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31 March 2000

David Rakel. Ph.D.
Babcock & Wilcox of Ohio, Inc.
1 Mound Road
P.O. Box 3030
Miamisburg, OH 45343-3030

RE: Parcel 3 Final Residual Risk Evaluation Report

Dear Mr. Rakel,

Science Applications International Corporation (SAIC) is pleased to submit to Babcock and Wilcox of Ohio, Inc. three copies of the Parcel 3 Residual Risk Evaluation Report. This report was prepared using the Mound 2000 Residual Risk Evaluation Methodology to quantify the potential for cancer and other non-cancer health effects from long-term, low-level exposures to site-related contaminants in Parcel 3. Residual risks were calculated for total risk, background risk and incremental risk for a current and future adult construction worker and a current and future adult site employee. The evaluation of potential cumulative exposure to contaminants in groundwater and air were not re-calculated but were brought forward from the Release Block H RRE and Technical Position Paper for Release Block H.

I will call you on Monday, April 3rd, to discuss any comments or questions you may have regarding this report and to set a schedule for the Parcel 4 RRE and Canal RRE comment resolution. We appreciate each opportunity to work with you.

Sincerely,

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Mari V. Johnson for

Hallie J. Serazin
Project Manager

Enclosure
cc: Vincent Krivda w/o enclosure

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RESIDUAL RISK EVALUATION
PARCEL 3

FINAL

Mound Plant
Miamisburg, Ohio

Prepared for:
U.S. Department of Energy

Prepared by:
Science Applications International Corporation
Dublin, Ohio

Managed by:
BWXT of Ohio, Inc.

March 31, 2000

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ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
BVA	Great Miami Buried Valley Aquifer
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPCs	constituents of potential concern
CSF	cancer slope factor
DOE	Department of Energy
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FFA	Federal Facilities Agreement
GH	Guard House
GP	Guard Post
GIS	Guard Island Station
GV	Guideline Value
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
LOAEL	lowest observed adverse effects level
MMCIC	Miamisburg Mound Community Improvement Corporation
NCEA	National Center for Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	Not detected
NOAEL	no observed adverse effect level
Ohio EPA	Ohio Environmental Protection Agency
OHPO	Ohio Historical Preservation Office
OSE	Operation Support East
OU	Operable Unit
pCi	picocuries
PRS	Potential Release Site
QAPP	quality assurance project plan
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance for Superfund
RfD	reference dose factor
RfC	reference concentration factor
RME	reasonable maximum exposure
RRE	residual risk evaluation
RREM	residual risk evaluation methodology
SVOC	semi-volatile organic compounds
UCL	upper confidence limit
UTL	upper tolerance limit
VOCs	volatile organic compounds

PARCEL 3 HUMAN HEALTH RESIDUAL RISK EVALUATION

EXECUTIVE SUMMARY

This report was prepared using the Mound 2000 Residual Risk Evaluation Methodology [(RREM) DOE 1999] to quantify the potential for cancer and other non-cancer health effects from long-term, low-level exposures to site-related contaminants in Parcel 3. A Residual Risk Evaluation (RRE) evaluates human health risks associated with residual levels of contamination remaining within an area to ensure that future users of the land will not be exposed contaminant levels that would pose unacceptable risks. Residual risks were calculated for total risk, background risk and incremental risk for a future construction worker and a future site employee.

No soil constituents of potential concern (COPCs) with non-carcinogenic toxicity criteria were identified in Parcel 3; therefore, the total, background and incremental non-cancer risk for both the construction worker and the site employee was zero indicating that a non-cancer risk does not exist for this parcel. Two radiological soil COPCs were identified for the construction worker in Parcel 3. Total residual cancer risk for a construction worker adult is 9.0E-06, which falls within the target or acceptable risk range of 1.0E-06 to 1.0E-04. Background residual risk for a construction worker in Parcel 3 was 2.3E-08, which is less than 1% of the total risk. Incremental residual soil risk (8.9E-06) was not substantially different from total residual risk and falls within the target risk range.

For the site employee scenario, radium-228, was the only COPC identified in soil for RRE calculations. Since no background concentration is available for radium-228, background risk could not be calculated. Therefore, total and incremental risks are equivalent. Total and incremental residual cancer risk for a site employee adult in Parcel 3 is 8.4E-06, which falls within the target risk range of 1.0E-06 to 1.0E-04.

Potential exposure to contaminants originating from outside Parcel 3 that may reach receptors in the parcel are termed potential cumulative exposures. Potential cumulative risk was calculated for current and future exposure to groundwater and air for Release Blocks D and H. These risks have been brought forward for Parcel 3. These values were not recalculated. Information on the derivation of these values is presented in Appendices A and B and the residual risk as reported in the Parcel 3 summary tables (Table 5.5 – 5.7)

Total and incremental non-carcinogenic residual risk from groundwater for the future construction worker scenario exceeded the target HI of 1 with values of 1.7 and 1.6, respectively. For the future site employee scenario, the target HI of 1 was exceeded in groundwater with a value of 1.6 for both total and incremental non-carcinogenic residual risks. Current and future background and current total and incremental non-carcinogenic residual risks in groundwater do not exceed target non-carcinogenic risk for either the construction worker or site employee. Total carcinogenic risk associated with exposure to groundwater falls within the target risk range of 1.0E-04 to 1.0E-06 for both potential receptors.

Potential cumulative carcinogenic risk due to exposure to contaminates in air was 2.1E-07, which is less than the target risk range. None of the COPCs identified in air have non-carcinogenic risk criteria so a HI was not calculated for exposure to contaminants in air.

Overall total, background, and incremental cancer and non-cancer risks are presented in the following table. The risk values in the table are the addition of all of the media and associated pathways for the construction worker and site employee scenarios. Total and incremental noncarcinogenic risks exceed target criteria for the future construction worker and future site employee and result from the groundwater pathway. Overall carcinogenic risks associated with exposure to soil, groundwater, and air fall within the target risk range of 1.0E-04 to 1.0E-06 for both potential receptors.

Overall Summary of Risks

Scenario and Receptor	Overall Risk Types	Total Noncarcinogen Risk HI	Total Carcinogenic Risk ELCR
Current Construction Worker	Total	3.7E-02	1.2E-05
	Background	9.6E-05	5.3E-07
	Incremental	3.7E-02	1.2E-05
Future Construction Worker	Total	1.7E-00	1.3E-05
	Background	3.1E-02	5.3E-07
	Incremental	1.6E-00	1.2E-05
Current Site Employee	Total	3.7E-02	2.4E-05
	Background	7.6E-05	2.5E-06
	Incremental	3.7E-02	2.4E-05
Future Site Employee	Total	1.6E-00	2.6E-05
	Background	3.1E-02	2.5E-06
	Incremental	1.6E-00	2.3E-05

1.0 INTRODUCTION

The U.S. Department of Energy's (DOE) Mound Plant is located on a 306-acre parcel of land within the City of Miamisburg, Ohio, about 10 miles southwest of Dayton, Ohio. Figure 1.1 shows the vicinity of the Mound Plant. The plant is located approximately 2000 feet east of the Great Miami River and partially overlies the Great Miami Buried Valley Aquifer (BVA). Since 1948, Mound has operated as a research, development, and production facility in support of DOE's weapons and energy programs. Mound's past weapons program mission included process development, production engineering, manufacturing, and surveillance of detonators, explosives, and nuclear components. Mound's current mission is to support DOE's efforts in environmental management and to transition the site, in cooperation with the City of Miamisburg, from a cold-war production facility to commercial or industrial use.

Parcel 3, the subject of this report, consists of an approximately 5.76 acre parcel of land located on the Main Hill at the Mound Plant. A map of the Parcel 3 is included as Figure 1.2. A removal action was completed at Parcel 3 in August and September 1999. In this report residual risk at Parcel 3 is evaluated for future commercial use of the parcel.

During past operations at the Mound facility the release of hazardous waste may have occurred. During subsequent facility investigations over 400 potential release sites (PRSs) have been identified. Since contamination at the Mound Plant occurs at discrete PRSs rather than being widespread across the site, a new decision-making process was formulated for Mound. The new process is known formally as the "removal site evaluation process" and informally as the "Mound 2000 process". The Mound 2000 process is consistent with the Federal Facilities Agreement (FFA) signed by DOE, the U. S. Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency (Ohio EPA), in accordance with the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) as defined in the National Contingency Plan [(NCP) EPA 1989].

This report was developed using the Mound 2000 Residual Risk Evaluation Methodology [RREM (DOE 1997a)] to quantify the potential for cancer and other non-cancer health effects from long-term, low-level exposures to site-related contaminants in Parcel 3. A Residual Risk Evaluation (RRE) assesses human health risks associated with residual levels of contamination remaining within an area to ensure that future users of the land will not be exposed to contaminant

levels that would pose unacceptable risks. The RRE results will be used, together with Applicable or Relevant and Appropriate Requirements (ARARs), to determine the need for additional site remediation or to demonstrate that a parcel is ready for release and economic redevelopment.

1.1 Purpose of Residual Risk Evaluation

The objective of the Parcel 3 RRE is to assess risks associated with residual levels of contamination that remain after all necessary actions within a release block have been taken. Although the RRE method was developed specifically for use at Mound, the method is consistent with the CERCLA baseline risk assessment method to ensure that future users of the land will not be exposed to contaminant levels that would pose unacceptable risks.

1.2 Scope of the Parcel 3 RRE

The RRE for Parcel 3 includes an evaluation of human health risk for potential residual contamination in the area. A detailed process history of the GH Building, located in Parcel 3, is presented in a document titled *DOE Mound Facility GH Building General Support Function Documentation Package* (DOE 1998). The Parcel 3 RRE was completed using the Mound 2000 RREM (DOE 1997a). Since commercial/industrial use of Parcel 3 is anticipated, receptor scenarios were selected to represent reasonable maximum exposures (RME) in a commercial/industrial setting. Residual contaminants in Parcel 3 were evaluated for two potential receptor groups: construction workers, who may be directly exposed to soil and groundwater for up to five years, and site employees, such as office workers, who may be exposed to soil and groundwater for up to 25 years. The construction worker and site employee were assumed to utilize groundwater from the Mound Plant Production Well for their potable water supply while at work. Exposure assumptions for the construction worker and site employee scenarios are site-specific adaptations of the standard scenarios presented in EPA's Risk Assessment Guidance for Superfund (RAGS), Part A (EPA 1989). These assumptions were documented in Table 1 in the Mound 2000 RREM (DOE 1997a) and are based on RME assumptions. RME exposure assumptions are conservative and are therefore, not likely to underestimate residual risk.

Parcel 3 residual risks were calculated for total risk, background risk and incremental risk. Total risk was calculated using the total concentration of identified constituents of potential concern (COPCs) detected in Parcel 3. Background risk was based on background levels of the

COPCs and incremental risk was calculated using the difference between total and background levels. Incremental risk can be used to assess the increase in risk above background levels due to contaminant releases from past Mound Plant operations.

1.3 Organization of Report

The RREM provides a framework for evaluating potential human health risks associated with residual levels of contamination. Although the RREM is similar to a traditional CERCLA baseline risk assessment, it serves a different purpose and, therefore, is not identical.
The RREM consists of five elements, including:

- identification of the contaminants to be evaluated,
- exposure assessment,
- toxicity assessment,
- risk characterization, and
- evaluation of potential cumulative risks.

