NA
156	9.6888E-04	NA
150	9.5961E-04	NA
333	9.5882E-04	NA
232	9.5349E-04	NA
230	9.5277E-04	NA
238	9.5137E-04	NA

TABLE C.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
276	9.4259E-04	NA
250	9.4227E-04	NA
208	9.4181E-04	NA
241	9.4053E-04	NA
205	9.3384E-04	NA
280	9.3203E-04	NA
231	9.2542E-04	NA
371	9.1600E-04	NA
358	9.0529E-04	NA
243	8.9914E-04	NA
372	8.9694E-04	NA
214	8.9456E-04	NA
224	8.9419E-04	NA
191	8.9343E-04	NA
317	8.9071E-04	NA
200	8.8815E-04	NA
292	8.8398E-04	NA
302	8.8371E-04	NA
370	8.7876E-04	NA
297	8.7506E-04	NA
247	8.7505E-04	NA
155	8.7267E-04	NA
235	8.6829E-04	NA
254	8.6551E-04	NA
190	8.6328E-04	NA
287	8.6297E-04	NA
192	8.5924E-04	NA
194	8.5792E-04	NA
195	8.5701E-04	NA
263	8.5486E-04	NA
196	8.4997E-04	NA
189	8.4728E-04	NA
330	8.4659E-04	NA
418	8.4638E-04	NA
416	8.4621E-04	NA
403	8.4536E-04	NA
266	8.3779E-04	NA
239	8.3666E-04	NA
400	8.3195E-04	NA
154	8.3030E-04	NA
212	8.2093E-04	NA
251	8.1763E-04	NA
374	8.1690E-04	NA
291	8.1357E-04	NA
271	8.1337E-04	NA

TABLE C.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
419	8.0970E-04	NA
373	8.0857E-04	NA
221	8.0809E-04	NA
417	8.0777E-04	NA
204	8.0173E-04	NA
198	8.0015E-04	NA
322	7.9976E-04	NA
345	7.9829E-04	NA
366	7.9451E-04	NA
279	7.9308E-04	NA
293	7.9126E-04	NA
286	7.8577E-04	NA
300	7.8443E-04	NA
398	7.8217E-04	NA
259	7.7560E-04	NA
285	7.7415E-04	NA
349	7.7274E-04	NA
364	7.6950E-04	NA
313	7.6494E-04	NA
203	7.6286E-04	NA
264	7.6269E-04	NA
299	7.6079E-04	NA
290	7.6066E-04	NA
352	7.5466E-04	NA
353	7.5345E-04	NA
207	7.5345E-04	NA
392	7.5160E-04	NA
391	7.4986E-04	NA
311	7.4632E-04	NA
199	7.4590E-04	NA
282	7.4538E-04	NA
265	7.4350E-04	NA
209	7.4330E-04	NA
420	7.4217E-04	NA
331	7.4171E-04	NA
409	7.4064E-04	NA
414	7.3804E-04	NA
301	7.3727E-04	NA
294	7.3461E-04	NA
344	7.3419E-04	NA
288	7.3308E-04	NA
258	7.3070E-04	NA
269	7.3043E-04	NA
DA6	7.2811E-04	NA
382	7.2654E-04	NA

TABLE C.4 (Cont.)

Confirmation Unit	Adult Resident *	Adult Visitor
270	7.2620E-04	NA
395	7.2466E-04	NA
356	7.2295E-04	NA
402	7.2135E-04	NA
314	7.1984E-04	NA
354	7.1936E-04	NA
404	7.1655E-04	NA
355	7.1591E-04	NA
202	7.1493E-04	NA
413	7.1054E-04	NA
342	7.0748E-04	NA
343	7.0605E-04	NA
348	7.0386E-04	NA
396	7.0355E-04	NA
376	6.9963E-04	NA
408	6.9711E-04	NA
350	6.9513E-04	NA
201	6.9414E-04	NA
213	6.9412E-04	NA
320	6.9392E-04	NA
338	6.9268E-04	NA
405	6.9195E-04	NA
315	6.9066E-04	NA
257	6.8861E-04	NA
339	6.8837E-04	NA
267	6.8670E-04	NA
407	6.8620E-04	NA
360	6.8443E-04	NA
244	6.8262E-04	NA
226	6.8015E-04	NA
284	6.7819E-04	NA
362	6.7475E-04	NA
260	6.7427E-04	NA
283	6.7061E-04	NA
406	6.6882E-04	NA
369	6.6870E-04	NA
296	6.6761E-04	NA
268	6.6722E-04	NA
197	6.6375E-04	NA
346	6.6201E-04	NA
401	6.5349E-04	NA
298	6.4794E-04	NA
295	6.4588E-04	NA
341	6.4317E-04	NA
245	6.3942E-04	NA

TABLE C.4 (Cont.)

Confirmation Unit	Adult Resident [a]	Adult Visitor
393	6.3094E-04	NA
225	6.2800E-04	NA
351	6.2704E-04	NA
377	6.1890E-04	NA
361	6.1042E-04	NA
410	6.0798E-04	NA
359	6.0793E-04	NA
256	6.0539E-04	NA
340	6.0394E-04	NA
394	6.0134E-04	NA
222	5.9531E-04	NA
357	5.6915E-04	NA
252	5.5935E-04	NA
255	5.5878E-04	NA
262	5.3341E-04	NA
363	4.9825E-04	NA
261	4.9102E-04	NA
347	2.4218E-04	NA

[a] NA = not applicable.

APPENDIX D:

RISK ESTIMATES CONSIDERING BACKGROUND CONCENTRATIONS OF THE NATURALLY OCCURRING CONTAMINANTS OF CONCERN FOR THE CHEMICAL PLANT OPERABLE UNIT

APPENDIX D:

RISK ESTIMATES CONSIDERING BACKGROUND CONCENTRATIONS OF THE NATURALLY OCCURRING CONTAMINANTS OF CONCERN FOR THE CHEMICAL PLANT OPERABLE UNIT

Calculations were also performed to estimate radiological risk, chemical risk, and hazard indices from background concentrations of the naturally occurring contaminants of concern. Background concentrations determined for the Weldon Spring site soil are presented in Table D.1. Risk estimates were derived for the hypothetical resident and recreational visitor scenarios using the same methodology as that presented in Sections 4 and 5 of this report. Tables D.2 and D.3 present the results of the risk calculations performed. Tables D.4 through D.7 present residual radiological risks, chemical risks, hazard indices, and radon risks, respectively, for the two scenarios evaluated. The estimates presented in the latter four tables represent the estimates for the individual confirmation units after background estimates were subtracted.

This appendix also includes four figures to delineate those confirmation units (CUs) that contain residual risks or a hazard index for a resident scenario above a certain selected level. The selected levels were chosen for discussion purposes only for this report. Figure D.1 shows the CUs that contain greater than 10^{-4} radiological risk after background is subtracted; 16 of which are outside the cell exclusion zone. Figure D.2 presents the CUs that contain greater than 10^{-6} chemical risk after background is subtracted; 42 of the CUs shown are outside the cell exclusion zone. Figure D.3 presents the CUs that contain a hazard index greater than 0.1 after background is subtracted; 6 of these CUs are outside the cell exclusion zone. Figure D.4 presents those CUs that contain a radon risk greater than 10^{-4} after background is subtracted; 29 of these CUs are outside of the cell exclusion zone.

TABLE D.1 Background Concentrations of the Chemical Plant Operable Unit Contaminants of Concern

Contaminant of Concern	Background Concentrations[a]
Radionuclides (pCi/g)	
Radium-226	1.2
Radium-223	1.2
Thorium-230	1.2
Uranium-238	1.2
Metals (mg/kg)	
Arsenic	26
Chromium	36
Lead	34
Thallium	16

[a] Source: DOE (1993). Organic contaminants of concern (i.e., polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and trinitrotoulene) are not considered to be naturally occurring, and, therefore, background concentrations were assumed to be zero.

TABLE D.2 Intake Estimates for the Background Concentrations of the Contaminants of Concern for the Chemical Plant Operable Unit[a]

	Carcinogenic					
	Resident			Visitor		
	External	Ingestion	Inhalation	External	Ingestion	Inhalation
Radium-226	2.460×10^{1}	1.512×10^{3}	4.642×10^{-2}	3.288×10^{1}	8.640×10^{1}	9.953×10^{-4}
Radium-228	2.460×10^{1}	1.512×10^{3}	4.642×10^{-2}	3.288×10^{1}	8.640×10^{1}	9.953×10^{-4}
Thorium-230	2.460×10^{1}	1.512×10^{3}	4.642×10^{-2}	3.288×10^{1}	8.640×10^{1}	9.953×10^{-4}
Uranium-238	2.460×10^{1}	1.512×10^{3}	4.642×10^{-2}	3.288×10^{1}	8.640×10^{1}	9.953×10^{-4}
Arsenic	NA[b]	4.071×10^{-5}	5.623×10^{-10}	NA	2.326×10^{-6}	1.206×10^{-11}
Chromium	NA	-[c]	7.786×10^{-10}	NA	-	1.669×10^{-11}
Thallium	NA	-	-	NA	-	-
Uranium	NA	-	-	NA	-	-

	Noncarcinogenic			
	Resident		Visitor	
	Ingestion	Inhalation	Ingestion	Inhalation
Arsenic	9.498×10^{-3}	-	5.427×10^{-6}	-
Chromium	1.315×10^{-4}	1.817×10^{-9}	7.515×10^{-6}	3.895×10^{-11}
Thallium	5.848×10^{-5}	-	3.340×10^{-6}	-
Uranium	1.315×10^{-5}	-	7.515×10^{-7}	-

[a] Only naturally occurring contaminants of concern are shown in the table. Background concentrations for organic contaminants of concern are assumed to be zero.

[b] NA indicates that the given pathway is not applicable.

[c] A hyphen indicates that the contaminant is not considered carcinogenic or toxic via the particular pathway.

TABLE D.3 Risk and Hazard Index Estimates for the Background Concentrations of the Contaminants of Concern for the Chemical Plant Operable Unit[a]

	Carcinogenic Risk					
	Resident			Visitor		
	External	Ingestion	Inhalation	External	Ingestion	Inhalation
Radium-226	2.1×10^{-4}	5.1×10^{-6}	1.2×10^{-9}	2.8×10^{-6}	2.9×10^{-7}	2.5×10^{-11}
Radium-228	3.0×10^{-4}	5.0×10^{-6}	8.9×10^{-9}	4.0×10^{-6}	2.9×10^{-7}	1.9×10^{-10}
Thorium-230	2.0×10^{-8}	3.1×10^{-7}	1.3×10^{-9}	2.7×10^{-10}	1.7×10^{-8}	2.8×10^{-11}
Uranium-238	3.4×10^{-6}	5.7×10^{-7}	9.8×10^{-10}	4.6×10^{-8}	3.2×10^{-8}	2.1×10^{-11}
Rad Total		5.3×10^{-4}			7.5×10^{-6}	
Arsenic	NA[b]	6.1×10^{-5}	8.4×10^{-9}	NA	3.5×10^{-6}	1.8×10^{-10}
Chromium	NA	-[c]	3.2×10^{-8}	NA	-	7.0×10^{-10}
Thallium	NA	-	-	NA	-	
Uranium	NA	-	-	NA	-	
Chem Total		6.1×10^{-5}			3.5×10^{-6}	
Total Risk		4.6×10^{-4}			5.9×10^{-6}	

	Hazard Index			
	Resident		Visitor	
	Ingestion	Inhalation	Ingestion	Inhalation
Arsenic	.3	-	.02	-
Chromium	.0001	.0006	<.0001	<.0001
Thallium	.7	-	.04	-
Uranium	.004	-	.0003	-
Hazard Index	1.1	.06		

[a] Only naturally occurring contaminants of concern are shown in the table. Background concentrations for organic contaminants of concern are assumed to be zero.

[b] NA indicates that the given pathway is not applicable.

[c] A hyphen indicates that the contaminant is not considered carcinogenic or toxic via the particular pathway.