The following sections describe each of these elements in more detail starting with Section 2.0, Data Compilation and Evaluation, which describes the methods used to compile Parcel 3 data and identify contaminants to be evaluated in the RRE. Section 3.0, Exposure Assessment, summarizes the pathways through which hazardous substances may reach potential receptors and intake assumptions that will be used to quantify exposure. In Section 4.0, Toxicity Assessment, exposure point concentrations, intake equations and toxicological reference values are presented. Information from the exposure assessment is combined with information from the toxicity assessment to characterize human health risks in Section 5.0, Risk Characterization. Section 6.0, Uncertainties, presents some of the sources of uncertainty inherent in risk assessments and in the RRE. Section 7.0, References, contains a list of all documents cited in this report.

2.0 DATA COMPILATION AND EVALUATION

Identification of contaminants to be carried through the RRE calculations is a multi-step process beginning with the identification of all contaminants detected in the area and then eliminating contaminants based upon a set of established screening criteria described in the RREM.

All available sampling data were compiled for use in the Parcel 3 RRE. Newer data were used to supplement, rather than supercede older data except when older data described materials that had subsequently been removed from the area. In this case, the older data no longer represent site conditions and were, therefore, not used in the RRE. Sampling data obtained from the Mound Soil Screening Facility were used except in the case where a sample was split and analyzed by both the Mound Soil Screening Facility and a commercial analytical laboratory. In such cases, the value from the commercial analytical laboratory was used to take advantage of the greater precision available from the commercial analytical laboratory.

Data used to characterize the Parcel 3 were drawn from the following data sets:

Project Code	Description	Reference
PRS99-100	Data from Further Assessment of PRS100 and Removal Action at PRS99	PRS 99 On-Scene Coordinator Report, To Be Published PRS 100 Package, To Be Published
RSS	Radiological Site Survey	Operable Unit 9 Site Scoping Report, Vol 3, Radiological Site Survey, June, 1993 (DOE 1993c)
SCRDATA	Mound Plant Screening Data	Not published
SPRFLG	Spring Fling Tritium Water Sampling	
Groundwater	BVA Mound Production Well Sampling Bedrock aquifer monitoring well sampling	Compiled from the MEIMS database and reported in Release Blocks H and D RRS reports.
Air	1994 Site Restoration activities	Mound Site Environmental Report for Calendar Year 1994, MLM-3814, (DOE 1994)

2.1 Data Quality Assessment

Samples were collected and analyzed according to the methods outlined in the Operable Unit (OU) 9 Quality Assurance Project Plan (QAPjP) (DOE 1993a) and the OU5 QAPjP (DOE 1993b). All data used in the risk assessment have undergone Quality Assurance/Quality Control (QA/QC) evaluation and data validation in accordance with the requirements described in the OU9 QAPjP (DOE 1993a) and the OU5 QAPjP (DOE 1993b).

2.2 Environmental Media Considered and Data Availability

Field investigations conducted for Parcel 3 are listed above. Samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), inorganic compounds, common anions, polychlorinated biphenyls, and radionuclides. Environmental media that were evaluated include surface soil (0-2 ft below land surface), subsurface soil (>2 feet below land surface), and groundwater. Parcel 3 does not contain any surface water.

Groundwater was assessed using the technique established in the RRE report for Release Block H (DOE, 1997b). This method assumes both current and future exposure to groundwater. Current groundwater exposures will be estimated using data collected from the Mound Plant Production Wells, which are finished in the BVA. The concentration of constituents in future groundwater was estimated using a model that assumes all contaminants currently detected in the Bedrock Aquifer of the Mound Plant property migrate to the BVA. Contaminant concentrations in the Bedrock Aquifer were added to the current contaminant concentrations detected in the Mound Plant Production Wells. This method is described in more detail in Appendix A. Potential cumulative risks due to contaminants released to the air are discussed in more detail in Appendix B.

2.3 Data Analysis

For each constituent detected in Parcel 3 soils the 95% upper confidence limit of the mean (UCL) was calculated to estimate the concentration that receptors in the area may be exposed to. This is known as the Exposure Point Concentration or EPC. In groundwater the maximum concentration was used as the current EPC. The modeled groundwater value was used as the future EPC. The 95% UCL was calculated in accordance with the Mound 2000 RREM (DOE 1997a), Gilbert's *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987), and the

Supplemental Guidance to RAGS: Calculating the Concentration Term (EPA, 1992a). Before calculating the 95% UCL the distribution of the data set was determined. If data were found to be normally distributed, the EPC was calculated as the 95% UCL of the arithmetic mean of the data, using the Student's t-statistic (EPA 1992a). If the data were found to be log normally distributed, the EPC was calculated as the 95% UCL using the H-statistic (EPA 1992a).

The 95% UCL on the arithmetic mean, was calculated as follows:

$$95\% \text{ UCL} = \text{Mean} + t(s/n^{1/2})$$

Where:

UCL = upper confidence limit,
t = t statistic (Table A2, Gilbert, 1987),
s = standard deviation, and
n = number of observation in the data set

The 95% UCL equation of the arithmetic mean for lognormal data sets was calculated as follows:

$$95\% \text{ UCL} = e^{\text{Mean}+H(s/(n-1)\ 1/2)}$$

Where:

UCL = upper confidence limit,
H = H statistic (Table A12, Gilbert, 1987),
s = standard deviation, and
n = number of observations in the data set
e = constant

If the 95% UCL exceeded the maximum value observed the maximum value was used as the EPC for that constituent (whether the data were normally or log normally distributed). For both chemical and radiological constituents "not detected" (ND) results were treated as one-half the limit of detection and included in the calculations of the mean and 95% UCL values. Samples reported as ND or zero with no detection limit were not utilized in calculating a 95% UCL.

Blind field duplicates were collected to assess variability in the sampling process. They are used in the data quality assessment but were not included in the calculation of the exposure point concentrations. If a data set had less than twenty observations (n<20) the maximum detected concentration was used as the EPC. For radionuclides, zero or negative results with no detection limits were excluded from the data set. Data qualified as "J", meaning estimated

values, at concentrations less than the detection limit, were evaluated as half the detection limit. For "J" data, which were greater than the detection limit or reported without the sample detection limit, the reported value was used in the 95% UCL calculations. Data flagged with an "R", meaning rejected, were not used in the Parcel 3 database.

2.4 Data Screening Process

All constituents detected one or more times were listed in constituent summary tables and sorted by media and the depth where they were detected. The constituent screening methods described below were then used to generate a final list of COPCs. The constituent summary tables also provide maximum detected concentrations, the range of contaminant detection limits, the frequency of detection, and the decision and rationale to include or exclude a constituent from further consideration in the RRE. The following section describes how COPCs were selected. Tables 2.1 and 2.2 identify the COPCs for the construction worker and site employee scenarios, respectively.

2.4.1 Screening Constituents Based on Background

Site-specific background concentrations described as the 95% Upper Tolerance Limit (UTL) of the background sample results for each constituent were calculated for Mound Plant soils and are presented in the Mound 2000 RREM (DOE 1997a). Constituents with a maximum detected concentration exceeding their level in background were identified as COPCs and carried to the next step of the RRE. Constituents with maximum concentrations less than their background concentration were not carried though the RRE. If no background value was available for a particular constituent (e.g., many organic compounds), the constituent was carried through to the next screening step of the RRE.

In cases where the 95% UCL of the arithmetic mean fell below the maximum detected value, the 95% UCL was compared to background to determine whether the 95% UCL was below background. If the 95% UCL was below the background value for the constituent, the constituent was not identified as a COPC in the RRE. Including constituents whose 95% UCL is less than background would cause that the incremental risk to be a "negative" risk. Eliminating these constituents focuses the RRE on constituents detected above background.

2.4.2 Screening Constituents Based on Guideline Values

Soil and groundwater constituents present at concentrations that exceed background concentration were compared to risk-based Guideline Values (GVs) for the Mound Facility (DOE 1997c). GVs are media-specific concentrations of constituents that correspond to specific human health risk levels for specified exposure scenarios. GVs were developed for construction worker and site employee scenarios (see DOE 1997c for the detailed derivation of GVs). Construction worker and site employee GVs, were use to screen detected constituents as COPCs to be retained for the quantitative risk assessment for each of the identified receptors.

The GVs used to screen COPCs were developed specifically for Mound, and were approved by the DOE, the U.S. EPA, and Ohio EPA. The GVs correspond to the 1.0E-6 risk level for carcinogens and radionuclides, and to a Hazard Quotient of one for each non-carcinogenic constituent. Some of the radionuclide GVs are designated as +D to indicate that cancer risk estimates and GVs include contributions from the radionuclide's short-lived decay products, or daughters. These calculations assumed equal activity concentrations (i.e. secular equilibrium) with the principal or parent nuclide in the environment. For Parcel 3 +D GVs were used for Actinium-227+D, Radium 228+D, Thorium 228+D, and Thorium-232+D. Guideline values for Thorium-232+D, Radium 228+D, Thorium 228+D, Lead-210, Potassium-40, and 1,1,2-Trichloro-1,2,2-trifluoroethane were calculated using the Mound G.V. methodology (DOE 1997c) due to updated toxicity criteria or lack of G.V.

A 1.0E-6-risk level represents an incremental increase of one chance in one million of developing cancer as a result of exposure to the GV concentration. A Hazard Quotient of one indicates that from an exposure at or below the given concentration, no adverse effects to humans are expected. Since the target risk level for carcinogenic constituents specified in the NCP is a range of 1.0E-04 to 1.0E-06, screening COPCs against the whole GV is protective. The target threshold for non-carcinogenic constituents is a Hazard Index (HI) of less than or equal to one. The GV values were calculated for a HI of one. To account for the possibility of more than one non-carcinogenic constituent, COPCs were screened using 1/10 the GV. Carcinogenic or radioactive constituents that exceed their GVs and non-carcinogenic constituents that exceed one-tenth of their GV were carried to the next step of the RRE.

2.4.3 Screening Constituents Based on Frequency of Detection

Constituents detected at concentrations above Mound background levels and above applicable GVs were next evaluated for their frequency of detection. RAGS Part A (EPA, 1989) states that infrequently detected compounds may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be site-related. Compounds that were detected infrequently in all media, not detected at high concentrations in any medium, and compounds unrelated to historical operations conducted within a release block were eliminated from further consideration by the RRE.

Infrequent detection was defined as five percent or less. This is equivalent to one detect in 20 samples. If there were an insufficient number of samples (e.g. less than 20) to determine whether the frequency of detection is five percent or less, the contaminant was not eliminated on the basis of frequency of detection. Other relevant factors such as whether the constituent is expected to be present based on historical data or degradation products of known contaminants also were considered in the decision to include or exclude infrequently detected constituents.

2.4.4 Screening Constituents Based on Essential Human Nutrients

According to RAGS Part A (EPA 1989): "Chemicals that are (1) essential human nutrients, (2) present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and (3) toxic only at very high doses (i.e., much higher than those that could be associated with contact at the site) need not be considered further in the quantitative risk assessment." Inorganic analytes meeting this description were not carried through the RRE. Calcium, chloride, iron, magnesium, potassium, and sodium are considered essential nutrients to humans. These compounds were detected in the Parcel 3 area at levels below or slightly elevated above background and are toxic only at very high doses. Concentrations of these compounds in on-site media would not be expected to result in intakes associated with a toxic response. Therefore, these compounds were eliminated as COPCs for the Parcel 3 area.

2.4.5 Additional Screening Procedures

In accordance with the RREM, additional screening procedures also were used to evaluate Parcel 3 constituents. For example, in accordance with EPA's Functional Guideline for Organics (EPA 1988) if a blank contains measurable levels of a common laboratory contaminant,

then the associated sample results were considered as positive results only if concentration in the samples exceeded ten times the concentration in the blank. If the concentration of a common laboratory contaminant was less than ten times the blank concentration, the constituent was considered to be an artifact of laboratory handling and was not included in the RRE. Common laboratory contaminants include acetone, 2-butanone, methylene chloride, toluene, and phthalate esters.

3.0 EXPOSURE ASSESSMENT

The goal of the RRE exposure assessment is to estimate the type and magnitude of contaminant exposures that may occur under current conditions with the area being used for construction worker purposes and in the future assuming that the area is developed for site employee use. The information gathered in the exposure assessment is integrated with toxicity information to characterize potential risks associated with exposure to residual contamination in the Parcel 3 area.

3.1 Characterization of Exposure Setting

Parcel 3 consists of approximately 5.76 acres and includes two buildings. Parcel 3 includes parts of the plant site that were developed as part of the original plant construction project [e.g., Guard House (GH) Building and the parking area west of GH Building]. Some of these areas were used for disposal (e.g., the parking area south of GH Building) and for additional development (e.g., construction, parking areas). A brief discussion of the histories of the areas and buildings (both past and present) located in Parcel 3 follows.

GH BUILDING: GH Building was constructed in 1948, in a grassy area on the northern end of the Main Hill at what was, in 1948, the main entrance to the plant site. The Ohio Historic Preservation Office (OHPO) declared GH Building eligible for the National Register. GH Building, originally designated as the "Guard House" was constructed as a one-story structure with a reinforced concrete roof bearing on exterior walls of face brick and masonry block. It was constructed to serve as an office area to house guard personnel and their equipment. It included a change room and office area for Mound site security staff.

In 1949, GH building also served as a visitors control center. The visitors control function remained in GH Building until about 1993. In the early 1950s, the Purchasing Group had offices at GH Building. From 1982, until 1994, GH Building was used as an office area for newly hired Mound employees who were not yet security cleared and could not access the site without an escort. From 1994 to 1996, GH Building was used as an office area for the "Mound Transition Center" offering employment search services to displaced Mound workers. In 1996, until early 1997, GH

Building served as an office area for Mound Health Physics staff members. In early 1997, the Health Physics staff moved out, and GH Building has remained vacant since that time.

Today GH Building is an unoccupied office complex surrounded by parking areas. The structure currently has 5,347 square foot of floor space. GH Building also has a utility penthouse that was built in 1966 out of built-up-membrane coal tar.

A detailed process history and structural history of GH Building was prepared as part of the documentation of this building as a National Register eligible structure. This package, titled *DOE Mound Facility GH Building General Support Function Documentation Package* was completed in December 1998. The documentation package was amended based upon comments from the OHPO, and re-submitted to the DOE in March 1999. The purpose of this package is to fulfill the requirements established under the National Historic Preservation Act by the OHPO under the National Historic Preservation Act and the resulting Memorandum of Agreement being negotiated between DOE and the OHPO.

GIS BUILDING: GIS (the "Guard Island Station") Building was constructed in about 1948, as one of the original structures in a grassy island in the roadway to the north of GH Building. This building was constructed as a guard station; a function that it served until it was demolished in 1997. GIS Building was not identified as being eligible for the National Register by the OHPO.

GP-1 BUILDING: Guard Post 1 (or GP-1) was constructed around 1950. This date is based upon the engineering drawings dated late 1949 and upon aerial photographs from late 1949. In the original architectural drawings, this building was designated as "Guard Station-1," a "trooper post". It was constructed to serve as a training center and to provide office space for security personnel. It was used as an office and training area until it was vacated in the late 1990s, in anticipation of its transfer to the Mound Miamisburg Community Improvement Corporation (MMCIC).

Initially GP-1 measured approximately 15'-0"x21' and 7-1/2." Additions to GP-1 in 1961, 1963, 1968, and 1981, increased the square footage of GP-1 by about 2,462 percent. Today, GP-1 is about 8000 ft^2. Following the construction of these additions GP-1 also housed a

practice firing range (previously located outside) and fitness center for the guard force. GP-1 Building was not identified as National Register eligible by the OHPO.

PAVED PARKING AREA WEST OF GH BUILDING AND THE ROADWAY: This parking area covers part of the area that was constructed to serve as the original Mound Laboratory parking area in 1948. Although the area has been reconfigured with the removal of the original grassy islands, and diminished in size due to the encroachment of buildings (e.g., Operational Support East (OSE) and the former Building 91), this area has remained in use as a parking area since the late 1940s.

PAVED PARKING AREA SOUTH OF GH BUILDING: This area was a sloped area on the northern side of the Main Hill. Through time, this area was used as a "landfill", receiving debris and waste materials from plant operations and construction projects. The hillside has been filled in, and the area leveled off to the approximate elevation of adjacent areas to the north and south. It was paved in about 1984 and used as a parking area. In 1999, as part of the plant sites cleanup program, parts of the "landfill" (PRSs 99 and 100) were sampled to determine if they were contaminated. A CERCLA Removal Action followed. The area was then back-filled and re-paved. It is again in use as a parking area.

PAVED PARKING AREA NORTH OF THE ROADWAY: This parking area is a smaller lot constructed atop an area that was back-filled. Initially, this lot was gravel and mat pavement, with space for 35 cars. The date that this area was constructed could not be determined. In plant site photographs from the 1970's and 1980's this area appears as a paved parking lot. According to Mound site drawing 352000-01005, this parking area was constructed in late 1950.

CERCLA PRSs IN PARCEL 3: The PRSs located in Parcel 3 include PRSs 99, 100, and 241. PRSs 99 and 100 are discussed above in conjunction with the paved parking area south of GH Building (a.k.a., the GH parking area). PRS 241 includes all of the existing parking areas, the roadway, the parts of the GH Parking Lot not included in PRSs 99 and 100. PRS 241 boundaries extend to the west beyond this parcel to encompass the DOE parking area.

OTHER STRUCTURES AND FEATURES IN PARCEL 3: In addition to the structures noted above, this area also included three additional guard posts. A modular structure was

located near the current OSE Building within the Parcel 3 area in the late 1980s. This structure was located just outside the fence north of the former Building 91 location, and east of OSE Building. The purpose of this structure was to serve as an entrance to the plant site (through the lobby and OSE Building). This building was a guard post, containing x-ray equipment used for surveillance of materials carried into the plant site.

Also included in Parcel 3 is a concrete stairway down the north end of the Main Hill extending to the fence line. This stairway once served as access to an emergency supply water pump-house and tank constructed in 1948. The City of Miamisburg provided water for the system through a hook up to a municipal water main. Today the stairway is somewhat overgrown with vegetation; a metal gate at the base of the stairway allows access to the plant property.

The small parking area on the bend in the roadway (east of GH Building) was constructed prior to the opening of the Mound site in 1949. Based upon the lot's location this area may have been used for a parking area for visitors being processed for access through GH Building and GIS Building or for vehicles that were not cleared for access. This parking area was recently demolished as part of the MMCIC East Boundary Improvement Project.

3.2 Identifying Exposure Pathways

Although many exposure pathways are possible, the RRE focuses on those pathways that are likely to occur and are likely to contribute significantly to the overall risk. When identifying exposure pathways it is important to keep in mind the four elements of an exposure pathway. An exposure pathway consists of: (1) a source of chemical release, (2) a transport media, (3) a point of potential human contact with the contaminant or contaminated media, and (4) an exposure route (e.g. ingestion). If any of these elements is missing or eliminated, the pathway will be incomplete and exposure will not occur.

A pictorial representation of the exposure pathways identified for potential receptors are included in a conceptual site model for the Parcel 3 (Figure 3.1). The conceptual site model summarizes the pathways that hazardous substances may take to reach potential receptors. Exposure assumptions used to evaluate potential exposure pathways were drawn from the Mound Plant *Risk-Based Guideline Values* (DOE 1997c) and the Mound 2000 RREM (DOE 1997a). Exposure assumptions used to quantify contaminant exposures are summarized in Table 3.1.

3.3 Identifying Exposure Scenarios

Residual contamination in the Parcel 3 was evaluated for two potential use scenarios. Residual contamination in the Parcel 3 area was evaluated for adult construction workers and for adult site employees. It was assumed that construction workers and site employees could potentially be exposed to soil and groundwater. The evaluation of risk associated with exposure to residual contamination in the Parcel 3 area for these receptors will indicate whether economic redevelopment can be safely conducted in the area.

3.3.1 Construction Worker Scenario

Since it is reasonable to assume that construction activities could occur within the Parcel 3 area, adult construction workers were identified as potential receptors. During construction activities these receptors could be exposed to residual contamination present in soil at or below land surface. Potential exposure pathways include incidental soil ingestion, external radiation exposure, and inhalation of airborne dust and vapors. It was also assumed that construction workers would use BVA groundwater for drinking water supply and for showering. Exposure pathways include ingestion, inhalation of vapors and dermal contact with groundwater while showering. Construction workers were assumed to be on the property 8 hours per day, 250 days per year over a 5-year period. Since construction workers are assumed to be adults, a body weight of 70-kilogram was used to assess exposure to chemical contaminants.

Current and future exposure scenarios for the construction worker scenario are identical except for groundwater. In order to estimate the future contaminant concentrations in groundwater, the concentration of contaminants detected in the bedrock aquifer were added to current contaminant concentrations in the Mound Plant Production wells. Exposure pathways evaluated for the construction worker for both current and future scenarios, include:

- incidental ingestion of soil at or below land surface;
- external exposure to ionizing radiation from radionuclides in soil at or below land surface;
- inhalation of airborne contaminated dust;
- inhalation of volatile emissions from soil;
- ingestion of contaminated groundwater as drinking water;

- inhalation of volatile contaminants from groundwater while showering at work; and
- dermal contact with contaminated groundwater while showering at work..

The parameters used to evaluate these pathways and their references are provided in Table 3.1.

3.3.2 Site Employee Scenarios

Although exposures will vary depending on the type of work performed, it is reasonable to assume future employee at Parcel 3 will be exposed to residual contamination left on the property. The exposure routes evaluated for the site employee are similar to those evaluated for the construction worker except the site employee is assumed to work indoors and therefore have less exposure to site soil. Potential soil exposure pathways include incidental soil ingestion, external radiation exposures and inhalation of airborne dust and vapors. Site employees were assumed to use BVA groundwater for potable supply, but are not expected to shower at work. Potential groundwater exposure pathways include ingestion of contaminated groundwater as a water supply. Site employees were assumed to be on the property 8 hours per day, 250 days per year over a 25-year period. Since site employees were assumed to be adults, a body weight of 70-kilogram was used to assess exposure to chemical contaminants.

The exposure pathways evaluated for the future site employee include:

- incidental ingestion of soil 0-2 feet below land surface;
- external exposure to ionizing radiation from radionuclides in soil 0-2 feet below land surface;
- inhalation of airborne contaminated dust;
- inhalation of volatile emissions from soil;
- ingestion of contaminated groundwater as drinking water;

The parameters used to evaluate these pathways and their references are provided in Table 3.1.

3.4 Exposure Point Concentrations

Exposure point concentrations (EPC) are the concentrations of contaminants available to human receptors at the point of contact. The EPC for the RRE was calculated as the 95% UCL of

the arithmetic mean of the data, using the Student's t-statistic. If the data were found to be log normally distributed, the RME estimate was calculated as the 95% UCL using the H-statistic (EPA 1992a).

Only surface soil data (0-2 feet below land surface) were used to calculate the EPC for the site employee. Site employees are assumed to spend most of their time indoors and have limited contact with surface soil. Construction workers were assumed to be exposed to both surface and subsurface soil. Therefore, the EPC for the construction worker was calculated using soil sample data collected at any depth.