TABLE D.4 Radiological Risk Ordered by Descending Risk (after subtracting background)

Confirmation Unit	Adult Resident	Adult Visitor
046	1.5776E-03	2.2330E-05
067	5.1365E-04	7.4364E-06
411	4.6587E-04	6.7706E-06
329	3.6843E-04	5.3543E-06
014	2.7616E-04	4.3534E-06
168	2.6443E-04	3.8359E-06
080	2.4269E-04	3.5675E-06
096	2.3492E-04	3.3686E-06
390	2.3403E-04	4.5960E-06
102	2.2607E-04	3.2331E-06
412	2.2482E-04	3.3435E-06
144	2.2472E-04	3.2664E-06
310	2.1233E-04	3.1571E-06
281	2.1008E-04	3.0433E-06
365	2.0836E-04	3.2671E-06
015	1.9952E-04	3.4446E-06
167	1.8848E-04	2.6960E-06
111	1.8711E-04	2.7364E-06
090	1.8497E-04	2.7113E-06
165	1.8494E-04	2.6660E-06
058	1.8062E-04	2.8723E-06
013	1.8038E-04	2.9300E-06
038	1.7829E-04	2.6264E-06
108	1.7796E-04	2.5713E-06
069	1.7713E-04	2.7289E-06
380	1.7188E-04	2.5945E-06
297	1.7166E-04	2.4788E-06
169	1.6887E-04	2.4302E-06
160	1.6770E-04	2.4142E-06
275	1.6743E-04	2.7095E-06
309	1.6698E-04	2.6046E-06
92	1.6645E-04	2.4396E-06
032	1.4839E-04	2.4838E-06
095	1.4785E-04	2.1443E-06
089	1.4726E-04	2.1550E-06
065	1.4534E-04	2.4184E-06
143	1.4430E-04	2.0897E-06
084	1.4414E-04	2.1107E-06
208	1.4172E-04	2.0500E-06
017	1.4026E-04	2.1791E-06
086	1.3953E-04	2.1429E-06
028	1.3902E-04	2.0242E-06

TABLE D.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
036	1.3811E-04	2.0436E-06
050	1.3650E-04	1.9909E-06
034	1.3448E-04	1.9477E-06
162	1.3106E-04	2.0814E-06
062	1.2951E-04	1.9735E-06
060	1.2846E-04	1.8602E-06
332	1.2815E-04	1.8807E-06
304	1.2620E-04	1.8750E-06
044	1.2144E-04	1.7998E-06
041	1.2134E-04	1.8165E-06
059	1.2015E-04	1.8926E-06
031	1.1985E-04	1.7657E-06
051	1.1975E-04	1.8348E-06
073	1.1800E-04	1.8340E-06
120	1.1576E-04	1.6655E-06
021	1.1466E-04	1.9537E-06
027	1.1372E-04	1.7991E-06
029	1.1323E-04	1.6828E-06
103	1.1275E-04	1.6553E-06
030	1.1188E-04	1.6788E-06
052	1.1159E-04	1.6513E-06
378	1.1101E-04	1.6007E-06
161	1.1090E-04	1.6194E-06
129	1.0973E-04	1.5849E-06
016	1.0703E-04	1.7133E-06
110	1.0635E-04	1.6033E-06
057	1.0626E-04	1.5683E-06
130	1.0555E-04	1.5213E-06
047	1.0420E-04	1.5390E-06
142	1.0376E-04	1.5347E-06
040	1.0280E-04	1.5134E-06
098	1.0263E-04	1.5028E-06
006	1.0227E-04	1.4805E-06
109	1.0089E-04	1.5094E-06
399	9.9900E-05	1.4551E-06
104	9.6833E-05	1.4205E-06
063	9.6240E-05	1.5128E-06
033	9.5117E-05	1.3843E-06
148	9.4849E-05	1.3796E-06
054	9.4414E-05	1.4097E-06
379	9.4177E-05	1.3836E-06
366	9.2757E-05	1.4950E-06
026	9.2132E-05	1.3339E-06
070	9.1847E-05	1.3755E-06
061	9.0936E-05	1.3626E-06
135	9.0209E-05	1.3043E-06
124	9.0118E-05	1.3238E-06

TABLE D.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
039	8.9970E-05	1.3977E-06
071	8.9286E-05	1.3223E-06
012	8.8405E-05	1.3970E-06
042	8.7811E-05	1.2692E-06
035	8.7662E-05	1.2919E-06
056	8.5020E-05	1.2737E-06
381	8.4372E-05	1.2616E-06
140	8.3919E-05	1.6442E-06
156	8.3666E-05	1.2133E-06
153	8.3567E-05	1.2275E-06
176	8.3374E-05	1.2095E-06
174	8.2846E-05	1.1973E-06
099	8.2429E-05	1.1983E-06
134	8.1817E-05	1.1812E-06
334	8.1432E-05	1.2866E-06
307	8.1101E-05	1.2346E-06
146	8.0472E-05	1.1711E-06
020	7.9677E-05	1.1850E-06
170	7.9002E-05	1.1406E-06
025	7.7506E-05	1.1295E-06
023	7.7180E-05	1.1503E-06
125	7.7017E-05	1.1150E-06
005	7.6079E-05	1.0967E-06
121	7.5868E-05	1.0852E-06
075	7.5664E-05	1.1296E-06
367	7.5430E-05	1.1614E-06
037	7.3567E-05	1.1385E-06
064	7.3022E-05	1.0865E-06
074	7.2822E-05	1.2984E-06
175	7.2711E-05	1.0608E-06
185	7.2634E-05	1.0570E-06
301	7.2513E-05	1.4265E-06
133	7.1802E-05	1.0438E-06
022	7.0227E-05	1.0618E-06
043	7.0043E-05	1.0825E-06
068	6.9909E-05	1.0724E-06
066	6.8852E-05	1.0350E-06
187	6.7801E-05	9.8693E-07
081	6.6044E-05	1.1185E-06
173	6.5230E-05	9.3564E-07
389	6.5085E-05	1.0314E-06
137	6.5082E-05	9.4367E-07
DA6	6.4620E-05	1.2763E-06
131	6.4023E-05	9.4028E-07
115	6.3231E-05	9.3229E-07
101	6.3107E-05	9.4089E-07
163	6.2926E-05	9.4465E-07

TABLE D.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
072	6.2625E-05	9.3698E-07
077	6.2433E-05	9.5957E-07
123	6.1912E-05	9.0348E-07
010	6.1826E-05	9.0788E-07
009	6.1732E-05	9.0728E-07
127	6.0600E-05	8.8045E-07
171	6.0421E-05	8.7399E-07
154	6.0402E-05	8.6803E-07
011	5.9931E-05	9.8343E-07
138	5.7176E-05	8.3631E-07
324	5.7116E-05	8.9518E-07
145	5.6376E-05	9.2169E-07
186	5.6264E-05	8.1741E-07
257	5.5868E-05	9.2641E-07
136	5.5789E-05	8.1942E-07
112	5.5421E-05	8.0369E-07
274	5.5386E-05	8.4672E-07
302	5.5105E-05	1.0866E-06
312	5.3530E-05	1.0531E-06
126	5.3431E-05	7.7587E-07
228	5.2921E-05	7.7215E-07
018	5.2383E-05	8.1113E-07
306	5.1940E-05	7.8662E-07
076	5.1603E-05	7.5953E-07
177	5.1065E-05	7.3417E-07
024	5.0940E-05	7.4915E-07
273	4.9327E-05	7.4799E-07
149	4.8618E-05	7.1415E-07
182	4.8525E-05	7.0465E-07
122	4.8513E-05	7.0194E-07
007	4.7849E-05	6.8974E-07
151	4.6268E-05	6.7163E-07
178	4.6234E-05	6.6183E-07
308	4.5228E-05	7.4787E-07
335	4.4745E-05	8.0642E-07
180	4.4561E-05	6.7726E-07
320	4.3547E-05	8.5628E-07
321	4.3438E-05	7.6278E-07
305	4.3161E-05	6.5459E-07
188	4.2875E-05	6.3136E-07
179	4.2297E-05	6.1513E-07
184	4.2227E-05	6.2233E-07
147	4.1110E-05	6.0217E-07
313	3.7662E-05	7.4264E-07
172	3.7633E-05	5.5076E-07
008	3.7422E-05	5.3944E-07
325	3.6588E-05	6.2369E-07

TABLE D.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
336	3.6587E-05	6.3937E-07
311	3.5649E-05	7.0881E-07
139	3.4773E-05	6.8131E-07
368	3.4622E-05	5.3280E-07
388	3.4551E-05	5.6959E-07
272	3.3907E-05	5.3645E-07
055	3.3897E-05	6.7904E-07
387	3.2437E-05	5.4142E-07
166	3.2219E-05	6.3132E-07
216	3.2195E-05	4.9026E-07
183	3.1975E-05	4.6989E-07
091	3.1708E-05	6.2125E-07
128	3.1654E-05	4.5841E-07
159	3.1007E-05	4.5315E-07
132	3.0412E-05	4.5156E-07
150	2.9825E-05	4.3810E-07
193	2.9127E-05	4.3065E-07
L36	2.7860E-05	5.4585E-07
330	2.7641E-05	5.5168E-07
376	2.7102E-05	3.9439E-07
085	2.5908E-05	4.1526E-07
322	2.5581E-05	5.1470E-07
293	2.2909E-05	4.5871E-07
289	2.2332E-05	3.3092E-07
211	2.2125E-05	3.4353E-07
260	2.1630E-05	4.2890E-07
285	2.0826E-05	4.2922E-07
L35	2.0272E-05	3.9719E-07
323	1.9821E-05	3.9782E-07
220	1.8854E-05	3.2776E-07
141	1.8070E-05	2.7621E-07
282	1.8011E-05	3.5898E-07
217	1.7946E-05	2.8716E-07
326	1.7557E-05	3.5442E-07
002	1.7556E-05	3.4397E-07
L34	1.6959E-05	3.3228E-07
328	1.6904E-05	3.4853E-07
152	1.6320E-05	2.5148E-07
256	1.6276E-05	3.1889E-07
155	1.5740E-05	2.3138E-07
218	1.5595E-05	2.3427E-07
181	1.4452E-05	2.2135E-07
303	1.3678E-05	2.7849E-07
001	1.3303E-05	2.6064E-07
094	1.3079E-05	2.5625E-07
377	1.2964E-05	1.8595E-07
100	1.2572E-05	2.4633E-07

TABLE D4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
045	1.2477E-05	2.4445E-07
333	1.2189E-05	2.4557E-07
292	1.2087E-05	2.4298E-07
319	1.1935E-05	2.3839E-07
210	1.1819E-05	1.8879E-07
276	1.1062E-05	2.1886E-07
255	1.0024E-05	1.9692E-07
396	1.0013E-05	1.6558E-07
286	9.9458E-06	2.0943E-07
261	9.9358E-06	1.9467E-07
283	9.8545E-06	2.0037E-07
317	9.6240E-06	1.9649E-07
262	9.4909E-06	1.8818E-07
280	9.1023E-06	1.9300E-07
416	9.0958E-06	1.4792E-07
287	9.0774E-06	1.8388E-07
232	8.4927E-06	1.8036E-07
331	8.2994E-06	1.6509E-07
236	8.1815E-06	1.6289E-07
083	8.1651E-06	1.6896E-07
318	7.9098E-06	1.6468E-07
164	7.6537E-06	1.4996E-07
048	7.4055E-06	1.4509E-07
420	6.8691E-06	1.3725E-07
298	6.3088E-06	1.2609E-07
364	6.2697E-06	1.2732E-07
107	6.0689E-06	1.1891E-07
213	5.9788E-06	1.2460E-07
004	5.9520E-06	1.1662E-07
116	5.9490E-06	1.1656E-07
049	5.8153E-06	1.1394E-07
003	5.7141E-06	1.1196E-07
291	5.6360E-06	1.1695E-07
418	5.6249E-06	9.5784E-08
088	5.5611E-06	1.0896E-07
113	5.4577E-06	1.0693E-07
087	5.2739E-06	1.0333E-07
219	5.2503E-06	1.0389E-07
337	5.2474E-06	1.0888E-07
191	5.2288E-06	1.0451E-07
375	5.1594E-06	1.1526E-07
093	5.1541E-06	1.0098E-07
097	4.9425E-06	9.6837E-08
119	4.9184E-06	9.6365E-08
082	4.8400E-06	9.4829E-08
158	4.7415E-06	9.2899E-08
105	4.6482E-06	9.1072E-08

TABLE D.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
114	4.5798E-06	8.9732E-08
314	4.5070E-06	9.0505E-08
327	4.4786E-06	9.9746E-08
237	4.3864E-06	8.1403E-08
252	4.3037E-06	8.4322E-08
118	4.1341E-06	8.0998E-08
190	4.0020E-06	8.3705E-08
117	3.9451E-06	7.7295E-08
360	3.8496E-06	8.1708E-08
338	3.8159E-06	7.6012E-08
196	3.6168E-06	8.1874E-08
357	3.5679E-06	7.6555E-08
340	3.5140E-06	7.2183E-08
106	3.2832E-06	6.4326E-08
265	3.2031E-06	6.8814E-08
361	3.1948E-06	7.4680E-08
359	3.1607E-06	7.2441E-08
242	3.1347E-06	8.3054E-08
419	3.0109E-06	6.1843E-08
417	2.9433E-06	6.4773E-08
358	2.8751E-06	6.2588E-08
343	2.8252E-06	6.2823E-08
222	2.8209E-06	5.6790E-08
264	2.8154E-06	5.6701E-08
290	2.7587E-06	6.0679E-08
192	2.6920E-06	5.5677E-08
315	2.5455E-06	5.2709E-08
221	2.5307E-06	5.2377E-08
239	2.4842E-06	5.9195E-08
229	2.4191E-06	5.0259E-08
233	2.3694E-06	5.6335E-08
157	2.3460E-06	4.5965E-08
296	2.3079E-06	5.1503E-08
294	2.2573E-06	4.8184E-08
362	2.1157E-06	4.2179E-08
019	2.0453E-06	4.0072E-08
230	2.0402E-06	4.7534E-08
339	2.0034E-06	4.1756E-08
288	1.9813E-06	4.4926E-08
246	1.9697E-06	5.0961E-08
269	1.9594E-06	4.5953E-08
231	1.9410E-06	4.3271E-08
316	1.9219E-06	4.1109E-08
300	1.9108E-06	4.0143E-08
279	1.8633E-06	4.5635E-08
278	1.7728E-06	3.4734E-08
344	1.7172E-06	4.2738E-08

TABLE D.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
223	1.7141E-06	3.5992E-08
346	1.7007E-06	3.3321E-08
299	1.6844E-06	3.3427E-08
201	1.6482E-06	4.2123E-08
414	1.6072E-06	3.1902E-08
371	1.5625E-06	3.6242E-08
373	1.4625E-06	3.9965E-08
241	1.4376E-06	5.4903E-08
194	1.4319E-06	3.3993E-08
212	1.4281E-06	3.6267E-08
240	1.3866E-06	3.9953E-08
258	1.3619E-06	3.3032E-08
370	1.3535E-06	3.1174E-08
254	1.3456E-06	2.6364E-08
195	1.3146E-06	3.1308E-08
251	1.3015E-06	3.2312E-08
199	1.2956E-06	3.3955E-08
271	1.2485E-06	3.4292E-08
253	1.1561E-06	2.5522E-08
235	1.1335E-06	2.9837E-08
227	1.1229E-06	2.8992E-08
200	1.0726E-06	3.5990E-08
263	1.0312E-06	2.0205E-08
270	1.0283E-06	3.3988E-08
202	1.0272E-06	3.2788E-08
393	1.0255E-06	2.5654E-08
409	1.0133E-06	3.1202E-08
203	1.0105E-06	3.7436E-08
247	9.9959E-07	2.2971E-08
250	9.8059E-07	2.7979E-08
234	9.6518E-07	3.8025E-08
363	9.5188E-07	2.4407E-08
372	9.3724E-07	2.4994E-08
277	9.2731E-07	1.8169E-08
243	9.2667E-07	2.5439E-08
403	9.0462E-07	2.2585E-08
238	8.8009E-07	2.9706E-08
204	8.6800E-07	2.6532E-08
198	8.5292E-07	2.9195E-08
374	8.4449E-07	2.8664E-08
249	8.3783E-07	2.2231E-08
225	8.2251E-07	2.4001E-08
353	7.9812E-07	1.6516E-08
345	7.9459E-07	4.3147E-08
391	7.9139E-07	2.7180E-08
268	7.5568E-07	1.7140E-08
413	7.5416E-07	4.0952E-08

TABLE D.4 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
392	7.5174E-07	1.7106E-08
259	7.1728E-07	1.9740E-08
248	6.9558E-07	1.5820E-08
266	6.4743E-07	1.8500E-08
189	6.2879E-07	2.0034E-08
384	6.1446E-07	1.2039E-08
215	5.7777E-07	1.3857E-08
244	5.3739E-07	2.0414E-08
224	4.9794E-07	1.5150E-08
397	4.3120E-07	1.1777E-08
245	4.2202E-07	1.4983E-08
197	4.0666E-07	7.9677E-09
406	4.0451E-07	7.9255E-09
400	3.1895E-07	8.5766E-09
342	3.0809E-07	1.6730E-08
226	2.9613E-07	1.2533E-08
205	2.9275E-07	8.4520E-09
284	2.1472E-07	5.8820E-09
394	1.9810E-07	3.8814E-09
408	1.9551E-07	1.0616E-08
69	1.6884E-07	8.7995E-09
267	1.5675E-07	5.5343E-09
405	1.4943E-07	2.9278E-09
295	8.8868E-08	2.7036E-09
209	8.8554E-08	1.7350E-09
410	7.7525E-08	4.2096E-09
214	5.5706E-08	1.2500E-09
355	5.4198E-08	2.9430E-09
349	5.3301E-08	2.8943E-09
395	2.9560E-08	1.6051E-09
341	2.1331E-08	1.1583E-09
398	1.4540E-08	7.8953E-10
354	1.0738E-08	5.8307E-10
404	5.4830E-09	2.9773E-10
407	2.4054E-09	1.3062E-10
402	0.0000E+00	0.0000E+00
401	0.0000E+00	0.0000E+00
382	0.0000E+00	0.0000E+00
356	0.0000E+00	0.0000E+00
351	0.0000E+00	0.0000E+00
350	0.0000E+00	0.0000E+00
348	0.0000E+00	0.0000E+00
347	0.0000E+00	0.0000E+00
207	0.0000E+00	0.0000E+00
206	0.0000E+00	0.0000E+00
352	0.0000E+00	0.0000E+00

TABLE D.5 Chemical Risk Ordered by Descending Risk (after subtracting background)

Confirmation Unit	Adult Resident	Adult Visitor
399	5.1007E-05	2.9147E-06
164	4.9540E-05	2.8309E-06
365	2.8878E-05	1.6501E-06
002	2.6857E-05	1.5347E-06
038	2.5237E-05	1.4421E-06
080	1.9888E-05	1.1364E-06
022	1.8438E-05	1.0536E-06
290	1.5795E-05	9.0259E-07
001	1.5607E-05	8.9183E-07
267	1.3714E-05	7.8367E-07
281	1.2778E-05	7.3017E-07
039	1.2563E-05	7.1787E-07
021	1.1505E-05	6.5744E-07
058	1.1202E-05	6.4014E-07
274	1.1027E-05	6.3011E-07
334	1.0628E-05	6.0733E-07
275	9.6557E-06	5.5175E-07
060	9.6311E-06	5.5035E-07
059	8.2948E-06	4.7399E-07
133	7.9186E-06	4.5249E-07
299	7.5603E-06	4.3194E-07
066	6.7286E-06	3.8449E-07
297	6.6124E-06	3.7785E-07
137	6.6075E-06	3.7757E-07
086	6.2559E-06	3.5748E-07
391	6.0903E-06	3.4802E-07
332	6.0780E-06	3.4732E-07
132	5.8970E-06	3.3697E-07
044	5.8004E-06	3.3145E-07
291	5.7667E-06	3.2953E-07
287	5.3425E-06	3.0528E-07
355	5.2297E-06	2.9884E-07
135	5.1179E-06	2.9245E-07
296	5.0850E-06	2.9057E-07
131	5.0645E-06	2.8940E-07
303	5.0024E-06	2.8585E-07
254	4.9229E-06	2.8131E-07
328	4.8347E-06	2.7627E-07
263	4.7160E-06	2.6948E-07
136	4.6849E-06	2.6771E-07
268	4.6841E-06	2.6766E-07
298	4.4431E-06	2.5389E-07
138	4.2865E-06	2.4494E-07
280	4.2543E-06	2.4310E-07

TABLE D.5 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
040	4.1761E-06	2.3864E-07
292	4.1633E-06	2.3790E-07
380	4.0936E-06	2.3392E-07
366	4.0404E-06	2.3088E-07
286	3.9814E-06	2.2751E-07
266	3.8920E-06	2.2240E-07
295	3.7028E-06	2.1159E-07
329	3.5935E-06	2.0534E-07
236	3.5160E-06	2.0091E-07
381	3.4121E-06	1.9497E-07
070	3.3714E-06	1.9265E-07
320	3.3577E-06	1.9187E-07
168	3.2000E-06	1.8286E-07
129	3.1275E-06	1.7872E-07
367	3.1082E-06	1.7761E-07
323	3.0844E-06	1.7625E-07
171	2.9894E-06	1.7082E-07
069	2.9571E-06	1.6898E-07
055	2.9523E-06	1.6870E-07
325	2.9088E-06	1.6622E-07
283	2.8215E-06	1.6123E-07
109	2.7642E-06	1.5795E-07
317	2.7150E-06	1.5514E-07
065	2.5476E-06	1.4558E-07
130	2.5165E-06	1.4380E-07
285	2.4688E-06	1.4108E-07
353	2.4686E-06	1.4106E-07
111	2.4623E-06	1.4071E-07
134	2.4029E-06	1.3731E-07
319	2.3873E-06	1.3642E-07
110	2.2959E-06	1.3120E-07
265	2.2865E-06	1.3066E-07
354	2.2802E-06	1.3030E-07
324	2.1351E-06	1.2201E-07
054	2.0642E-06	1.1795E-07
128	2.0608E-06	1.1776E-07
318	2.0306E-06	1.1603E-07
123	1.9494E-06	1.1140E-07
124	1.9156E-06	1.0946E-07
336	1.8718E-06	1.0696E-07
333	1.7639E-06	1.0079E-07
337	1.7537E-06	1.0021E-07
370	1.7489E-06	9.9939E-08
304	1.5984E-06	9.1339E-08
106	1.4377E-06	8.2155E-08
260	1.4173E-06	8.0989E-08
301	1.3943E-06	7.9673E-08

TABLE D.5 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
335	1.3175E-06	7.5288E-08
DA6	1.3013E-06	7.4361E-08
357	1.1779E-06	6.7311E-08
307	1.1769E-06	6.7253E-08
314	1.1360E-06	6.4916E-08
308	1.1347E-06	6.4842E-08
282	1.0718E-06	6.1248E-08
037	1.0593E-06	6.0529E-08
103	1.0442E-06	5.9666E-08
041	1.0245E-06	5.8545E-08
315	1.0171E-06	5.8122E-08
253	9.7694E-07	5.5825E-08
338	9.6411E-07	5.5092E-08
293	9.2118E-07	5.2639E-08
330	8.4166E-07	4.8095E-08
300	8.3564E-07	4.7751E-08
347	8.2035E-07	4.6877E-08
313	7.9899E-07	4.5656E-08
327	7.9025E-07	4.5157E-08
101	7.4752E-07	4.2716E-08
064	7.0766E-07	4.0438E-08
309	6.9777E-07	3.9873E-08
358	6.9744E-07	3.9854E-08
227	6.9301E-07	3.9601E-08
063	6.8540E-07	3.9166E-08
371	6.6767E-07	3.8153E-08
047	6.6310E-07	3.7891E-08
302	6.5311E-07	3.7321E-08
331	5.9976E-07	3.4272E-08
389	5.7063E-07	3.2607E-08
305	5.4712E-07	3.1264E-08
125	5.4325E-07	3.1043E-08
062	5.2093E-07	2.9767E-08
098	4.9855E-07	2.8489E-08
096	4.9639E-07	2.8365E-08
127	4.6430E-07	2.6531E-08
073	4.6329E-07	2.6474E-08
312	4.6200E-07	2.6400E-08
104	4.4388E-07	2.5365E-08
208	4.3780E-07	2.5017E-08
043	4.0483E-07	2.3133E-08
033	3.9733E-07	2.2705E-08
273	3.9220E-07	2.2412E-08
372	3.8563E-07	2.2036E-08
311	3.8044E-07	2.1740E-08
310	3.7081E-07	2.1189E-08
102	3.5257E-07	2.0147E-08

TABLE D.5 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
181	3.4992E-07	1.9995E-08
205	3.4967E-07	1.9981E-08
251	3.4286E-07	1.9592E-08
326	3.2715E-07	1.8694E-08
052	3.2000E-07	1.8286E-08
097	3.1521E-07	1.8012E-08
162	3.0987E-07	1.7707E-08
034	3.0871E-07	1.7641E-08
213	3.0016E-07	1.7152E-08
072	2.9319E-07	1.6754E-08
294	2.9274E-07	1.6728E-08
379	2.4423E-07	1.3956E-08
321	2.4357E-07	1.3918E-08
197	2.3525E-07	1.3443E-08
212	2.3138E-07	1.3222E-08
126	2.2068E-07	1.2610E-08
163	2.0818E-07	1.1896E-08
364	2.0444E-07	1.1682E-08
099	1.7609E-07	1.0063E-08
392	1.6510E-07	9.4344E-09
233	1.6438E-07	9.3933E-09
252	1.3544E-07	7.7397E-09
203	1.3454E-07	7.6882E-09
067	1.3442E-07	7.6809E-09
322	1.2649E-07	7.2281E-09
032	1.2313E-07	7.0362E-09
219	1.1818E-07	6.7531E-09
068	1.1775E-07	6.7288E-09
077	1.1065E-07	6.3228E-09
074	1.0566E-07	6.0377E-09
362	1.0395E-07	5.9400E-09
359	1.0270E-07	5.8684E-09
199	1.0226E-07	5.8436E-09
209	1.0037E-07	5.7354E-09
306	9.5469E-08	5.4554E-09
289	9.1192E-08	5.2110E-09
284	7.1553E-08	4.0888E-09
373	6.9395E-08	3.9654E-09
143	6.4369E-08	3.6782E-09
232	6.3027E-08	3.6016E-09
100	6.1057E-08	3.4890E-09
222	5.8039E-08	3.3165E-09
020	5.6224E-08	3.2128E-09
023	5.3534E-08	3.0591E-09
146	5.3146E-08	3.0369E-09
075	4.9415E-08	2.8237E-09
198	4.8914E-08	2.7951E-09