3.5 Human Intake Equations and Assumptions

This section presents the exposure equations and assumptions used to derive contaminant-specific intake estimates for the populations and exposure pathways evaluated in the risk assessment. The use of the intake equations presented in this section is in accordance with methods presented by EPA in RAGS Part A (EPA 1989) and the RREM presented in Mound 2000 (DOE 1997a). Exposure assumptions have been developed to represent high-end RME conditions. Exposure assumptions for each of the potential receptors, and corresponding guidance or rationale used in this assessment are presented in Table 3.1.

There is a fundamental difference between exposures to chemical contaminants as compared to radionuclide contaminants. For chemicals, exposure generally refers to the intake (e.g., inhalation, ingestion, dermal exposure) of the chemical, expressed in units of mg/kg-day. Toxicity values for chemicals are generally expressed in these terms; therefore, the product of the intake estimate with the toxicity value yields a risk value. Another key difference is that radionuclides can have deleterious effects on humans without being taken into the body. External radiation exposure can result from exposure to gamma and x-ray emitting radionuclides.

The approach used to estimate intake for chemical contaminants largely applies to radionuclides. However, there are a few key differences in the methods. For example, in addition to the ingestion, inhalation, and direct contact pathways considered for chemical contaminants, external exposure to penetrating radiation was also evaluated for radionuclides. Equations for estimating the intake of radionuclides have been modified by omitting the body weight and averaging time from the denominator. The slope factors for radionuclides are expressed as the

average risk per unit intake or exposure for an individual in a stationary population; therefore, radionuclide intakes and slope factors are not expressed as a function of body weight and time.

Another key difference in the method used to assess radiological risk is the inclusion of short-lived decay products, or daughter products, for radionuclides designated with the suffix +D. The calculation of risk for radioactive decay chain products assumed equal activity concentrations (i.e. secular equilibrium) with the principal or parent nuclide in the environment. Risk calculations for decay chain products were assessed by summing the ingestion, inhalation, and external slope factors for the parent radionuclide and decay members of continuous decay chains (EPA 2000).

Chemical intakes from oral and inhalation exposure are expressed as the amount of chemical at the exchange boundary (e.g., skin, lungs, intestine) that is available for absorption. These intakes are not equivalent to the absorbed dose (the amount of chemical actually absorbed into the blood stream). Dermal doses are expressed as estimates of absorbed dose. The toxicological reference values used to calculate risk have been adjusted to account for this difference; however, this discrepancy is a source of uncertainty when comparing or combining dermal doses with intakes from other exposure routes.

3.5.1 Soil Exposure Pathways

Exposure to soil through incidental ingestion was evaluated for construction workers and site employees under current and future land use scenarios. Intake estimates for the chemical contaminants in soil ingestion pathway were estimated by means of the following equation:

$$Intake\,(mg/kg\text{-}day) = \frac{C_{SO} \times IR \times EF \times ED \times CF}{BW \times AT}$$

Where:

C_{SO}	=	Contaminant concentration in soil (mg/kg)
IR	=	Ingestion rate (mg/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)

CF	=	Conversion factor (10^{-6} kg/mg)
BW	=	Body weight (kg)
AT	=	Averaging time for cancer and non-cancer effects (days)

Radionuclide intake estimates for the soil via incidental ingestion was estimated by means of the following equation:

$$Intake\ (pCi) = C_{SO}\ x\ IR\ x\ EF\ x\ ED\ x\ CF$$

Where:

C_{SO}	=	Radiological activity in soil (pCi/g)
IR	=	Ingestion rate (mg/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF	=	Conversion factor (10^{-3} g/mg)

Unlike inhalation and ingestion exposure to soil, the external radiation exposure term is defined as an equivalent radionuclide concentration in soil that an onsite receptor would be exposed to for a particular duration. This exposure term is adjusted for exposure time and shielding. For the Parcel 3 area RRE a default-shielding factor of 20% was assumed. These assumptions provide for a conservative estimate of external radiation exposure.

The intake equation for radionuclide contaminants via the external exposure pathway was estimated using the following equation:

$$Intake\ (pCi) = C_{SO}\ x\ IR\ x\ ED_2\ x\ (1 - Se) x Te$$

Where:

Cso	=	Radiological activity of soil (pCi/g)
ED_2	=	Exposure Duration x 0.685
Se	=	Gamma Shielding Factor
Te	=	Gamma Exposure Time Factor

Intake of soil (fugitive dust) via inhalation was evaluated for construction workers and site employees under current and future use scenarios. The intake equation for chemical contaminants by this means is provided below:

$$Intake\ (mg/kg\text{ - }day) = \frac{C_{SO}\ x\ IR\ x\ EF\ x\ ED}{PEF\ x\ BW\ x\ AT}$$

Where:

C_{SO}	=	Contaminant concentration in soil (mg/kg)
IR	=	Inhalation rate (m^3/hr)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
PEF	=	Particulate emission factor (4.28 x 10^9 m^3/kg, EPA default value)
BW	=	Body weight (kg)
AT	=	Averaging time for cancer and non-cancer effects (days)

The intake equation for radionuclide contaminants via inhalation of fugitive dust was estimated using the following equation:

$$Intake\ (pCi) = \frac{C_{SO}\ x\ IR\ x\ EF\ x\ ED}{PEF}$$

Where:

C_{SO}	=	Radiological activity in soil (pCi/g)
IR	=	Inhalation rate (m^3/hr)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
PEF	=	Particulate emission factor (4.28 x 10^9 m^3/g, EPA default value)

The PEF relates the concentration of the contaminant in soil to the concentration of respirable particles in the air from fugitive dust emissions. These emissions result from wind erosion. The default value of 4.28×10^{10} m^3/kg was taken from Risk-Based Guideline Values (DOE 1997c).

Volatilization of chemical contaminants from soils may result in exposures via inhalation for construction workers and site employees; however, no volatile COPCs were identified in the Parcel 3 area. Therefore, this pathway was not evaluated for chemical constituents.

3.5.2 Groundwater Exposure Pathways

Intake from the ingestion of groundwater was evaluated for construction workers and site employees under current and future use scenarios. The current concentration of contaminants in groundwater was based on the concentrations detected in the Mound Plant Production wells. The future concentration of contaminants in groundwater assumes that all contaminants currently detected in the bedrock aquifer will migrate to the Great Miami BVA and be withdrawn at the Mound Plant Production wells. Current bedrock contamination was added to current contaminant concentrations in the Mound Plant Production Well to estimate future contaminant concentrations in groundwater. Potential cumulative risks due to exposure to groundwater were not recalculated but were brought forward from the RRE reports for Release Blocks D and H and the associated Technical Position Reports in Support of Release Blocks D and H RREs. The following equation was used to estimate current and future intake of chemical COPCS from the ingestion of groundwater as a drinking water source for both the construction worker and the site employee:

$$\textit{Constituent Intake (mg / kg – d)} = \frac{C_w \times IR_w \times EF \times ED}{BW \times AT}$$

Where:

C_w	=	constituent concentration in water (mg/L)
IR_w	=	ingestion rate (L/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)

In addition to groundwater ingestion the construction worker was assumed to shower at work. While showering they were assumed to have dermal exposure to contaminants in groundwater and to inhale volatile contaminants while showering. The dermal absorbed dose from dermal contact with constituents in surface water or groundwater was calculated as follows:

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

Where:

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

For inorganics, DA_{event} (mg/cm^2-event) was calculated as follows:

$$DA_{event} = K_p\ x\ C_w\ x\ t_{event}$$

Where:

DA_{event}	=	absorbed dose per event in water (mg/cm^2-event)
K_p	=	permeability coefficient from water (constituent-specific, cm/hr)
C_w	=	concentration of chemical in water ($mg/cm^3 = 10^{-3}$ X mg/L)
t_{event}	=	duration of event (hr/event)

For organics, DA_{event} (mg/cm^2-event) was calculated as follows:

$$DA_{event} = 2\ K_p\ C_w\ (6t_{event}/\pi)^{1/2}$$

Where:

DA_{event}	=	absorbed dose per event in water (mg/cm^2-event)

K_p	=	permeability coefficient from water (constituent-specific, cm/hr)
C_w	=	concentration of chemical in water ($mg/cm^3 = 10^{-3}$ X mg/L)
t_{event}	=	duration of event (hr/event)
t	=	lag time (hour)
π	=	constant (3.14159)

Values and equations for K_p, t*, and τ were taken from Chapter 5 of *Dermal Exposure Assessment: Principles and Applications* (EPA 1992b). If a K_p was not found, it was calculated using the following formula:

$$\log (PC) = -2.72 + 0.71 \log (K_{ow}) - 0.0061\, MW$$

Where:

K_{ow}	=	octanol/water coefficient (constituent-specific)
MW	=	molecular weight (g/mole)

Tritium is the only radionuclide present at the Mound Plant that is volatile enough that its vapor needs to be considered for the inhalation pathway. The following equation was used to calculate tritium intake from inhalation during showering:

$$\text{Intake(pCi)} = C_w \times IR_{air} \times EF \times ED \times M_{total} \times ETs \times \frac{L}{1000g}$$

Where:

Cw	=	Tritium concentration in water (pCi/L)
IRair	=	inhalation rate (m^3/d
EF	=	exposure frequency (d/yr)
ED	=	exposure duration (y)
M_{Total}	=	airborne mass concentration of water in shower (66.96 g/m^3, HAZWRAP, 1995)
ET_s	=	shower duration (hr/d)

The following equation was used to calculate the intake of radionuclides from dermal contact with water:

$$\text{Intake(pCi)} = C_w \times SA \times K_p \times EF \times ED \times ETs \times 1000 \times \frac{L}{m^3}$$

Where:

C_w	=	concentration of contaminant in water (pCi/L)
SA	=	surface area of skin exposed (cm^2)
K_p	=	chemical-specific permeability constant
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
ETs	=	duration of event (hours/day)

4.0 TOXICITY ASSESSMENT

The objectives of the toxicity assessment are to identify and select toxicological values for use in estimating the significance of the exposure and to evaluate potential adverse effects associated with exposure to compounds detected in Parcel 3. The RRE for the Parcel 3 area evaluated chronic exposures. The RRE utilized methods recommended by EPA for evaluating human cancer and non-cancer effects resulting from exposure to the COPCs. All the COPCs detected in Parcel 3 soil were radionuclides that are considered to be human carcinogens. These constituents do not have non-cancer toxicity criteria so non-carcinogenic health effects were not evaluated in soils. A cancer and non-cancer toxicity assessment for COPCs in groundwater was conducted as part of the RREs for Release Blocks D and H. For Parcel 3 no additional toxicity assessment was conducted for groundwater. The groundwater results in Release Blocks D and H and the groundwater risk updates in the associated Technical Position Reports for Release Blocks D and H were used and risk was not recalculated.

The toxicity criteria used in the RRE were obtained from the most current update of the EPA Integrated Risk Information System (IRIS) or, if the information was not available in IRIS, the EPA Health Effects Assessment Summary Tables (HEAST). IRIS is an electronic database containing the most current descriptive and quantitative EPA regulatory information on chemical and radiological constituents. Constituent files maintained in IRIS contain information related to non-carcinogenic and carcinogenic health effects of constituents. HEAST is a published reference, updated periodically by EPA. HEAST contains slope factors needed to evaluate the carcinogenicity of radionuclides. Table 4.1 presents a summary of toxicological criteria used to calculate risk to soil COPCs, along with the chemical-specific characteristics used to estimate dermal absorbed dose and the concentrations present in vapors or dust. Since groundwater and air risk was not recalculated for Parcel 3, no toxicity criteria are presented for COPCs.