TABLE D.5 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
071	4.8756E-08	2.7861E-09
035	4.2301E-08	2.4172E-09
051	4.1790E-08	2.3880E-09
374	3.9888E-08	2.2793E-09
202	3.8024E-08	2.1728E-09
061	3.5888E-08	2.0508E-09
201	3.0219E-08	1.7268E-09
182	2.9921E-08	1.7098E-09
172	2.8815E-08	1.6466E-09
360	2.8554E-08	1.6316E-09
024	2.8048E-08	1.6027E-09
393	2.7808E-08	1.5890E-09
204	2.3807E-08	1.3604E-09
025	2.3264E-08	1.3294E-09
215	2.3209E-08	1.3262E-09
031	2.1687E-08	1.2392E-09
200	2.0564E-08	1.1751E-09
122	1.9567E-08	1.1181E-09
030	1.6996E-08	9.7118E-10
165	1.6464E-08	9.4082E-10
027	1.0551E-08	6.0290E-10
029	8.1026E-09	4.6301E-10
042	7.7197E-09	4.4113E-10
169	2.4383E-09	1.3933E-10
217	1.5561E-09	8.8920E-11
279	1.1092E-09	6.3385E-11
145	1.0802E-09	6.1728E-11
216	3.7069E-10	2.1183E-11
211	9.1862E-11	5.2493E-12
264	0.0000E+00	0.0000E+00
343	0.0000E+00	0.0000E+00
036	0.0000E+00	0.0000E+00
342	0.0000E+00	0.0000E+00
316	0.0000E+00	0.0000E+00
288	0.0000E+00	0.0000E+00
276	0.0000E+00	0.0000E+00
272	0.0000E+00	0.0000E+00
210	0.0000E+00	0.0000E+00
270	0.0000E+00	0.0000E+00
348	0.0000E+00	0.0000E+00
259	0.0000E+00	0.0000E+00
246	0.0000E+00	0.0000E+00
239	0.0000E+00	0.0000E+00
238	0.0000E+00	0.0000E+00
237	0.0000E+00	0.0000E+00
057	0.0000E+00	0.0000E+00
235	0.0000E+00	0.0000E+00

TABLE D.5 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
271	0.0000E+00	0.0000E+00
382	0.0000E+00	0.0000E+00
003	0.0000E+00	0.0000E+00
011	0.0000E+00	0.0000E+00
014	0.0000E+00	0.0000E+00
015	0.0000E+00	0.0000E+00
018	0.0000E+00	0.0000E+00
397	0.0000E+00	0.0000E+00
395	0.0000E+00	0.0000E+00
344	0.0000E+00	0.0000E+00
386	0.0000E+00	0.0000E+00
346	0.0000E+00	0.0000E+00
363	0.0000E+00	0.0000E+00
026	0.0000E+00	0.0000E+00
361	0.0000E+00	0.0000E+00
028	0.0000E+00	0.0000E+00
356	0.0000E+00	0.0000E+00
350	0.0000E+00	0.0000E+00
349	0.0000E+00	0.0000E+00
226	0.0000E+00	0.0000E+00
387	0.0000E+00	0.0000E+00
157	0.0000E+00	0.0000E+00
185	0.0000E+00	0.0000E+00
183	0.0000E+00	0.0000E+00
180	0.0000E+00	0.0000E+00
179	0.0000E+00	0.0000E+00
170	0.0000E+00	0.0000E+00
167	0.0000E+00	0.0000E+00
166	0.0000E+00	0.0000E+00
234	0.0000E+00	0.0000E+00
158	0.0000E+00	0.0000E+00
189	0.0000E+00	0.0000E+00
107	0.0000E+00	0.0000E+00
108	0.0000E+00	0.0000E+00
153	0.0000E+00	0.0000E+00
152	0.0000E+00	0.0000E+00
147	0.0000E+00	0.0000E+00
112	0.0000E+00	0.0000E+00
116	0.0000E+00	0.0000E+00
117	0.0000E+00	0.0000E+00
159	0.0000E+00	0.0000E+00
195	0.0000E+00	0.0000E+00
121	0.0000E+00	0.0000E+00
225	0.0000E+00	0.0000E+00
224	0.0000E+00	0.0000E+00
223	0.0000E+00	0.0000E+00
221	0.0000E+00	0.0000E+00

TABLE D.5 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
218	0.0000E+00	0.0000E+00
214	0.0000E+00	0.0000E+00
207	0.0000E+00	0.0000E+00
092	0.0000E+00	0.0000E+00
196	0.0000E+00	0.0000E+00
090	0.0000E+00	0.0000E+00
194	0.0000E+00	0.0000E+00
193	0.0000E+00	0.0000E+00
192	0.0000E+00	0.0000E+00
076	0.0000E+00	0.0000E+00
191	0.0000E+00	0.0000E+00
190	0.0000E+00	0.0000E+00
085	0.0000E+00	0.0000E+00
228	0.0000E+00	0.0000E+00
206	0.0000E+00	0.0000E+00

TABLE D.6 Chemical Hazard Index Ordered by Descending Hazard (after subtracting background)

Confirmation Unit	Adult Resident	Adult Visitor
399	7.9369E+00	4.5354E-01
086	3.9629E-01	2.2645E-02
390	2.5657E-01	1.4661E-02
106	2.2725E-01	1.2986E-02
381	2.1141E-01	1.2081E-02
059	1.9074E-01	1.0899E-02
365	1.8423E-01	1.0528E-02
171	1.7648E-01	1.0084E-02
080	1.7338E-01	9.9071E-03
283	1.3057E-01	7.4614E-03
318	1.2518E-01	7.1531E-03
275	1.2280E-01	7.0174E-03
015	1.2208E-01	6.9760E-03
110	1.0973E-01	6.2701E-03
260	1.0626E-01	6.0720E-03
336	9.8928E-02	5.6530E-03
317	9.5201E-02	5.4400E-03
140	9.2122E-02	5.2641E-03
055	9.0705E-02	5.1832E-03
319	8.7983E-02	5.0276E-03
DA6	8.4739E-02	4.8422E-03
301	8.4651E-02	4.8372E-03
014	8.3767E-02	4.7867E-03
292	8.1046E-02	4.6312E-03
308	8.0915E-02	4.6237E-03
335	7.8148E-02	4.4656E-03
054	7.6702E-02	4.3830E-03
037	7.6342E-02	4.3624E-03
032	7.6065E-02	4.3466E-03
313	7.5302E-02	4.3030E-03
065	7.5079E-02	4.2902E-03
013	7.2976E-02	4.1701E-03
058	7.1697E-02	4.0970E-03
103	7.0741E-02	4.0423E-03
063	6.9260E-02	3.9577E-03
038	6.7837E-02	3.8764E-03
312	6.7074E-02	3.8328E-03
021	6.5913E-02	3.7665E-03
302	6.4988E-02	3.7136E-03
162	6.0295E-02	3.4454E-03
074	6.0085E-02	3.4334E-03
073	5.8307E-02	3.3318E-03
062	5.7201E-02	3.2687E-03
285	5.6215E-02	3.2123E-03

TABLE D.6 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
101	5.6158E-02	3.2090E-03
307	5.4574E-02	3.1185E-03
236	5.4403E-02	3.1087E-03
133	5.4049E-02	3.0885E-03
334	5.1056E-02	2.9175E-03
320	4.9514E-02	2.8294E-03
039	4.9293E-02	2.8167E-03
299	4.8981E-02	2.7974E-03
314	4.8760E-02	2.7863E-03
280	4.8756E-02	2.7861E-03
347	4.7854E-02	2.7345E-03
309	4.6894E-02	2.6797E-03
047	4.6545E-02	2.6597E-03
069	4.5656E-02	2.6089E-03
287	4.5107E-02	2.5775E-03
282	4.3590E-02	2.4908E-03
366	4.2832E-02	2.4475E-03
109	4.1756E-02	2.3861E-03
311	4.1435E-02	2.3677E-03
098	4.0527E-02	2.3158E-03
370	3.9210E-02	2.2406E-03
139	3.8172E-02	2.1813E-03
016	3.7454E-02	2.1403E-03
286	3.7408E-02	2.1376E-03
017	3.6222E-02	2.0698E-03
166	3.5367E-02	2.0210E-03
291	3.5341E-02	2.0195E-03
081	3.5296E-02	2.0169E-03
104	3.5240E-02	2.0137E-03
027	3.5051E-02	2.0029E-03
091	3.4807E-02	1.9890E-03
096	3.4258E-02	1.9576E-03
328	3.4085E-02	1.9477E-03
040	3.2763E-02	1.8722E-03
330	3.2286E-02	1.8449E-03
L36	3.0583E-02	1.7476E-03
033	2.9922E-02	1.7098E-03
322	2.9615E-02	1.6923E-03
296	2.9135E-02	1.6648E-03
321	2.8927E-02	1.6530E-03
323	2.8628E-02	1.6359E-03
329	2.8454E-02	1.6260E-03
208	2.8186E-02	1.6107E-03
051	2.8054E-02	1.6031E-03
233	2.7858E-02	1.5919E-03
324	2.7768E-02	1.5867E-03
072	2.7711E-02	1.5835E-03

TABLE D.6 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
257	2.7575E-02	1.5757E-03
034	2.6503E-02	1.5145E-03
293	2.6282E-02	1.5018E-03
012	2.6008E-02	1.4862E-03
102	2.5604E-02	1.4631E-03
325	2.5342E-02	1.4481E-03
011	2.5340E-02	1.4480E-03
128	2.5321E-02	1.4469E-03
337	2.4511E-02	1.4006E-03
044	2.4450E-02	1.3972E-03
380	2.4400E-02	1.3943E-03
097	2.3813E-02	1.3607E-03
298	2.3603E-02	1.3488E-03
041	2.3493E-02	1.3424E-03
100	2.3299E-02	1.3314E-03
145	2.2926E-02	1.3101E-03
389	2.2686E-02	1.2964E-03
L35	2.2254E-02	1.2716E-03
367	2.1934E-02	1.2534E-03
326	2.1469E-02	1.2268E-03
164	2.0828E-02	1.1902E-03
077	2.0388E-02	1.1650E-03
300	2.0172E-02	1.1527E-03
163	2.0110E-02	1.1491E-03
111	1.9677E-02	1.1244E-03
297	1.9511E-02	1.1149E-03
043	1.9300E-02	1.1029E-03
002	1.9272E-02	1.1012E-03
379	1.9211E-02	1.0978E-03
303	1.8946E-02	1.0826E-03
068	1.8756E-02	1.0718E-03
232	1.8686E-02	1.0677E-03
L34	1.8617E-02	1.0638E-03
310	1.8457E-02	1.0547E-03
333	1.8312E-02	1.0464E-03
256	1.7867E-02	1.0210E-03
099	1.7263E-02	9.8648E-04
090	1.6508E-02	9.4332E-04
030	1.6120E-02	9.2113E-04
295	1.5958E-02	9.1187E-04
387	1.5603E-02	8.9159E-04
061	1.5378E-02	8.7872E-04
388	1.5333E-02	8.7615E-04
281	1.5274E-02	8.7279E-04
020	1.4688E-02	8.3930E-04
001	1.4603E-02	8.3447E-04
022	1.4577E-02	8.3300E-04

TABLE D.6 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
124	1.4497E-02	8.2841E-04
094	1.4357E-02	8.2042E-04
143	1.4319E-02	8.1820E-04
075	1.4275E-02	8.1574E-04
031	1.4274E-02	8.1566E-04
359	1.4240E-02	8.1371E-04
197	1.4169E-02	8.0966E-04
092	1.4092E-02	8.0525E-04
036	1.3837E-02	7.9067E-04
045	1.3696E-02	7.8264E-04
052	1.3309E-02	7.6053E-04
332	1.3304E-02	7.6023E-04
412	1.3136E-02	7.5064E-04
071	1.3086E-02	7.4780E-04
219	1.2765E-02	7.2944E-04
137	1.2622E-02	7.2127E-04
023	1.2405E-02	7.0883E-04
132	1.2265E-02	7.0086E-04
327	1.2196E-02	6.9691E-04
276	1.2077E-02	6.9011E-04
067	1.2017E-02	6.8668E-04
018	1.1876E-02	6.7866E-04
294	1.1839E-02	6.7653E-04
220	1.1547E-02	6.5985E-04
127	1.1372E-02	6.4980E-04
131	1.1348E-02	6.4844E-04
306	1.1292E-02	6.4524E-04
029	1.1214E-02	6.4079E-04
142	1.1211E-02	6.4062E-04
056	1.1157E-02	6.3753E-04
134	1.1123E-02	6.3559E-04
089	1.1043E-02	6.3105E-04
146	1.1029E-02	6.3022E-04
255	1.0987E-02	6.2781E-04
108	1.0924E-02	6.2420E-04
261	1.0907E-02	6.2326E-04
136	1.0859E-02	6.2052E-04
331	1.0745E-02	6.1399E-04
064	1.0646E-02	6.0837E-04
272	1.0590E-02	6.0513E-04
304	1.0459E-02	5.9767E-04
066	1.0351E-02	5.9147E-04
262	1.0348E-02	5.9132E-04
035	1.0303E-02	5.8874E-04
129	1.0259E-02	5.8624E-04
274	1.0245E-02	5.8543E-04
046	9.9199E-03	5.6685E-04

TABLE D.6 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
070	9.8610E-03	5.6349E-04
144	9.8339E-03	5.6194E-04
050	9.5945E-03	5.4825E-04
273	9.2887E-03	5.3078E-04
135	9.2574E-03	5.2900E-04
085	8.8599E-03	5.0628E-04
083	8.6792E-03	4.9595E-04
180	8.3869E-03	4.7925E-04
362	8.3634E-03	4.7791E-04
084	8.3376E-03	4.7643E-04
048	8.1294E-03	4.6454E-04
368	7.9384E-03	4.5362E-04
057	7.8517E-03	4.4867E-04
357	7.5430E-03	4.3103E-04
420	7.4562E-03	4.2607E-04
181	7.4151E-03	4.2372E-04
358	7.1962E-03	4.1121E-04
182	7.1062E-03	4.0607E-04
060	6.9245E-03	3.9569E-04
364	6.7409E-03	3.8520E-04
115	6.7159E-03	3.8377E-04
095	6.6809E-03	3.8176E-04
138	6.6767E-03	3.8152E-04
107	6.6622E-03	3.8069E-04
004	6.5338E-03	3.7336E-04
116	6.5306E-03	3.7317E-04
049	6.3838E-03	3.6479E-04
290	6.3654E-03	3.6374E-04
213	6.3272E-03	3.6156E-04
003	6.2727E-03	3.5844E-04
088	6.1047E-03	3.4884E-04
113	5.9912E-03	3.4235E-04
305	5.8609E-03	3.3491E-04
087	5.7894E-03	3.3082E-04
161	5.7108E-03	3.2633E-04
360	5.6927E-03	3.2530E-04
191	5.6745E-03	3.2426E-04
093	5.6579E-03	3.2331E-04
119	5.3992E-03	3.0853E-04
082	5.3131E-03	3.0361E-04
375	5.2155E-03	2.9803E-04
158	5.2050E-03	2.9743E-04
105	5.1026E-03	2.9158E-04
024	5.0913E-03	2.9093E-04
114	5.0275E-03	2.8729E-04
076	4.9934E-03	2.8534E-04
122	4.8640E-03	2.7794E-04

TABLE D.6 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
028	4.7739E-03	2.7280E-04
252	4.7244E-03	2.6997E-04
175	4.6867E-03	2.6781E-04
112	4.6092E-03	2.6338E-04
118	4.5382E-03	2.5932E-04
188	4.5244E-03	2.5853E-04
117	4.3307E-03	2.4747E-04
187	4.2639E-03	2.4365E-04
025	4.2402E-03	2.4230E-04
190	4.2258E-03	2.4147E-04
148	4.1808E-03	2.3890E-04
120	4.1716E-03	2.3838E-04
338	4.1494E-03	2.3711E-04
172	4.0130E-03	2.2931E-04
123	3.9664E-03	2.2665E-04
340	3.7521E-03	2.1441E-04
176	3.7124E-03	2.1213E-04
009	3.6895E-03	2.1083E-04
196	3.6222E-03	2.0698E-04
042	3.5775E-03	2.0443E-04
010	3.5306E-03	2.0175E-04
185	3.4082E-03	1.9475E-04
169	3.3493E-03	1.9139E-04
121	3.3270E-03	1.9012E-04
265	3.3247E-03	1.8998E-04
378	3.3108E-03	1.8919E-04
006	3.3059E-03	1.8891E-04
371	3.3004E-03	1.8859E-04
026	3.2687E-03	1.8678E-04
201	3.2612E-03	1.8635E-04
419	3.2150E-03	1.8371E-04
160	3.1390E-03	1.7937E-04
361	3.1248E-03	1.7856E-04
152	3.0876E-03	1.7644E-04
130	3.0729E-03	1.7559E-04
222	3.0486E-03	1.7420E-04
264	3.0419E-03	1.7382E-04
417	3.0062E-03	1.7178E-04
211	2.9893E-03	1.7082E-04
202	2.9453E-03	1.6830E-04
210	2.9421E-03	1.6812E-04
184	2.8881E-03	1.6503E-04
343	2.8651E-03	1.6372E-04
147	2.8628E-03	1.6359E-04
192	2.8624E-03	1.6357E-04
289	2.8528E-03	1.6302E-04
167	2.8311E-03	1.6177E-04

TABLE D.6 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
242	2.7567E-03	1.5753E-04
418	2.7489E-03	1.5708E-04
411	2.7319E-03	1.5611E-04
156	2.7220E-03	1.5554E-04
183	2.7058E-03	1.5462E-04
315	2.7046E-03	1.5455E-04
186	2.7034E-03	1.5448E-04
221	2.6898E-03	1.5370E-04
125	2.6771E-03	1.5298E-04
237	2.6309E-03	1.5034E-04
157	2.5753E-03	1.4716E-04
393	2.5720E-03	1.4697E-04
170	2.5236E-03	1.4420E-04
174	2.5184E-03	1.4391E-04
239	2.3942E-03	1.3681E-04
216	2.3810E-03	1.3606E-04
126	2.3694E-03	1.3539E-04
151	2.3140E-03	1.3223E-04
019	2.2452E-03	1.2830E-04
217	2.2207E-03	1.2690E-04
153	2.1897E-03	1.2512E-04
178	2.1248E-03	1.2142E-04
339	2.1199E-03	1.2114E-04
396	2.0624E-03	1.1785E-04
141	2.0457E-03	1.1689E-04
230	2.0005E-03	1.1431E-04
316	2.0005E-03	1.1431E-04
159	1.9946E-03	1.1398E-04
288	1.9819E-03	1.1325E-04
231	1.9649E-03	1.1228E-04
179	1.9642E-03	1.1224E-04
278	1.9461E-03	1.1120E-04
215	1.9352E-03	1.1058E-04
154	1.9350E-03	1.1057E-04
279	1.9293E-03	1.1024E-04
155	1.9167E-03	1.0952E-04
269	1.9117E-03	1.0924E-04
149	1.9009E-03	1.0862E-04
173	1.8967E-03	1.0839E-04
150	1.8691E-03	1.0680E-04
346	1.8669E-03	1.0668E-04
223	1.8054E-03	1.0317E-04
246	1.7710E-03	1.0120E-04
414	1.7512E-03	1.0007E-04
165	1.7230E-03	9.8455E-05
177	1.6888E-03	9.6505E-05
344	1.5975E-03	9.1288E-05

TABLE D.6 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
376	1.4951E-03	8.5432E-05
254	1.4771E-03	8.4407E-05
229	1.4238E-03	8.1359E-05
194	1.3840E-03	7.9085E-05
212	1.3056E-03	7.4603E-05
258	1.2942E-03	7.3955E-05
195	1.2675E-03	7.2430E-05
373	1.2477E-03	7.1295E-05
251	1.2134E-03	6.9335E-05
228	1.2033E-03	6.8760E-05
253	1.1783E-03	6.7334E-05
193	1.1770E-03	6.7257E-05
416	1.1623E-03	6.6416E-05
199	1.1513E-03	6.5787E-05
263	1.1320E-03	6.4688E-05
271	1.0595E-03	6.0546E-05
277	1.0180E-03	5.8169E-05
227	1.0115E-03	5.7802E-05
235	1.0031E-03	5.7320E-05
247	9.9022E-04	5.6584E-05
363	8.6284E-04	4.9305E-05
353	8.4837E-04	4.8478E-05
403	8.3930E-04	4.7960E-05
372	8.1914E-04	4.6808E-05
250	7.9917E-04	4.5667E-05
243	7.8691E-04	4.4966E-05
240	7.6843E-04	4.3910E-05
268	7.5571E-04	4.3183E-05
409	7.5333E-04	4.3047E-05
392	7.5003E-04	4.2859E-05
249	7.3579E-04	4.2045E-05
241	7.3246E-04	4.1855E-05
200	7.0380E-04	4.0217E-05
248	6.9426E-04	3.9672E-05
270	6.9101E-04	3.9486E-05
384	6.7452E-04	3.8544E-05
225	6.5350E-04	3.7343E-05
204	6.5157E-04	3.7233E-05
259	6.0753E-04	3.4716E-05
238	5.7194E-04	3.2682E-05
203	5.5136E-04	3.1506E-05
374	5.4378E-04	3.1073E-05
198	5.4143E-04	3.0939E-05
266	5.2680E-04	3.0103E-05
391	4.9949E-04	2.8542E-05
218	4.8743E-04	2.7853E-05
234	4.5496E-04	2.5998E-05

TABLE D.6 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
189	4.4627E-04	2.5501E-05
406	4.4405E-04	2.5374E-05
224	3.7601E-04	2.1486E-05
397	3.6808E-04	2.1033E-05
244	2.7728E-04	1.5844E-05
400	2.7652E-04	1.5801E-05
245	2.5089E-04	1.4337E-05
205	2.3545E-04	1.3455E-05
394	2.1747E-04	1.2427E-05
284	1.8274E-04	1.0442E-05
405	1.6404E-04	9.3736E-06
226	1.1219E-04	6.4111E-06
209	9.7210E-05	5.5548E-06
377	9.5477E-05	5.4558E-06
267	9.4162E-05	5.3807E-06
214	5.6135E-05	3.2077E-06
369	1.1660E-05	6.6631E-07
407	0.0000E+00	0.0000E+00
168	0.0000E+00	0.0000E+00
206	0.0000E+00	0.0000E+00
402	0.0000E+00	0.0000E+00
413	0.0000E+00	0.0000E+00
410	0.0000E+00	0.0000E+00
408	0.0000E+00	0.0000E+00
401	0.0000E+00	0.0000E+00
404	0.0000E+00	0.0000E+00
355	0.0000E+00	0.0000E+00
342	0.0000E+00	0.0000E+00
345	0.0000E+00	0.0000E+00
348	0.0000E+00	0.0000E+00
349	0.0000E+00	0.0000E+00
350	0.0000E+00	0.0000E+00
351	0.0000E+00	0.0000E+00
386	0.0000E+00	0.0000E+00
354	0.0000E+00	0.0000E+00
398	0.0000E+00	0.0000E+00
356	0.0000E+00	0.0000E+00
382	0.0000E+00	0.0000E+00
341	0.0000E+00	0.0000E+00
385	0.0000E+00	0.0000E+00
395	0.0000E+00	0.0000E+00
207	0.0000E+00	0.0000E+00
352	0.0000E+00	0.0000E+00

TABLE D.7 Radon Risk Ordered by Descending Risk (after subtracting background)

Confirmation Unit	Adult Resident	Adult Visitor
067	2.4915E-03	NA*
168	1.3267E-03	NA
412	1.0652E-03	NA
310	9.8674E-04	NA
046	9.3284E-04	NA
165	9.3000E-04	NA
411	8.5864E-04	NA
329	7.3592E-04	NA
380	5.9652E-04	NA
304	5.9231E-04	NA
014	5.6633E-04	NA
281	5.1244E-04	NA
309	4.9638E-04	NA
275	4.9183E-04	NA
399	4.9075E-04	NA
169	4.7809E-04	NA
096	4.7681E-04	NA
058	4.6433E-04	NA
160	4.5354E-04	NA
095	4.3305E-04	NA
167	4.0672E-04	NA
057	4.0621E-04	NA
080	4.0047E-04	NA
005	3.8257E-04	NA
028	3.7496E-04	NA
092	3.7323E-04	NA
089	3.6775E-04	NA
162	3.5886E-04	NA
006	3.5747E-04	NA
013	3.5383E-04	NA
090	3.5058E-04	NA
084	3.4981E-04	NA
069	3.4656E-04	NA
102	3.4084E-04	NA
015	3.3479E-04	NA
017	3.3331E-04	NA
012	3.2541E-04	NA
144	3.2439E-04	NA
129	3.1541E-04	NA
066	3.1114E-04	NA
041	3.1070E-04	NA
050	3.0760E-04	NA
124	3.0713E-04	NA
086	3.0670E-04	NA