In assessing the potential for non-cancer health effects, EPA assumes that there is a threshold below which no adverse toxic effects are expected. For example, a toxic threshold would exist if a substance had no toxic effect at a certain level of exposure, but did have a toxic effect at a higher level. EPA derives and publishes reference doses (RfDs) and reference concentrations (RfCs) for use in evaluating adverse non-carcinogenic effects. These are estimates (with uncertainty spanning an order of magnitude or greater) of daily human exposures, including

sensitive sub-populations, that may go without appreciable deleterious effects during a lifetime (EPA 1989). EPA derives RfDs and RfCs for humans, based on estimates of the no-observable-adverse-effect-level (NOAEL) or lowest-observable-adverse-effect-level (LOAEL) observed in test organisms.

EPA classifies all radionuclides as carcinogens and the process of carcinogenesis is generally thought to be a phenomenon without a threshold for effect (EPA 1989). The basis for this presumption is that an extremely low level of exposure to some carcinogens may result in chromosomal or enzyme changes leading to uncontrolled cellular proliferation, or cancer. EPA does not therefore, estimate an effect threshold for carcinogenic chemicals. EPA uses a two-part evaluation for carcinogens. First the constituent is assigned a weight-of-evidence classification based on both epidemiological evidence of carcinogenic effects and laboratory tests conducted with animals. Then a cancer slope factor (CSF), is calculated. The HEAST lists ingestion, inhalation, and external exposure CSF for radionuclides in the units of picocuries (pCi). Ingestion and inhalation slope factors are central estimates in a linear model of the age-averaged, lifetime-attributable radiation cancer incidence (fatal and nonfatal) risk per unit of activity inhaled or ingested. The slope factor is a plausible upper-bound estimate of the slope of the dose-response curve in the low dose range. In risk assessment, the cancer slope factor is used to estimate the excess lifetime probability of a carcinogenic effect occurring in exposed receptors.

4.1 Toxicity Values for Evaluating the Dermal Pathway

Toxicological reference values are available only for the oral and inhalation pathways and the majority of these values are based on intake (i.e., administered dose) rather than an absorbed dose. Because the intake equation for the dermal contact pathway calculates absorbed dose (by incorporating a dermal absorption factor or a permeability coefficient), it is necessary to convert the administered dose toxicity value to an absorbed dose toxicity value in order to calculate risk. For the Parcel 3 RRE oral administered-dose toxicity values were adjusted using compound specific gastrointestinal absorption factors. For non-carcinogens, the administered dose toxicity value (i.e., the RfD) was multiplied by the gastrointestinal absorption factor. For carcinogens, the slope factor was divided by the gastrointestinal absorption factor.

5.0 RISK CHARACTERIZATION

This section presents the risk characterization for the Parcel 3. In risk characterization information from the exposure assessment (Section 3) combined with information from the toxicity assessment (Section 4) is used to characterize human health risks.

5.1 Risk Characterization Methods

Risk characterization integrates the exposure and toxicity assessments by comparing estimates of intake or dose with appropriate toxicity values. This in turn provides an indication of the potential for adverse effects to exposed receptors. The objective of the risk characterization is to determine if exposure to contaminants associated with the site pose risks that exceed EPA target levels for human health effects. The results of the risk assessment may thus support the determination of site release or the need for site remediation.

The RRE reports the incremental risk, total risk, and risk from background for each contaminant evaluated in the Parcel 3 RRE. The incremental risk is the risk posed by site-related contamination above the risk posed by background environmental levels. Background risk is the risk resulting from sources other than the Mound-related residual contamination. Total risk is the sum of the background and incremental risk. This risk characterization presents a separate evaluation of non-carcinogenic and carcinogenic effects. The assessment distinguishes cancer from non-cancer effects because organisms typically respond differently following exposure to carcinogenic or non-carcinogenic agents. Quantification methods for cancer and non-cancer effects are discussed separately in the following sections.

5.1.1 Quantification of Carcinogenic Risk

Cancer risks are probabilistic estimates of the excess lifetime cancer risk for an individual specifically attributable to long term exposure to site-related chemicals. The procedure for calculating risk associated with exposure to carcinogenic compounds has been established by EPA (EPA 1989). A non-threshold, dose-response model was used to calculate a cancer slope (potency) factor for each COPC. To derive an estimate of risk, the cancer slope factor was multiplied by the estimated chronic daily intake experienced by the exposed individual:

$$\text{Risk} = \text{CDI} \times \text{CSF}$$

Where:

Risk	=	High end estimate of the excess lifetime cancer risk to an individual (unitless probability)
CDI	=	Chronic daily intake averaged over a 70-year period (mg/kg body weight/day)
CSF	=	Cancer slope factor (95% upper-bound estimate of the slope of the dose-response curve) expressed as $(\text{mg/kg body weight/day})^{-1}$.

To evaluate the risk of exposure to more than one carcinogen COPC, the risk estimate for each COPC was summed to provide an overall estimate of total carcinogenic risk (EPA 1989).

$$\text{Risk}_T = \sum_{i=1}^{n} \text{Risk}_i$$

Where:

Risk_T	=	The combined excess lifetime cancer risk across chemical carcinogens
Risk_i	=	The risk estimate for the ith chemical of n chemicals under evaluation.

5.1.2 Quantification of Non-carcinogenic Risk

The traditionally accepted practice of evaluating exposure to non-carcinogenic compounds has been to experimentally determine a NOAEL and to divide this by a safety factor to establish an acceptable human dose, for example, acceptable daily intake or RfD. The RfD is then compared to the average daily intake experienced by the exposed population to obtain a measure of concern for adverse non-carcinogenic effects:

$$\text{HQ} = \frac{Intake}{\text{RfD}}$$

Where:

HQ	=	Hazard Quotient: potential for adverse non-carcinogenic effects

Intake = Average daily intake for subchronic or chronic exposure (mg/kg body weight/day)

RfD = Acceptable intake for subchronic or chronic exposure (mg/kg body weight/day).

To evaluate exposure to multiple non-carcinogenic COPCs the HQs for all COPCs were summed to obtain the Hazard Index (HI).

$$HI = \sum_{i=1}^{n} HQ$$

Where:

HI = The combined excess non-cancer risk

HQ: = the hazard quotient risk estimate for the ith chemical of n chemicals under evaluation.

EPA has established target risk levels for use in determining the need for site remediation. For non-carcinogenic effects, EPA has set the target HQ at one. If the HQ is >1, there is the potential for adverse health effects at the given exposure/dose level, but the HQ value is not an indication of the severity of the effects. For multiple non-carcinogens, the HQs for all of the chemicals under evaluation are summed resulting in the HI. If the HI is > 1, the potential also exists for adverse health effects resulting from exposure to mixtures of chemicals. In cases where the HQ for individual substances is below 1 yet several HQs sum to greater than 1, EPA recommends segregating the compounds into groups with like or common toxicological effects and re-evaluating the potential for the various adverse health effects. In cases where HQs for individual substances are greater than 1, this step is not necessary or useful.

5.2 Risk Characterization Results

The following sections present the risk characterization results for the Parcel 3 by potential receptor. Risk estimates for individual soil COPCs for all scenarios and pathways are presented in Tables 5.1 through 5.4. Tables 5.1 through 5.3 present risk estimates based on construction worker exposure parameters, and Table 5.4 presents risk estimates based on site employee exposure parameters. Total risk was calculated using total concentration of the COPCs detected in the area. Background risk was based on background levels of the COPCs and incremental risk was calculated using the difference between total and background levels.

Incremental risk can be used to assess the increase in risk above background levels due to Mound Plant operations. Tables 5.5 through 5.7 present summaries of the risk results for all scenarios for exposure pathways assessed in the RRE.

Residual risk due to exposure to groundwater was assessed using the same database, method, and results as presented in the RRE for Parcel H (DOE 1997b) and updates presented in the Technical Position Paper for Release Block H (DOE 1999). Risk in groundwater was not recalculated for Parcel 3. Summaries of potential risks due to exposure to current and future groundwater are presented in Tables 5.5 through 5.7. In the summary tables, risk estimates that are at or above the non-cancer HI of 1 and the cancer target risk level of 1×10^{-6} (1.0E-06) are bolded.

5.2.1 Construction Worker Risk Results

Tables 5.1 through 5.3 present total, background, and incremental risk for a construction worker adult in the Parcel 3, respectively. No soil COPCs with non-carcinogenic toxicity criteria were identified in Parcel 3, therefore, the total, background, and incremental non-cancer risk was zero indicating that a non-cancer risk does not exist for this parcel. Two radiological soil COPCs were identified in Parcel 3. Total residual cancer risk for a construction worker adult is 9.0E-06, which falls within the target risk range of 1.0E-06 to 1.0E-04. Background residual risk for a construction worker in Parcel 3 was 2.3E-08, which is less than 1% of the total risk. Incremental residual soil risk (8.9E-06) was not substantially different from total residual risk and falls within the target risk range. External exposure to radiation is the exposure pathway that contributes most significantly to residual cancer risk. External radiation contributes 85% of the total residual cancer risk for a construction worker in Parcel 3 soil.

Groundwater

Total and incremental non-carcinogenic residual risk for the future construction worker scenario exceeds the target HI of 1 with values of 1.7 and 1.6, respectively. Background non-carcinogenic residual risk for the construction work, and current total and incremental residual risk due to exposure to groundwater does not exceed target non-carcinogenic risk. Total and incremental carcinogenic risks associated with exposure to groundwater fall within the target risk range of 1.0E-04 to 1.0E-06 for the current and future construction worker scenarios.

Air

Potential cumulative carcinogenic risk due to exposure to contaminates in air was 2.1E-07, which is less than the target risk range. None of the COPCs identified in air have non-carcinogenic risk criteria so a HI was not calculated for exposure to contaminants in air.

5.2.2 Site Employee Risk Results

Table 5.4 presents total and incremental residual soil risk for an adult site employee in Parcel 3. For the site employee scenario, radium-228, was the only COPC identified in soil for RRE calculations. Since no background concentration is available for radium-228, background risk could not be calculated. Therefore, total and incremental risks are equivalent. No non-carcinogenic soil COPCs were identified in Parcel 3, therefore, the total, background and incremental non-cancer risk was zero indicating that a non-cancer risk soil does not exist for this parcel in soil. Total and incremental residual cancer risk for a site employee adult in Parcel 3 is 8.4E-06, which falls within the target risk range of 1.0E-06 to 1.0E-04. External exposure to radiation is the exposure pathway that contributes most significantly to residual cancer risk. External radiation contributes 99% of the total residual cancer risk for the site employee in Parcel 3 soil.

Groundwater

Total and incremental non-carcinogenic residual risk for the future site employee scenario exceeds the target HI of 1 with a value of 1.6. Background non-carcinogenic residual risk for the site employee scenario, and current total and incremental residual risk due to exposure to groundwater does not exceed target non-carcinogenic risk. Total and incremental carcinogenic risks associated with exposure to groundwater fall within the target risk range of 1.0E-04 to 1.0E-06 for the current and future site employee scenarios.

Air

Potential cumulative carcinogenic risk due to site employee exposure to contaminates in air was 9.9E-07, which is slightly less than the target risk range. None of the COPCs identified in air have non-carcinogenic risk criteria so a HI was not calculated for exposure to contaminants in air.

5.2.3 Overall Summary of Risk Results

Overall total, background, and incremental cancer and non-cancer risks are presented in Table 5.8. The risk values in the table are the addition of all of the media and associated pathways for the construction worker and site employee scenarios. Total and incremental noncarcinogenic risks exceed target criteria for the future construction worker and future site employee and result from the groundwater pathway. Overall carcinogenic risks associated with exposure to soil, groundwater, and air fall within the target risk range of 1.0E-04 to 1.0E-06 for both potential receptors.

6.0 UNCERTAINTY IN THE RISK ASSESSMENT

In the following section, an evaluation is presented of the sources of uncertainty in the Parcel 3 RRE and the relative influence of these sources on the results of the evaluation. Uncertainty is inherent in the selection of input parameters and in every step of the risk assessment process. Risk assessment of contaminated sites must not be viewed as yielding single value, invariant results. Rather, the results of risk assessment are estimates that span a range of possible values, and which must be understood only in light of the assumptions and methods used in the evaluation.

The results of the RRE are presented in terms of the potential for adverse effects based upon a number of conservative assumptions. The tendency to be conservative is an effort to error toward protecting health. Uncertainty can be found at all phases in the risk assessment: in the analytical data, the exposure assessment, the toxicity assessment, and the risk characterization. Where uncertainty does exist, the RRE uses conservative assumptions to ensure that the outcome will be protective.

6.1 Uncertainty in Analytical Data

Uncertainty is introduced to the RRE when sample locations are selected and when samples are collected and analyzed. In the RRE, the long-term exposure concentrations were upper estimates of site concentrations (e.g., maximum detect or 95% UCL); therefore, a conservative bias to overestimate potential exposure has been incorporated into the risk estimates. The uncertainty associated with the statistical analysis of environmental data is low, with little introduction of bias. However, it is possible that contaminated areas of Parcel 3 were not sampled. This is unlikely given the extent of sampling conducted. Radium-228 was only analyzed in one sample, which presents uncertainty for the EPC of this radionculide.

6.2 Uncertainty in Exposure Assessment

Exposure assessment may introduce considerable uncertainty in the risk assessment process. The RREM presents exposure and intake calculations based on EPA procedures that were used in the Parcel 3 RRE. Exposure assumptions values were also used to develop site-specific risk-based guideline values for the Mound Plant which were by Ohio EPA and EPA.

Exposure assumptions are based on speculation regarding potential land use, assumptions concerning contaminant fate and transport, and receptor behavior. The uncertainty associated with the exposure assumptions used in the risk assessment is low to moderate, and most likely overestimates the actual risks.

Another source of uncertainty in the Parcel 3 RRE involves external exposure to gamma-emitting radionuclides. External exposure refers to the irradiation of tissues by radiations emitted by radionuclides located outside the body either dispersed in air, on skin surfaces, or deposited on ground surfaces. Gamma and x-rays are the most penetrating of the emitted radiations and comprise the primary contribution to radiation dose from external exposures. The calculation of risk from external radiation exposure assumes that any gamma-emitting radionuclide in soil is uniformly distributed in soil. The calculation of external radiation exposure risk includes a gamma shielding factor (S_e) to account for attenuation of radiation by structures, terrain or engineered barriers. S_e is expressed as a fractional value between 0 and 1, representing the possible risk reduction range from 0% to 100% due to shield. For the Parcel 3 RRE a default value of 0.2 or 20% shielding for the site employee and 0.1 or 10% shielding for the construction worker scenarios was used in the risk calculations. These are conservative values, which do not account for backfill material that was placed over the excavated area (SAIC 1997). It is possible that backfill in the Parcel 3 area provides a greater shielding from gamma radiation, resulting in lower risk than what is presented here.

6.3 Uncertainties Related to Toxicity Information

Although EPA approved toxicity values were used for the RRE a significant amount of uncertainty may surround these values. Identification of the sources of this uncertainty enables the risk assessor to establish the degree of confidence associated with the toxicity measures.

Uncertainty is inherent within the toxicity assessment and is primarily due to differences in study design, species, sex, routes of exposure, or dose-response relationships. A major source of uncertainty involves using toxicity values based on experimental studies that substantially differ from typical human exposure scenarios. The derivation of the toxicity values must take into account such differences as 1) using dose-response information from animal studies to predict effects in humans, 2) extrapolating dose-response information from high-dose studies to predict

adverse health effects from low doses, 3) using data from short-term studies to predict chronic effects, and 4) extrapolating from uniform animal populations to variable human populations.

The cancer slope factors in particular are based on studies that may differ greatly from realistic situations. Experimental cancer bioassays typically expose animals to very high levels of chemicals (i.e., the maximum tolerated dose) for their entire lifetime. After appropriate studies have been identified, the slope factor is calculated as the upper 95th percent confidence limit of the slope of the dose-response curve. This introduces conservatism into the risk assessment. In addition, carcinogens are assumed to be human carcinogens regardless of EPA's weight-of-evidence classification.

The derivation of reference doses involves the use of animal studies. Uncertainty factors ranging from 1 to 1,000 are incorporated into the reference dose to provide an extra level of health protection. The factors used depend on the type of study from which the value has been derived (e.g., animal or human, chronic or acute, study design). The scientific basis for this practice is somewhat subjective. In general, high uncertainty factors are meant to bias the results conservatively so that exposures at the reference dose level will not result in adverse health effects.

Toxicity values derived from oral administered dose studies have been converted to absorbed dose toxicity values for use in evaluating the dermal contact pathway. This is considered a more accurate approach than using unadjusted oral toxicity values for the dermal pathway. Uncertainty is introduced in the use of the gastrointestinal absorption factors. Limited information is available on the gastrointestinal absorption of some analytes and many have no information at all. In addition, no adjustments have been made for the medium of exposure (e.g., when the medium of exposure in the site differs from the medium of exposure assumed by the toxicity value). The uncertainty associated with using the absorbed dose toxicity values for the dermal pathway is moderate and the bias unknown.

There are some chemicals for which no toxicity value exists and for which little information is available. Therefore, a quantitative risk estimate cannot be calculated for these chemicals. For example, many chemicals are not evaluated for the inhalation pathway because of limited inhalation-based toxicological information. The lack of toxicity information for some chemicals contributes to the underestimation of risks.

Cancer and non-cancer risks are summed in the risk characterization process (separately for carcinogens and non-carcinogens) to estimate potential risks associated with the simultaneous exposure to multiple chemicals. In the case of carcinogens, this gives carcinogens with a class B or class C weight-of-evidence the same weight as carcinogens with a class A weight-of-evidence. It also equally weights slope factors derived from animal data with those derived from human data. Uncertainties in the combined risks are also compounded because RfDs and cancer slope factors do not have equal accuracy or levels of confidence and are not based on the same severity of effect.

6.4 Uncertainties in Risk Characterization

Uncertainties in any phase of the risk analysis are reflected in the risk estimates. Some uncertainty is associated with the summation of risks and HQs for multiple chemical contaminants. As stated in RAGS (EPA 1989), "The assumption of dose additivity ignores possible synergisms or antagonisms among chemicals, and assumes similarity in mechanisms of action and metabolism." However, summing risks and HQs for multiple substances in this risk assessment provides a conservative estimate.

7.0 REFERENCES

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TABLES

Table 2.1 Identification of Constituents of Potential Concern for the Construction Worker Scenario in Release Block 3.

CAS Number	Chemical	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	95 Percent UCL	Concentration Used for Screening	Background Value	Construction Worker Screening GV	Reference Screening GV	COPC?
Metals												
7440-43-9	Cadmium	0.09	0.75	mg/kg	G4	132-144	0.24	0.24	2.1	21.0	a	NO:2,3
7440-47-3	Chromium	5.20	26.00	mg/kg	X10	144-144	15.00	15.00	20	21000.0	a	NO:2,3
7440-47-3	Chromium (VI)	0.98	2.30	mg/kg	A5, X2	6-152	0.55	0.55		62.0	e	NO:1
7439-92-1	Lead	3.60	41.70	mg/kg	X10	144-144	13.60	13.60	48			NO:2
7440-02-0	Nickel	4.10	64.10	mg/kg	D3	144-144	19.80	19.80	32	430.0	a	NO:2,3
Volatile Organic Compounds												
76-13-1	1,1,2 trichloro-1,2,2-trifluoroethane	1.41	1.41	ug/kg	607	1-10	NC	1.41		640000000.0	a, e	NO:3
78-93-3	2-Butanone	3.33	28.13	ug/kg	603	10-10	NC	28.13		930000.0	b	NO:3
67-64-1	Acetone	12.59	142.36	ug/kg	603	9-10	NC	143.36		2100000.0	a	NO:3
100-41-4	Ethylbenzene	18.01	18.01	ug/kg	602	1-10	NC	18.01		48.0	b	NO:3
75-09-2	Methylene Chloride	8.07	20.24	ug/kg	602	10-10	NC	8.07		100000.0	c	NO:3
79-34-5	Tetrachloroethene	2.94	2.94	ug/kg	602	1-10	NC	2.94		210000.0	a	NO:3
108-88-3	Toluene	1.32 J	23.44 J	ug/kg	602	3-10	NC	1.32		25000.0	b	NO:3
1330-20-7	Xylenes, Total	76.90 J	76.90 J	ug/kg	602	1-10	NC	76.90		43000000.0	a	NO:3
Radionuclides												
7440-34-8	Actinium-227+D	0.11	0.43	pCi/g	4444	6-25	0.20	0.20		1.0	d	NO:3
14596-10-2	Americium-241	0.11	0.11	pCi/g	4444	1-60	0.17	0.11		5.0	d	NO:1
10045-97-3	Cesium-137	0.04	0.50	pCi/g	S011	24-60	0.14	0.14	0.42	0.5	d	NO:2,3
7440-48-4	Cobalt-60	0.03	0.07	pCi/g	602	3-60	0.10	0.07		0.1	d	NO:3
14255-04-0	Lead-210	0.58	2.99	pCi/g	4459	23-35	1.29	1.29		1.7	e	NO:3
13981-16-3	Plutonium-238	0.02	35.00	pCi/g	SCR412	39-90	6.85	6.85	0.13	5.5	d	YES
13981-16-3	Plutonium-239/240	0.01	0.31	pCi/g	602	5-24	0.06	0.06	0.18	5.5	d	NO:2,3
13966-00-2	Potassium-40	3.70	31.20	pCi/g	601	24-24	21.70	21.70	37	1.6	e	NO:2
13982-63-3	Radium-226	0.40	3.88	pCi/g	4444	57-59	1.67	1.67	2	0.1	d	NO:2
13982-63-3	Radium-228	1.52	1.52	pCi/g	601	1- 1	NC	1.52		0.3	e	YES
14274-82-9	Thorium-228	0.44	0.95	pCi/g	D1	24-24	0.74	0.74	1.5	0.2	e	NO:2
14269-63-7	Thorium-230	0.40	17.88	pCi/g	4444	29-49	3.49	3.49	1.9	44.0	d	NO:3
7440-29-1	Thorium-232	0.37	4.47	pCi/g	C0004	26-66	0.87	0.87	1.4	50.0	d	NO:2,3
7440-29-1	Thorium-232+D	0.21	0.94	pCi/g	4444	25-25	0.65	0.65	1.4	0.1	e	NO:2
10028-17-8	Tritium	1.32	1.54	pCi/g	S0078	2- 2	NC	1.54	1.6	23500.0	d	NO:2,3
13966-29-5	Uranium-234	0.16	0.37	pCi/g	X5	13-13	NC	0.37	1.1	37.5	d	NO:2,3
15117-96-1	Uranium-235	0.02	0.03	pCi/g	E3	2-13	NC	0.03	0.11	3.4	d	NO:2,3
7440-61-1	Uranium-238	0.18	0.34	pCi/g	X5	13-13	NC	0.34	1.2	11.0	d	NO:2,3

a= 1/10th HI for ingestion
b= 1/10th HI for ingestion + inhalation
c= cancer risk for ingestion
d= cancer risk for ingestion + inhalation + external
e = Screening Guidance Values calculated using the methodology, equations, and parameters presented in Mound Screening GV 3/97
NC= not calculated, less than 20 samples in the data set.