TABLE D.7 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
038	3.0575E-04	NA
133	3.0443E-04	NA
135	3.0229E-04	NA
051	2.9866E-04	NA
068	2.9600E-04	NA
010	2.9472E-04	NA
009	2.9352E-04	NA
029	2.9252E-04	NA
130	2.9180E-04	NA
030	2.8827E-04	NA
101	2.8703E-04	NA
070	2.8620E-04	NA
163	2.7993E-04	NA
027	2.7820E-04	NA
044	2.7806E-04	NA
103	2.7381E-04	NA
016	2.7158E-04	NA
174	2.7112E-04	NA
161	2.6256E-04	NA
134	2.6184E-04	NA
228	2.6015E-04	NA
056	2.6012E-04	NA
142	2.5975E-04	NA
111	2.5974E-04	NA
185	2.5728E-04	NA
125	2.5554E-04	NA
059	2.5390E-04	NA
176	2.5195E-04	NA
025	2.4947E-04	NA
023	2.4776E-04	NA
060	2.4597E-04	NA
138	2.4315E-04	NA
307	2.4265E-04	NA
378	2.4218E-04	NA
007	2.4061E-04	NA
047	2.3975E-04	NA
026	2.3923E-04	NA
379	2.3359E-04	NA
274	2.3158E-04	NA
170	2.3125E-04	NA
136	2.3119E-04	NA
061	2.3016E-04	NA
040	2.2987E-04	NA
131	2.2624E-04	NA
039	2.2622E-04	NA
062	2.2548E-04	NA
306	2.2473E-04	NA

TABLE D.7 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
143	2.1885E-04	NA
120	2.1527E-04	NA
024	2.1261E-04	NA
018	2.0901E-04	NA
022	2.0848E-04	NA
043	2.0603E-04	NA
037	2.0519E-04	NA
042	2.0310E-04	NA
175	2.0066E-04	NA
184	1.9911E-04	NA
137	1.9670E-04	NA
332	1.9526E-04	NA
052	1.9446E-04	NA
305	1.9404E-04	NA
036	1.9293E-04	NA
171	1.8988E-04	NA
008	1.8818E-04	NA
031	1.8750E-04	NA
011	1.8529E-04	NA
064	1.8472E-04	NA
073	1.8111E-04	NA
065	1.7946E-04	NA
334	1.7765E-04	NA
123	1.7618E-04	NA
126	1.7387E-04	NA
186	1.7347E-04	NA
081	1.7042E-04	NA
032	1.6363E-04	NA
381	1.6145E-04	NA
187	1.6131E-04	NA
021	1.5929E-04	NA
063	1.5750E-04	NA
071	1.5658E-04	NA
108	1.5248E-04	NA
216	1.4934E-04	NA
104	1.4844E-04	NA
324	1.4596E-04	NA
179	1.4519E-04	NA
193	1.4041E-04	NA
132	1.4013E-04	NA
172	1.3713E-04	NA
182	1.3531E-04	NA
153	1.2793E-04	NA
115	1.2198E-04	NA
076	1.1696E-04	NA
035	1.1612E-04	NA
180	1.1505E-04	NA

TABLE D.7 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
173	1.1279E-04	NA
289	1.0829E-04	NA
075	1.0263E-04	NA
273	1.0104E-04	NA
177	9.8635E-05	NA
321	9.3786E-05	NA
127	9.3692E-05	NA
387	9.1610E-05	NA
183	9.0806E-05	NA
146	9.0760E-05	NA
085	8.9696E-05	NA
054	8.7822E-05	NA
272	8.7510E-05	NA
336	8.7210E-05	NA
077	8.5578E-05	NA
335	8.4904E-05	NA
020	8.4488E-05	NA
388	8.3958E-05	NA
368	8.1079E-05	NA
141	8.0726E-05	NA
217	7.8762E-05	NA
218	7.5281E-05	NA
110	7.5185E-05	NA
188	7.2954E-05	NA
365	6.1071E-05	NA
147	6.1004E-05	NA
181	6.0028E-05	NA
220	4.1720E-05	NA
148	4.0171E-05	NA
367	3.6762E-05	NA
325	3.6209E-05	NA
308	3.5767E-05	NA
099	3.3943E-05	NA
074	3.3193E-05	NA
152	3.1326E-05	NA
109	2.8231E-05	NA
210	2.8158E-05	NA
072	2.6376E-05	NA
033	2.3841E-05	NA
389	9.7535E-06	NA
237	9.2786E-06	NA
229	4.5493E-06	NA
211	3.9264E-06	NA
034	3.8146E-06	NA
240	1.3923E-06	NA
192	0.0000E+00	NA
199	0.0000E+00	NA

TABLE D.7 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
098	0.0000E+00	NA
195	0.0000E+00	NA
198	0.0000E+00	NA
191	0.0000E+00	NA
194	0.0000E+00	NA
196	0.0000E+00	NA
197	0.0000E+00	NA
190	0.0000E+00	NA
178	0.0000E+00	NA
156	0.0000E+00	NA
155	0.0000E+00	NA
154	0.0000E+00	NA
151	0.0000E+00	NA
150	0.0000E+00	NA
112	0.0000E+00	NA
145	0.0000E+00	NA
227	0.0000E+00	NA
128	0.0000E+00	NA
122	0.0000E+00	NA
159	0.0000E+00	NA
121	0.0000E+00	NA
200	0.0000E+00	NA
189	0.0000E+00	NA
149	0.0000E+00	NA
354	0.0000E+00	NA
345	0.0000E+00	NA
346	0.0000E+00	NA
347	0.0000E+00	NA
348	0.0000E+00	NA
349	0.0000E+00	NA
350	0.0000E+00	NA
351	0.0000E+00	NA
363	0.0000E+00	NA
353	0.0000E+00	NA
342	0.0000E+00	NA
355	0.0000E+00	NA
356	0.0000E+00	NA
357	0.0000E+00	NA
358	0.0000E+00	NA
359	0.0000E+00	NA
360	0.0000E+00	NA
361	0.0000E+00	NA
225	0.0000E+00	NA
352	0.0000E+00	NA
330	0.0000E+00	NA
313	0.0000E+00	NA
314	0.0000E+00	NA

TABLE D.7 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
315	0.0000E+00	NA
316	0.0000E+00	NA
317	0.0000E+00	NA
318	0.0000E+00	NA
319	0.0000E+00	NA
320	0.0000E+00	NA
344	0.0000E+00	NA
323	0.0000E+00	NA
343	0.0000E+00	NA
331	0.0000E+00	NA
333	0.0000E+00	NA
337	0.0000E+00	NA
338	0.0000E+00	NA
339	0.0000E+00	NA
340	0.0000E+00	NA
341	0.0000E+00	NA
364	0.0000E+00	NA
322	0.0000E+00	NA
413	0.0000E+00	NA
402	0.0000E+00	NA
403	0.0000E+00	NA
404	0.0000E+00	NA
405	0.0000E+00	NA
406	0.0000E+00	NA
407	0.0000E+00	NA
408	0.0000E+00	NA
362	0.0000E+00	NA
410	0.0000E+00	NA
398	0.0000E+00	NA
414	0.0000E+00	NA
416	0.0000E+00	NA
417	0.0000E+00	NA
418	0.0000E+00	NA
419	0.0000E+00	NA
420	0.0000E+00	NA
DA6	0.0000E+00	NA
409	0.0000E+00	NA
390	0.0000E+00	NA
366	0.0000E+00	NA
369	0.0000E+00	NA
370	0.0000E+00	NA
371	0.0000E+00	NA
372	0.0000E+00	NA
373	0.0000E+00	NA
374	0.0000E+00	NA
376	0.0000E+00	NA
401	0.0000E+00	NA

TABLE D.7 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
382	0.0000E+00	NA
400	0.0000E+00	NA
391	0.0000E+00	NA
392	0.0000E+00	NA
393	0.0000E+00	NA
394	0.0000E+00	NA
395	0.0000E+00	NA
396	0.0000E+00	NA
397	0.0000E+00	NA
303	0.0000E+00	NA
377	0.0000E+00	NA
245	0.0000E+00	NA
234	0.0000E+00	NA
235	0.0000E+00	NA
236	0.0000E+00	NA
238	0.0000E+00	NA
239	0.0000E+00	NA
241	0.0000E+00	NA
242	0.0000E+00	NA
312	0.0000E+00	NA
244	0.0000E+00	NA
231	0.0000E+00	NA
246	0.0000E+00	NA
247	0.0000E+00	NA
248	0.0000E+00	NA
249	0.0000E+00	NA
250	0.0000E+00	NA
251	0.0000E+00	NA
252	0.0000E+00	NA
253	0.0000E+00	NA
243	0.0000E+00	NA
215	0.0000E+00	NA
202	0.0000E+00	NA
203	0.0000E+00	NA
204	0.0000E+00	NA
205	0.0000E+00	NA
207	0.0000E+00	NA
208	0.0000E+00	NA
209	0.0000E+00	NA
212	0.0000E+00	NA
233	0.0000E+00	NA
214	0.0000E+00	NA
232	0.0000E+00	NA
219	0.0000E+00	NA
221	0.0000E+00	NA
222	0.0000E+00	NA
223	0.0000E+00	NA

TABLE D.7 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
224	0.0000E+00	NA
226	0.0000E+00	NA
230	0.0000E+00	NA
256	0.0000E+00	NA
213	0.0000E+00	NA
295	0.0000E+00	NA
254	0.0000E+00	NA
285	0.0000E+00	NA
286	0.0000E+00	NA
287	0.0000E+00	NA
288	0.0000E+00	NA
290	0.0000E+00	NA
291	0.0000E+00	NA
292	0.0000E+00	NA
283	0.0000E+00	NA
294	0.0000E+00	NA
282	0.0000E+00	NA
296	0.0000E+00	NA
297	0.0000E+00	NA
298	0.0000E+00	NA
299	0.0000E+00	NA
300	0.0000E+00	NA
301	0.0000E+00	NA
302	0.0000E+00	NA
201	0.0000E+00	NA
293	0.0000E+00	NA
266	0.0000E+00	NA
311	0.0000E+00	NA
257	0.0000E+00	NA
258	0.0000E+00	NA
259	0.0000E+00	NA
260	0.0000E+00	NA
261	0.0000E+00	NA
262	0.0000E+00	NA
263	0.0000E+00	NA
284	0.0000E+00	NA
265	0.0000E+00	NA
255	0.0000E+00	NA
267	0.0000E+00	NA
268	0.0000E+00	NA
269	0.0000E+00	NA
270	0.0000E+00	NA
271	0.0000E+00	NA
276	0.0000E+00	NA
279	0.0000E+00	NA

TABLE D.7 (Cont.)

Confirmation Unit	Adult Resident	Adult Visitor
280	0.0000E+00	NA
264	0.0000E+00	NA

[a] NA = not applicable.

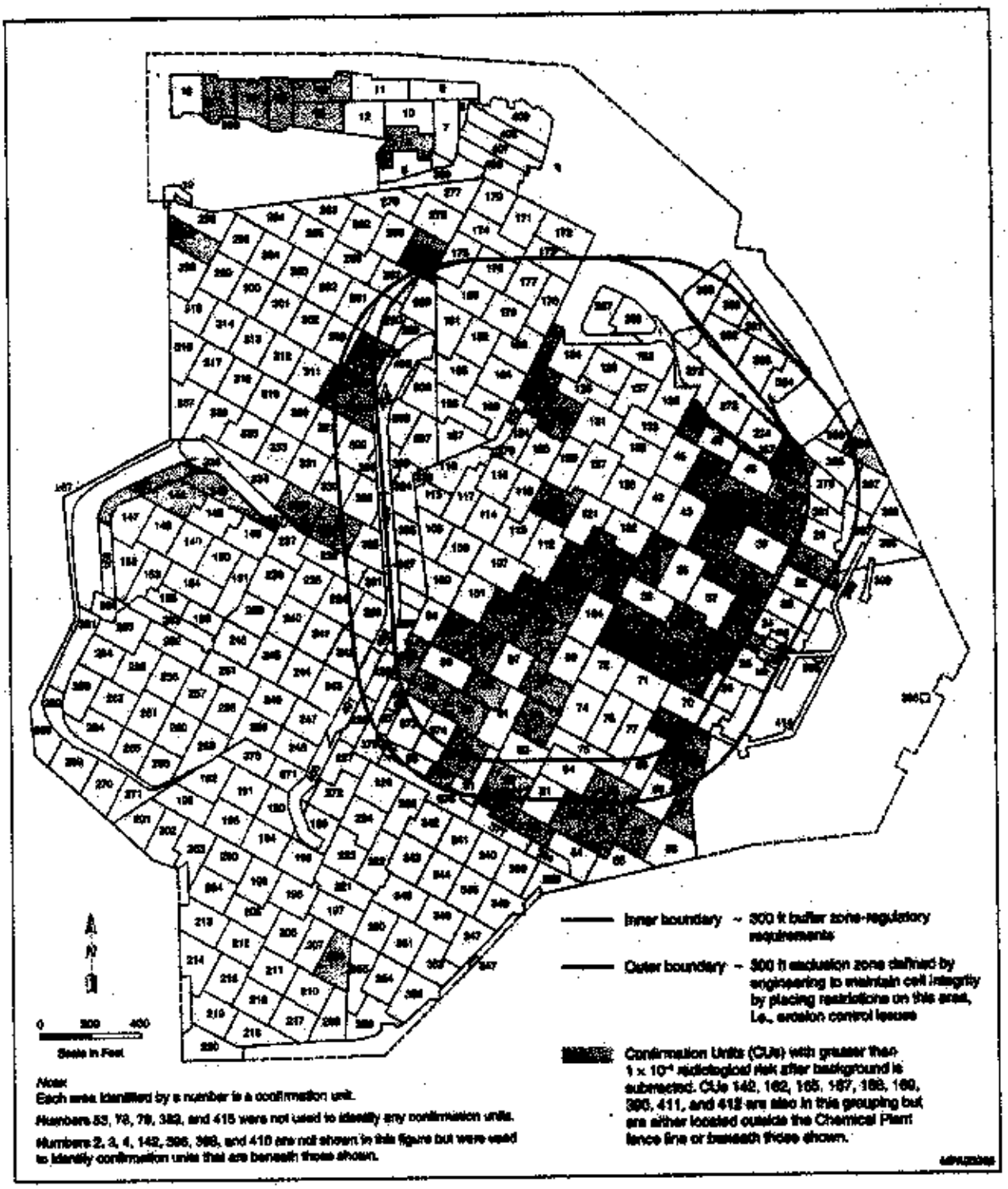

FIGURE D.1 Confirmation Units for the Chemical Plant Operable Unit with a Residual Radiological Risk Greater Than 1×10^{-4} after Background Is Subtracted