NO:1 - <5% Detects
NO:2 - <Background
NO:3 - < Screening Toxicity Value
NO:2,3 - <Background, Screening Toxicity

Table 2.2 Identification of Constituents of Potential Concern for the Site Worker Scenario in Release Block 3

CAS Number	Chemical	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	95 Percent UCL	Concentration Used for Screening	Background Value	Site Employee Screening GV	Reference Screening GV	COPC?
Volatile Organic Compounds												
	1,1,2 trichloro-1,2,2-trifluoroethane	1.41	1.41	ug/kg	607	1-10	NC	1.41		6100000000.0	e	NO:3
78-93-3	2-Butanone	3.33	28.13	ug/kg	603	10-10	NC	28.13		930000.0	b	NO:3
67-64-1	Acetone	12.59	142.36	ug/kg	603	9-10	NC	142.36		20000000.0	a	NO:3
100-41-4	Ethylbenzene	18.01	18.01	ug/kg	602	1-10	NC	18.01		48.0	b	NO:3
75-09-2	Methylene Chloride	8.07	20.24	ug/kg	602	10-10	NC	20.24		100000.0	c	NO:3
79-34-5	Tetrachloroethane	2.94	2.94	ug/kg	602	1-10	NC	2.94		2000000.0	b	NO:3
108-88-3	Toluene	1.32 J	23.44 J	ug/kg	602	3-10	NC	23.44		25000.0	b	NO:3
1330-20-7	Xylenes, Total	76.90 J	76.90 J	ug/kg	602	1-10	NC	76.90		410000000.0	a	NO:3
Radionuclides												
7440-34-8	Actinium-227+D	0.11	0.43	pCi/g	4444	6-25	0.20	0.20		1.1	d	NO:3
14596-10-2	Americium-241	0.11	0.11	pCi/g	4444	1-37	0.11	0.11		9.2	d	NO:1
10045-97-3	Cesium-137	0.04	0.50	pCi/g	S011	23-37	1.32	0.13	0.42	0.4	d	NO:2,3
7440-48-4	Cobalt-60	0.03	0.70	pCi/g	602	3-37	0.06	0.06		0.1	d	NO:3
14255-04-0	Lead-210	0.58	2.99	pCi/g	4459	23-35	1.29	1.29		3.2	e	NO:3
13981-16-3	Plutonium-238	0.02	35.00	pCi/g	SCR412	31-71	8.31	8.31	0.13	11.0	d	NO:3
PU-239/240	Plutonium-239/240	0.01	0.31	pCi/g	602	5-10	NC	0.31	0.18	10.0	d	NO:3
13966-00-2	Potassium-40	16.80	31.20	pCi/g	601	10-10	NC	31.10	37	1.4	e	NO:2
13982-63-3	Radium-226	0.40	3.88	pCi/g	4444	34-36	1.92	1.92	2	0.1	d	NO:2
13982-63-3	Radium-228	1.52	1.52	pCi/g	601	1-1	NC	1.52		0.3	e	YES
14274-82-9	Thorium-228	0.60	0.82	pCi/g	601	10-10	NC	0.82	1.5	0.1	e	NO:2
14269-63-7	Thorium-230	0.40	17.88	pCi/g	4444	15-35	4.21	4.21	1.9	81.0	d	NO:3
7440-29-1	Thorium-232	0.41	0.70	pCi/g	601	10-47	0.76	0.70	1.4	92.0	d	NO:2,3
7440-29-1	Thorium-232+D	0.21	0.94	pCi/g	4444	25-25	0.65	0.65	1.4	0.1	e	NO:2
10028-17-8	Tritium	1.32	1.54	pCi/g	S0078	2- 2	NC	1.54	1.6	45000.0	d	NO:2,3

a= 1/10th HI for ingestion
b= 1/10th HI for ingestion + inhalation
c= cancer risk for ingestion
d= cancer risk for ingestion + inhalation + external
e= Screening Guidance Values calculated using the methodology, equations, and parameters presented in Mound Screening GV 3/97
NC= not calculated, less than 20 samples in the data set.

NO:1 - <5% Detects
NO:2 - <Background
NO:3 - < Screening Toxicity Value
NO:2,3 - <Background, Screening Toxicity

Table 3.1 Exposure Assumptions for Construction Worker and Site Employee in Parcel 3

Parameter	Units	Construction Worker Adult	Site-Employee Adult	Reference
Medium/pathway				
Surface soil (0 - 2 ft.) & Sediment				
Incidental ingestion				
Soil ingestion rate	mg/day	480	50	a
Exposure frequency	days/year	250	250	b
Exposure duration	years	5	25	c
Body weight	kg	70	70	d
Carcinogen averaging time	days	25550	25550	e
Noncarcinogen averaging time	days	1825	9125	e
Conversion Factor	kg/mg	1.00E-06	1.00E-06	
Inhalation of VOCs and dust				
Inhalation rate	m^3/day	20	20	f
Exposure frequency	days/year	250	250	b
Exposure duration	years	5	25	c
Body weight	kg	70	70	d
Carcinogen averaging time	days	25550	25550	e
Noncarcinogen averaging time	days	1825	9125	e
Conversion Factor	days/hour	0.042	0.042	
Air Exchange Rate	air changes/hour	N/A	0.45	h
Surface/Subsurface soil (0 - 10 ft.)				
Incidental ingestion				
Soil ingestion rate	mg/day	480	NA	a
Exposure frequency	days/year	250	NA	b
Exposure duration	years	5	NA	c
Body weight	kg	70	NA	d
Carcinogen averaging time	days	25550	NA	e
Noncarcinogen averaging time	days	1825	NA	e
Conversion Factor	kg/mg	1.00E-06	NA	
Inhalation of VOCs and dust				
Inhalation rate	m^3/day	20	20	f
Exposure frequency	days/year	250	250	b
Exposure time	hours/day	8	8	g
Exposure duration	years	5	25	c
Body weight	kg	70	70	d
Carcinogen averaging time	days	25550	25550	e
Noncarcinogen averaging time	days	1825	9125	e
Particle Emissions Factor	m^3/kg	4.28×10^9	4.28×10^9	
Conversion Factor	g/kg	1000	1000	
Conversion Factor	days/hour	0.042	0.042	
External Exposure				
Gamma Shielding Factor		0.1	0.2	
Gamma Exposure Time Factor		1/3	1/12	
Exposure Duration 2	years	5 X 0.685	25 X 0.685	c
Exposure Frequency	day/year	250	250	b

Table 3.1 Exposure Assumptions for Construction Worker and Site Employee in Parcel 3

Parameter	Units	Construction Worker Adult	Site-Employee Adult	Reference
Groundwater				
Drinking water ingestion				
Drinking water ingestion rate	L/day	1	1	i
Exposure frequency	days/year	250	250	b
Exposure time	years	5	25	g
Body weight	kg	70	70	d
Carcinogen averaging time	days	25550	25550	e
Noncarcinogen averaging time	days	1825	9125	e
Dermal contact while showering				
Skin surface area available for contact	cm^2	19400	NA	j
Exposure time	hr/day	0.167	NA	g
Exposure frequency	days/year	250	NA	b
Exposure duration	years	5	NA	c
Body weight	kg	70	NA	d
Carcinogen averaging time	days	25550	NA	e
Noncarcinogen averaging time	days	1825	NA	e
Conversion factor	L/cm^3	0.001	NA	
Inhalation of VOCs while showering				
Inhalation rate	m^3/day	20	NA	f
Exposure time	hr/day	0	NA	g
Exposure frequency	days/year	250	NA	b
Exposure duration	years	5	NA	c
Body weight	kg	70	NA	d
Carcinogen averaging time	days	25550	NA	e
Noncarcinogen averaging time	days	1825	NA	e

Table 3.1 (continued)
Exposure Assumption References

a	Soil ingestion rate	Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio. (DOE 1997c) and RAGS Part A (EPA 1989)
b	Exposure frequency	Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio. (DOE 1997c) and RAGS Part A (EPA 1989)
c	Exposure duration	Exposure duration for the construction worker and site employee is based on Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio. (DOE 1997c) and RAGS Part A (EPA 1989)
d	Body weight	Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio. (DOE 1997c) and RAGS Part A (EPA 1989).
e	Averaging time	Carcinogenic averaging time = 70 yrs * 365 days/year. Non-carcinogenic averaging time = exposure duration (yrs) * 365 days/year.
f	Inhalation rate	Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio. (DOE 1997c) and EFH Volume I, Table 1-2.
g	Exposure time	Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio. (DOE 1997c) and RAGS Part A (EPA 1989)
h	Air exchange rate	Volume of residential homes, EFH, Volume III, Table 17-3. 50th percentile air exchange rate of 0.45 air changes per hour, EFH, Volume III, Table 17-10 (EPA 1997).
i	Drinking water ingestion	Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio.(DOE 1997c) and RAGS Part A (EPA 1989).
j	Skin surface available for contact	Risk-Based Guideline Values, Mound Plant, Miamisburg, Ohio. (DOE 1997c) and RAGS Part A (EPA 1989).

Table 4.1 Toxicity Values and Chemical-Specific Parameters for Constituents of Potential Concern in Parcel 3

	Non-Cancer			Cancer				Dermal Exposure Parameters				
								General		Soil	Water	
Chemical	Oral RFDo (mg/kg/day)	Dermal Adjusted RFDa (mg/kg/day)	Inhalation RFDi (mg/kg/day)	Oral CSFo $(mg/kg/day)^{-1}$	Dermal Adjusted CSFa $(mg/kg/day)^{-1}$	External Radiation $(mg/kg/day)^{-1}$	Inhalation CSFi $(mg/kg/day)^{-1}$	GI Factor (Unitless)	Source (Unitless)	Dermal ABS (Unitless)	Kp (cm/hr)	tau (hour)
INORGANICS												
Beryllium	2.00E-03	2.00E-05	5.70E-06	NA	NA	NA	8.40E+00	0.01	a	0.01	1.00E-03	
Bismuth	NA	NA	NA	NA	NA	NA	NA	0.01			1.00E-03	
Cadmium	5.00E-04	5.00E-06	NA	NA	NA	NA	6.30E+00	0.01		0.001	1.00E-03	
Chromium	5.00E-04	5.00E-06	NA	NA	NA	NA	6.30E+00	0.01	a	0.1	1.00E-03	
Cobalt	6.00E-02	4.80E-02	NA	NA	NA	NA	NA	0.80	a	0.01	1.00E-03	
Copper	3.70E-02	1.11E-02	NA	NA	NA	NA	NA	0.3	a	0.01	1.00E-03	
Lead	NA	NA	NA	NA	NA	NA	NA	0.15	a	0.01	1.00E-03	
Molybdenum	5.00E-03	1.90E-03	NA	NA	NA	NA	NA	0.38	a	0.01	1.00E-03	
VOCs						NA						
1,1-Dichloroethene	9.00E-03	7.20E-03	9.00E-03	6.00E-01	7.50E-01	NA	1.80E-01	0.8	b	0.3		
1,1,1-Trichloroethane	NA	NA	2.90E-01	NA	NA	NA	NA	0.8	b	0.3		
1,1,2-Trichloro-1,2,2-triflouroethane	3.00E+01	2.40E+01	8.60E+00	NA	NA	NA	NA	0.8	b	0.3		
Radionuclides (Risk/pCi)												
Actinium-227+D	NA	NA	NA	6.26E-10	6.26E-07	9.30E-07	7.87E-08	0.001	c			
Bismuth-210	NA	NA	NA	7.29E-12	1.46E-10	0.00E+00	5.12E-11	0.05	c			
Plutonium-238	NA	NA	NA	2.95E-10	2.95E-07	1.94E-11	2.74E-08	0.001	c			
Plutonium-239/240	NA	NA	NA	3.16E-10	3.16E-07	1.26E-11	2.78E-08	0.001	c			
Radium-228+D	NA	NA	NA	2.48E-10	1.24E-09	3.28E-06	9.68E-08	0.20	c			
Strontium-85	NA	NA	NA	1.40E-12	4.67E-12	1.54E-06	1.14E-12	0.30	c			
Thorium-228+D	NA	NA	NA	2.31E-10	1.16E-06	6.20E-06	9.68E-08	0.0002	c			
Tritium	NA	NA	NA	7.20E-14	NA	0.00E+00	9.60E-14	NA	d			
Uranium-233/234	NA	NA	NA	4.48E-11	8.96E-11	3.52E-11	1.41E-08	0.50	c	NA		
Uranium-238+D	NA	NA	NA	6.20E-11	1.24E-10	6.57E-08	1.24E-08	0.50	c	NA		