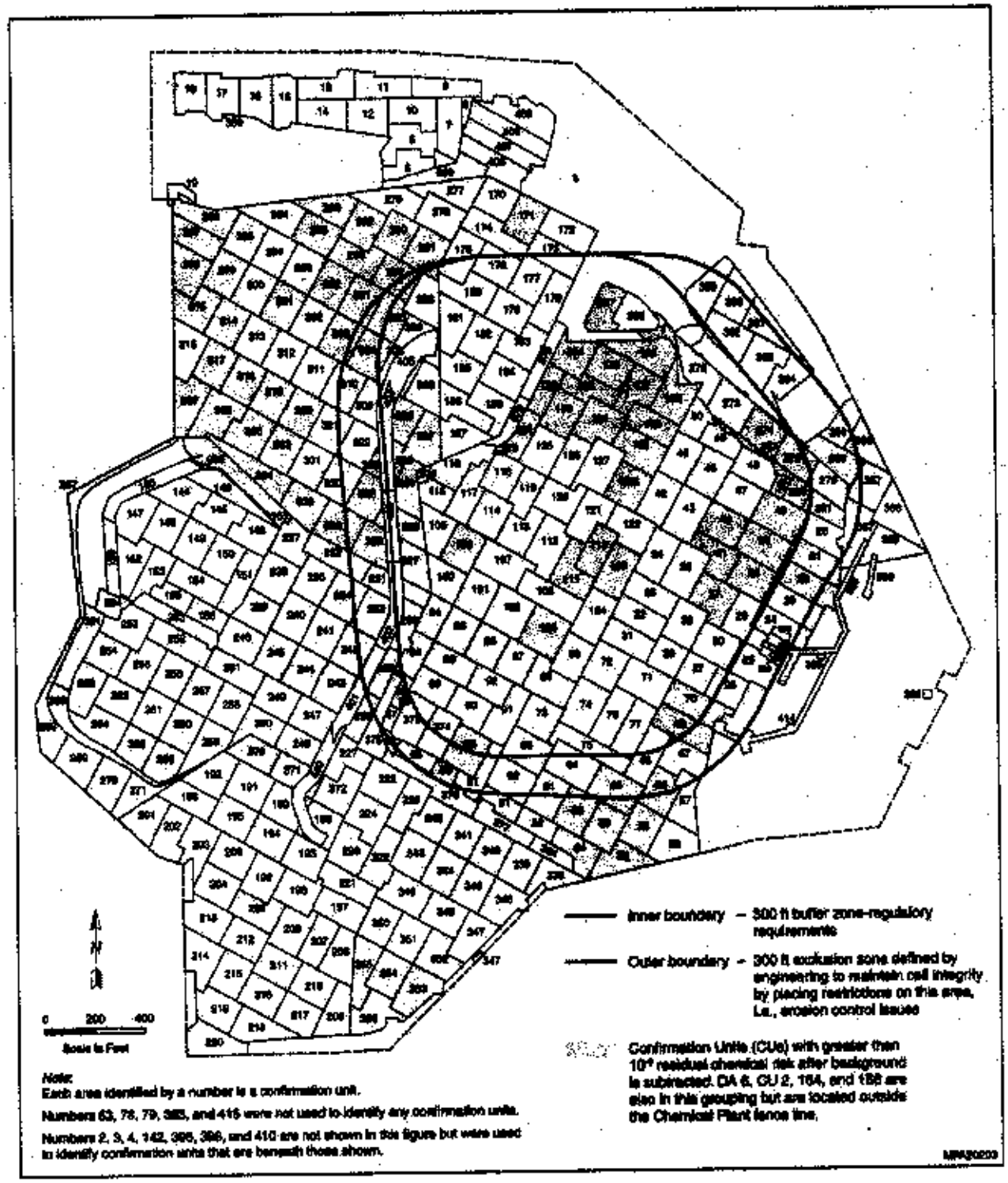

FIGURE D.2 Confirmation Units for the Chemical Plant Operable Unit with a Residual Chemical Risk Greater Than 10^{-6} after Background Is Subtracted

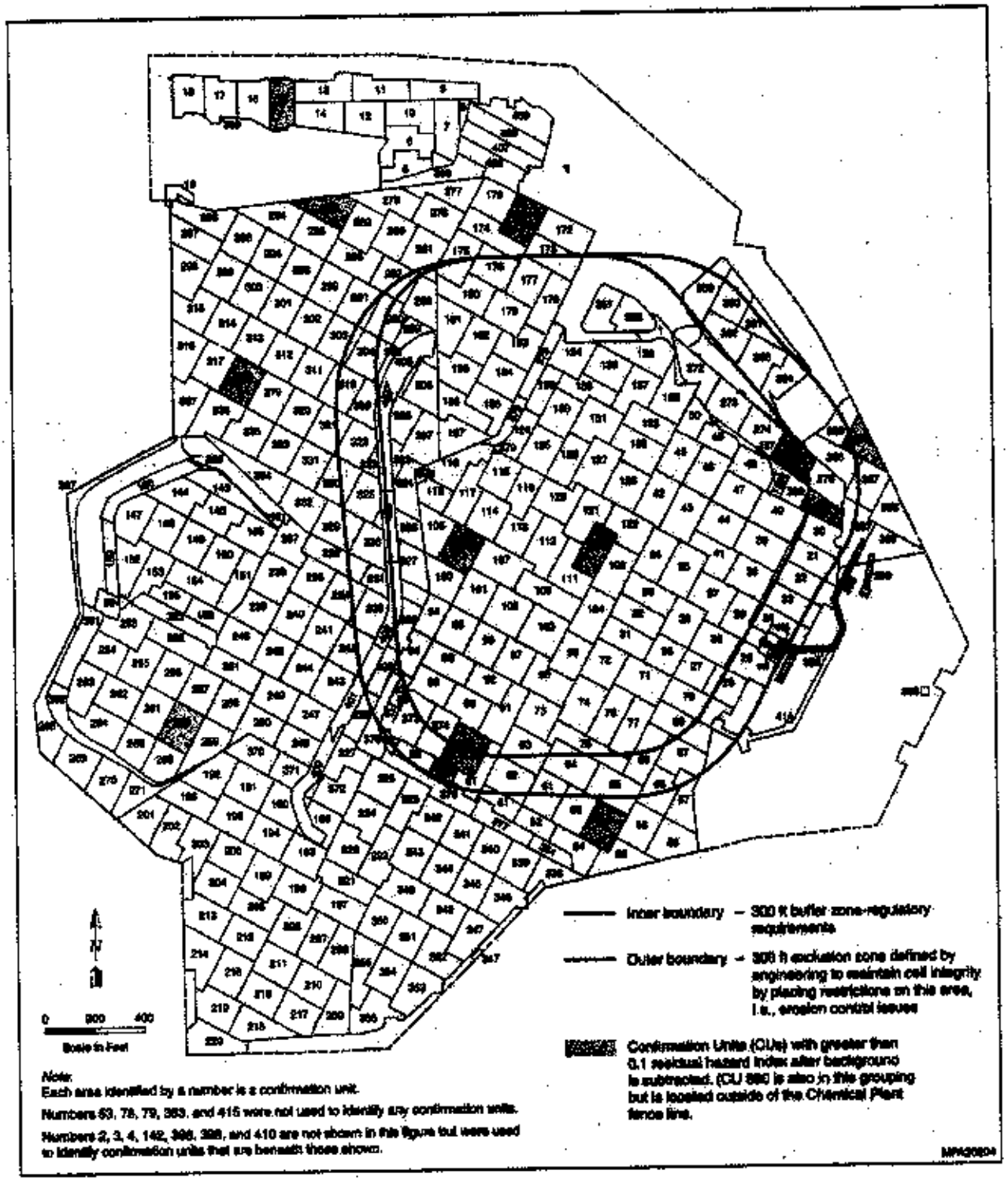

FIGURE D.3 Confirmation Units with a Residual Hazard Index Greater Than 0.1 after Background Is Subtracted

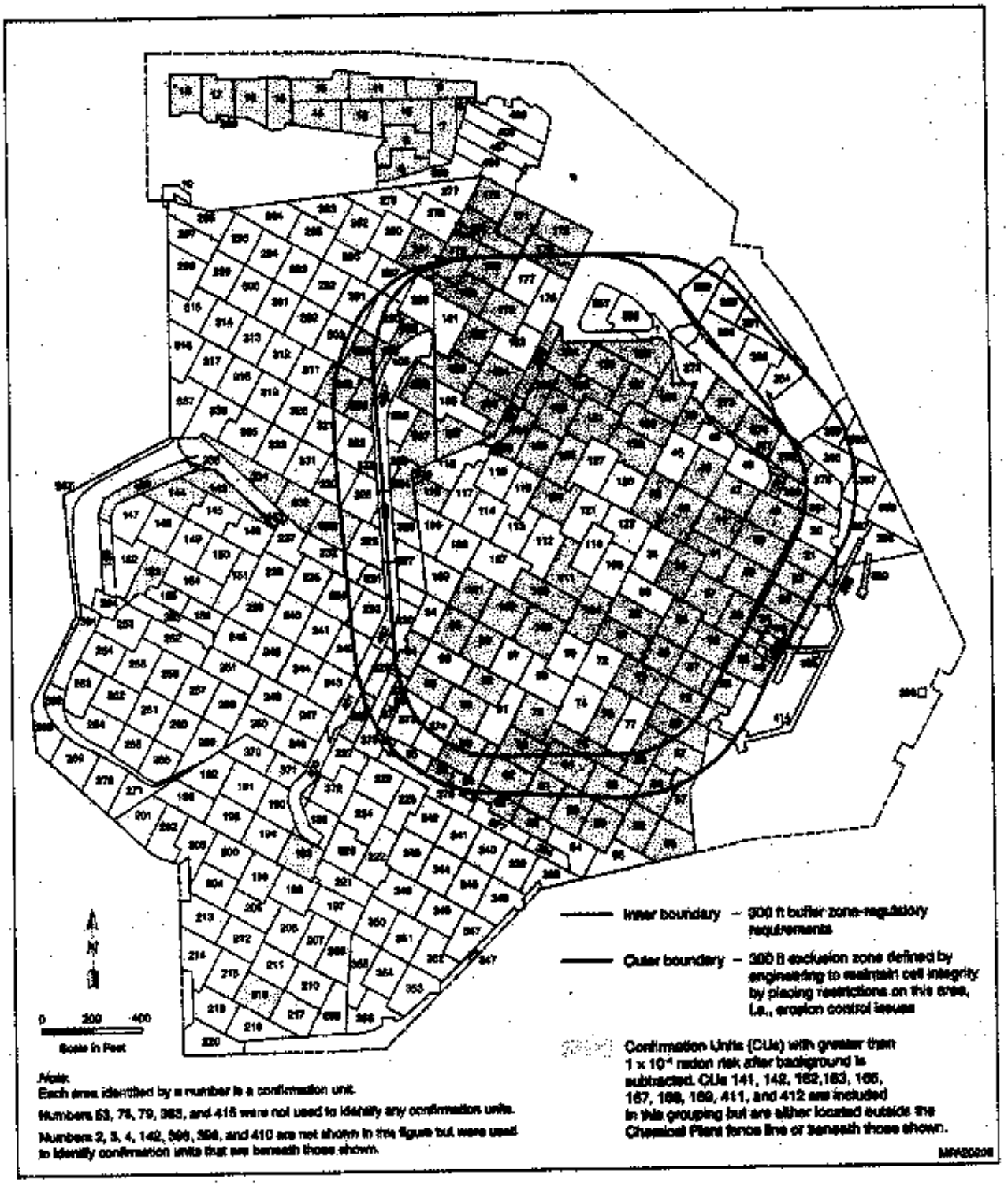

FIGURE D.4 Confirmation Units with a Residual Radon Risk Greater Than 1×10^{-4} after Background Is Subtracted

APPENDIX E:

LEGACY WASTE REMAINING AT THE WELDON SPRING CHEMICAL PLANT AREA

APPENDIX E:

LEGACY WASTE REMAINING AT THE WELDON SPRING CHEMICAL PLANT AREA

After remediation activities at the Chemical Plant are completed, some small structural items (e.g., manhole covers) containing low levels but marginally greater than background radioactivity would remain. An inventory of these items is presented in Tables E.1 and E.2, and their approximate locations are shown in Figure E.1. To distinguish these wastes from other waste material and because they were part of the site before remediation activities began, these materials are referred to as legacy wastes. Levels of radioactivity determined from the surfaces of these materials in counts per minute (cpm) are also presented in Table E.1. The road asphalt in the parking lots has been previously evaluated and was determined to contain radioactivity comparable to background values (Picel 2001).

To provide perspective on the level of radioactivity that the legacy wastes contain, background reference materials were surveyed to obtain surface cpm for comparison. These data are presented in Table E.3. To facilitate the comparison, the 95th upper confidence limit (UCL) of the arithmetic average of the counts was determined for the individual background reference materials and for the legacy waste materials. A summary of the UCLs and the supporting statistics is presented in Table E.4. On the basis of the data presented in Tables E.3 and E.4, the levels of radioactivity in the legacy wastes are either the same or no more than 3 times greater than those for the appropriate background reference material. In addition, measurements were also taken on the surface of in-situ background soils at the south end of the Administration Building. The readings were reported at 55, 64, 50, 73, 70, and 60 cpm. These readings are comparable to those obtained for the background reference materials discussed above.

Risk calculations specific to the legacy wastes have not been performed. However, the impact to human health from potential exposure to these materials can be inferred from the risk estimates obtained for background soil levels presented in Appendix D of this report. In fact, exposure to the legacy wastes is expected to result in lower risk than that estimated for background soil since not all pathways considered for soil are applicable to the legacy wastes. For example, inhalation and ingestion of a contaminated portion of a manhole or the chemical stabilization and solidification (CSS) plant slabs is not as likely as inhalation or ingestion of contaminated soil material.

TABLE E.1 Inventory of Legacy Waste Remaining at the Chemical Plant Area

	Item[a]	cpm[b]											
A.	RCP[c] Culvert under HWY 94	58	60	52	65	57	59						
B.	Concrete Base of Old Flag Pole	97	85	89	55	71	28						
C.	CMP[d] Culvert under Gate B Road	38	41	40	42	34	39	43	39	51	45		
D.	CMP Culvert under Main Entrance Road	45	58	50	48	66	47						
E.	CMP Culvert under Old Main Entrance Road	57	53	68	48	52	40	51					
F.	CMP Culvert South of Old Main Entrance Road	114	151	102	100								
G.	Manhole Cover at Southwest Corner of Admin. Bldg.	53	49	60	59								
H.	Post Indicator Valve Army Rd.	66	65	40	43	69							
I.	Water Valve Box Army Rd.	53	56	61									
J.	Manhole Cover Army Rd.	234	200	181	180	156	145	144	140	126	120	110	90
K.	Manhole Cover Army Rd.	180	160	158	156	156	150	144	140	122	120	112	90
L.	CMP Culvert under Army Rd.	157	133	187	217	143	129						
M.	RCP Culvert under Army Rd.	143	113	107	115	147	75						
N.	Manhole Cover Outside Old Main Entrance SW Bell	54	58	61	80	71							
CSS Slabs[e]		(see Table E.2)											
Asphalt Parking Lot[a]		(see Picel 2001)											

[a] These items contain radioactivity in excess of background considered to be part of the site before remedial activities begun. In addition to these items, the road asphalt in the parking lot is also considered "legacy" waste.

[b] cpm = counts per minute. Collected with various Ludlum 44-9 GM detectors (1-minute count time) on various dates and times.

[c] RCP = reinforced concrete pipe.

[d] CMP = corrugated metal pipe.

[e] Refers to the slabs remaining from the chemical stabilization and solidification (CSS) plant.

TABLE E.2 Gross Alpha Measurements from CSS Concrete Slab Surveys

cpm																			
34	51	21	37	36	24	6	13	7	25	46	26	23	32	39	19	7	21	38	30
38	7	4	8	22	21	31	4	16	13	17	17	11	18	4	24	35	32	24	23
45	12	11	14	7	16	67	7	4	4	8	2	5	35	0	0	2	3	48	50
2	2	24	24	6	7	2	6	4	4	8	7	6	2	2	0	3	3	4	5
3	4	2	4	1	4	1	7	3	6	3	3	2	3	5	6	10	26	4	9
5	2	4	6	0	4	4	2	4	4	2	11	3	2	7	4	5	4	4	4
4	5	5	2	1	2	4	3	3	2	3	1	4	9	3	1	4	3	3	0
5	0	3	11	5	6	2	3	8	7	2	2	5	12	17	4	6	5	2	4
4	4	4	2	7	9	8	6	2	4	6	2	1	2	11	6	0	6	3	4
3	6	15	8	7	5	3	1	6	9	2	5	4	2	2	8	2	2	3	3
5	2	3	2	1	9	14	6												

Source: Fleming (2002).

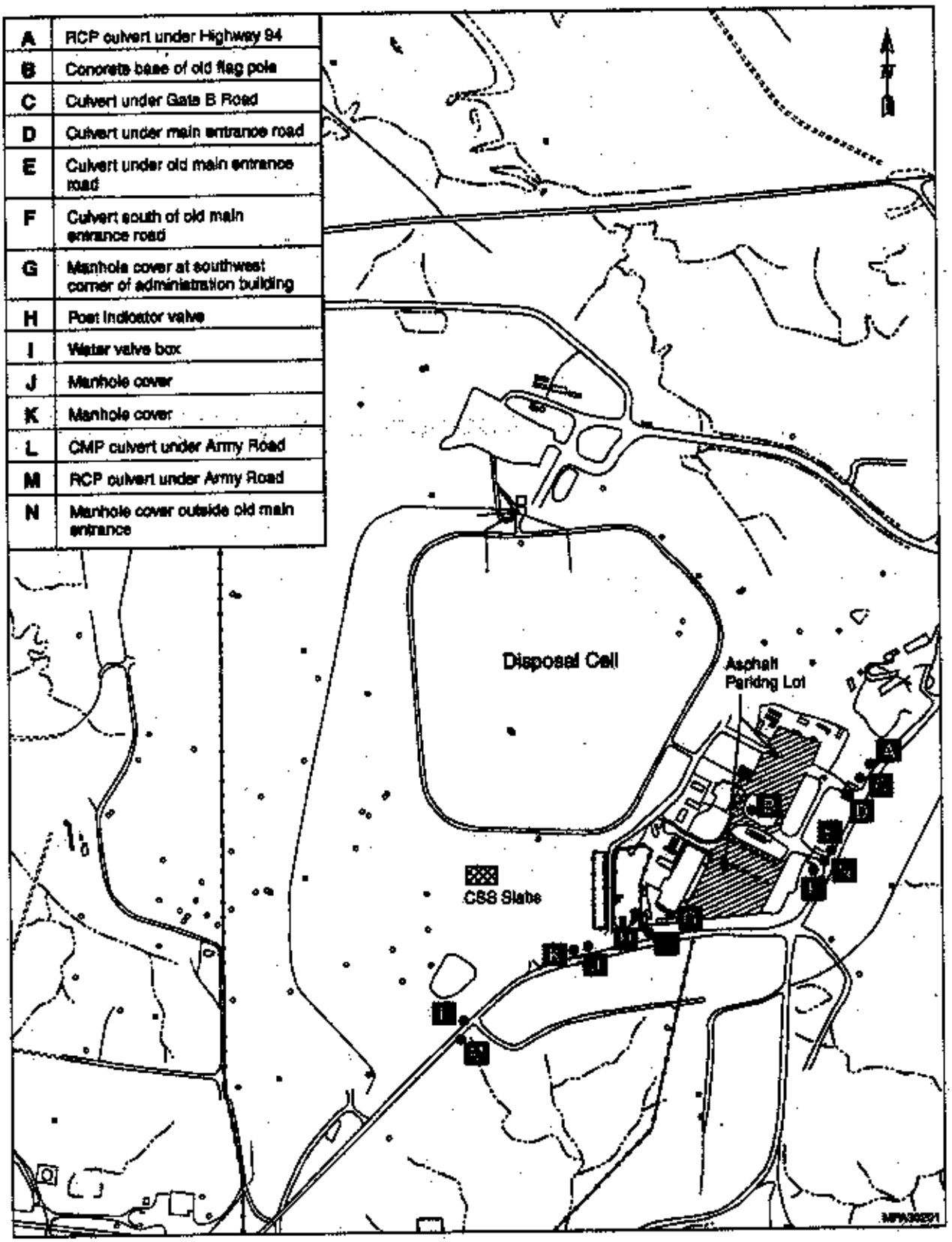

FIGURE E.1 Legacy Items with Above Background Radioactivity Levels

TABLE E.3 Background Reference Measurements for Various Materials

Type	cpm[a]														
Concrete[b]	37	33	54	34	40	57	38	42	38	40	36	45	35	51	49
CMP Culvert[c]	43	35	44	40	23	24									
Manhole Cover[d]	37	42	36	53	50	46									
Hydrant[e]	32	45	37	37	39										
RCP Culvert[f]	56	50	66	44	34	66									

[a] cpm = counts per minute; collected with various Ludium 44-9 GM detectors (1-minute count time) on various dates and times.

[b] For comparison with item B in Table E.1.

[c] For comparison with items C, D, E, F, and L in Table E.1.

[d] For comparison with items G, I, J, K, and N in Table E.1.

[e] For comparison with item H in Table E.1.

[f] For comparison with items A and M in Table E.1.

Source: Hixson (2002).

TABLE E.4 Summary Statistics for Data Obtained for the Legacy Waste Remaining at the Chemical Plant Area

	Waste Item	No. of Counts	Range	Avg.	SD[a]	UCL[b]
A.	RCP[c] Culvert under HWY 94[c]	6	52–65	59	4.2	62
B.	Concrete Base of Old Flag Pole	6	28–97	71	26	92
C.	CMP[d] Culvert under Gate B Road	10	34–51	41	4.6	44
D.	CMP Culvert under Main Entrance Road	6	45–66	52	8.1	59
E.	CMP Culvert under Old Main Entrance Road	7	40–68	53	8.6	59
F.	CMP Culvert South of Old Main Entrance Road	4	100–151	120	24	140
G.	Manhole Cover at Southwest Corner of Admin. Bldg.	4	49–60	55	5.2	60
H.	Post Indicator Valve Army Rd.	5	40–69	57	14	69
I.	Water Valve Box Army Rd.	3	53–61	57	4	61
J.	Manhole Cover Army Rd.	12	90–234	150	41	170
K.	Manhole Cover Army Rd.	12	90–180	140	25	150
L.	CMP Culvert under Army Rd.	6	129–217	160	35	190
M.	RCP Culvert under Army Rd.	6	75–147	120	26	140
N.	Manhole Cover Outside Old Main Entrance SW Bell	5	54–80	65	11	75
CSS Slabs[e]		208	0–67	9.4	11	11
Background Reference Item						
Concrete		15	33–57	42	7.6	45
CMP Culvert		6	23–44	35	9.3	43
Manhole Cover		6	36–53	44	6.9	50
Hydrant		5	32–45	38	4.7	42
RCP Culvert		6	34–66	53	13	63

[a] SD = standard deviation.

[b] UCL value is the upper 95% limit of the arithmetic average.

[c] RCP = reinforced concrete pipe.

[d] CMP = corrugated metal pipe.

[e] Refers to the slabs remaining from the chemical stabilization and solidification (CSS) plant.

APPENDIX E REFERENCES

Picel, M., 2001, letter from Picel (Argonne National laboratory, Argonne, Ill.) to T. Pauling (U.S. Department of Energy, Weldon Spring Remedial Action Project, St. Charles, Mo.) April 25.

Hixson, D., 2002, e-mail from Hixon (MK Ferguson and Jacobs Engineering, Inc., Weldon Spring, Mo.) to M. Picel (Argonne National Laboratory, Argonne, Ill.) March 13.

Fleming, D., 2002, e-mail from Fleming (MK Ferguson and Jacobs Engineering, Inc.) to M. Picel (Argonne National Laboratory, Argonne, Ill.) March 14.