a. These gastrointestinal absorption factors have been compiled by the Biomedical and Environmental Information Analysis Section (BEIAS) of the Health and Safety Research Division of Oak Ridge National Laboratory (ORNL) for use at all DOE-OR/ERD sites;
b. Default gastrointestinal absorption factors (0.8 for VOCs, 0.5 for SVOCs, 0.2 for inorganics) were assumed if no other information could be located (EPA Region IV guidance).
c. HEAST Table 4: Radionuclide Carcinogenicity Slope Factors.
d. Risk-Based Guideline Values, (DOE 1997c).
NA = Not Available
RfD = Reference Dose
CSF = Cancer Slope Factor
GI = Gastrointestinal
ABS = Dermal Absorption Factor

Table 5.1 Total Residual Soil Risk for a Construction Worker in Release Block 3

Constituent	EPC	CANCER EFFECTS						NON-CANCER EFFECTS					
		Route-Specific Risk					Cancer Risk Total	Route-Specific HQ					Non-Cancer HI Total
		Oral	Dermal	Inhalation Dust	Inhalation VOCs	External		Oral	Dermal	Inhalation Dust	Inhalation VOCs	External	
Radionuclides	pCi/g												
Plutonium-238	6.85	1.2E-06	NA	1.1E-09	NAP	2.0E-10	**1.2E-06**	NA	NA	NA	NAP	NA	0.0E+00
Radium-228	1.52	2.3E-07	NA	8.8E-12	NAP	7.5E-06	**7.7E-06**	NA	NA	NA	NAP	NA	0.0E+00
TOTAL		1.4E-06	0.0E+00	1.1E-09	0.0E+00	7.5E-06	**8.9E-06**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

EPC	Exposure point concentration
mg/kg	Milligram per kilogram.
NA	Not available; insufficient toxicity data.
NAP	Not applicable pathway.
pCi/g	Picocuries per gram
VOCs	Volatile organic compounds.

Table 5.2 Background Residual Soil Risk for a Construction Worker in Release Block 3

Constituent	EPC	CANCER EFFECTS						NON-CANCER EFFECTS					
		Route-Specific Risk					Cancer Risk Total	Route-Specific HQ					Non-Cancer HI Total
		Oral	Dermal	Inhalation Dust	Inhalation VOCs	External		Oral	Dermal	Inhalation Dust	Inhalation VOCs	External	
Radionuclides	pCi/g												
Plutonium-238	0.13	2.3E-08	NA	2.1E-11	NAP	3.8E-12	2.3E-08	NA	NA	NA	NAP	NA	0.0E+00
Radium-228		0.0E+00	NA	0.0E+00	NAP	0.0E+00	0.0E+00	NA	NA	NA	NAP	NA	0.0E+00
TOTAL		2.3E-08	0.0E+00	2.1E-11	0.0E+00	3.8E-12	2.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

EPC Exposure point concentration
mg/kg Milligram per kilogram.
NA Not available; insufficient toxicity data.
NAP Not applicable pathway.
pCi/g Picocuries per gram
VOCs Volatile organic compounds.

Table 5.3 Incremental Residual Soil Risk for Construction Worker in Release Block 3

Constituent	EPC pCi/g	CANCER EFFECTS: Route-Specific Risk: Oral	Dermal	Inhalation Dust	Inhalation VOCs	External	Cancer Risk Total	NON-CANCER EFFECTS: Route-Specific HQ: Oral	Dermal	Inhalation Dust	Inhalation VOCs	External	Non-Cancer HI Total
Radionuclides													
Plutonium-238	6.72	1.2E-06	NA	1.1E-09	NAP	2.0E-10	**1.2E-06**	NA	NA	NA	NAP	NA	0.0E+00
Radium-228	1.52	2.3E-07	NA	8.8E-12	NAP	7.5E-06	**7.7E-06**	NA	NA	NA	NAP	NA	0.0E+00
TOTAL		1.4E-06	0.0E+00	1.1E-09	0.0E+00	7.5E-06	**8.9E-06**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

EPC	Exposure point concentration
mg/kg	Milligram per kilogram.
NA	Not available; insufficient toxicity data.
NAP	Not applicable pathway.
pCi/g	Picocuries per gram
VOCs	Volatile organic compounds.

Table 5.4 Total and Incremental Residual Soil (0 - 2 ft) Risk for a Site Employee in Release Block 3

Constituent	EPC	CANCER EFFECTS						NON-CANCER EFFECTS					
		Route-Specific Risk					Cancer	Route-Specific HQ					Non-Cancer
		Oral	Dermal	Inhalation Dust	Inhalation VOCs	External	Risk Total	Oral	Dermal	Inhalation Dust	Inhalation VOCs	External	HI Total
	pCi/g												
Radionuclides													
Ra-228	1.52	1.2E-07	NA	4.4E-11	NAP	8.3E-06	8.4E-06	NA	NA	NA	NAP	NA	0.0E+00
TOTAL		1.2E-07	0.0E+00	4.4E-11	0.0E+00	8.3E-06	8.4E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

EPC Exposure point concentration
mg/kg Milligram per kilogram.
NA Not available; insufficient toxicity data.
NAP Not applicable pathway.
pCi/g Picocuries per gram
VOCs Volatile organic compounds.

Table 5.5 Total Residual Risk for Release Block 3 Summary Table

Scenario and Receptor	Media	Constituents	Pathway	Total Noncarcinogen Risk HI	Total Carcinogenic Risk ELCR
Construction Worker Scenario	Soil (all sample depths)	Chemical	Ingestion	NA	NA
			Dermal	NA	NA
			Inhalation of Dust	NA	NA
			Inhalation of VOCs	NA	NA
		Radiological	Ingestion	NA	**1.5E-06**
			Inhalation of Dust	NA	1.1E-09
			External	NA	**7.5E-06**
			TOTAL	NA	**9.0E-06**
	Groundwater* (Current)	Chemical	Sum of Ingestion, Dermal Contact and Inhalation While Showering	3.7E-02	NA
		Radiological	Sum of Ingestion, Dermal Contact and Inhalation While Showering	NA	**3.0E-06**
			TOTAL	3.7E-02	**3.0E-06**
	Groundwater* (Future)	Chemical	Sum of Ingestion, Dermal Contact and Inhalation While Showering	**1.7E+00**	NA
		Radiological	Sum of Ingestion, Dermal Contact and Inhalation While Showering	NA	**3.4E-06**
			TOTAL	**1.7E+00**	**3.4E-06**
	Air*	Radiological	Inhalation	NA	2.0E-07
			TOTAL	NA	2.0E-07
Site Employee Scenario	Soil (0-2 ft bls)	Chemical	Ingestion	NA	NA
			Dermal	NA	NA
			Inhalation of Dust	NA	NA
			Inhalation of VOCs	NA	NA
		Radiological	Ingestion	NA	1.2E-07
			Inhalation of Dust	NA	4.4E-11
			External	NA	**8.3E-06**
			TOTAL	NA	**8.4E-06**
	Groundwater* (Current)	Chemical	Ingestion	3.7E-02	NA
		Radiological	Ingestion	NA	**1.5E-05**
			TOTAL	3.7E-02	**1.5E-05**
	Groundwater * (Future)	Chemical	Ingestion	**1.6E+00**	NA
		Radiological	Ingestion	NA	**1.7E-05**
			TOTAL	**1.6E+00**	**1.7E-05**
	Air*	Radiological	Inhalation	NA	9.9E-07
			TOTAL	NA	9.9E-07

NA - Not applicable

* - RRE for groundwater and air were brought forward from the Technical Position Report for Release Block H. (DOE 1999).

Table 5.6 Background Residual Risk for Release Block 3 Summary Table

Scenario and Receptor	Media	Constituents	Pathway	Total Noncarcinogen Risk HI	Total Carcinogenic Risk ELCR
Construction Worker Scenario	Soil (all sample depths)	Chemical	Ingestion	NA	NA
			Dermal	NA	NA
			Inhalation of Dust	NA	NA
			Inhalation of VOCs	NA	NA
		Radiological	Ingestion	NA	2.3E-08
			Inhalation of Dust	NA	2.1E-11
			External	NA	3.8E-12
			TOTAL	NA	2.3E-08
	Groundwater* (Current)	Chemical	Sum of Ingestion, Dermal Contact and Inhalation While Showering	9.6E-05	NA
		Radiological	Sum of Ingestion, Dermal Contact and Inhalation While Showering	NA	5.1E-07
			TOTAL	9.6E-05	5.1E-07
	Groundwater * (Future)	Chemical	Sum of Ingestion, Dermal Contact and Inhalation While Showering	3.1E-02	NA
		Radiological	Sum of Ingestion, Dermal Contact and Inhalation While Showering	NA	5.1E-07
			TOTAL	3.1E-02	5.1E-07
	Air*	Radiological	Inhalation	NA	NA
			TOTAL	NA	NA
Site Employee Scenario	Soil (0-2 ft bls)	Chemical	Ingestion	NA	NA
			Dermal	NA	NA
			Inhalation of Dust	NA	NA
			Inhalation of VOCs	NA	NA
		Radiological	Ingestion	NA	2.3E-08
			Inhalation of Dust	NA	2.1E-11
			External	NA	3.8E-12
			TOTAL	NA	2.3E-08
	Groundwater* (Current)	Chemical	Ingestion	7.6E-05	NA
		Radiological	Ingestion	NA	**2.5E-06**
			TOTAL	7.6E-05	**2.5E-06**
	Groundwater* (Future)	Chemical	Ingestion	3.1E-02	NA
		Radiological	Ingestion	NA	**2.5E-06**
			TOTAL	3.1E-02	**2.5E-06**
	Air*	Radiological	Inhalation	NA	NA
			TOTAL	NA	NA

NA - Not applicable

* - RRE for groundwater and air were brought forward from the Technical Position Report for Release Block H. (DOE 1999)

Table 5.7 Incremental Residual Risk for Release Block 3 Summary Table

Scenario and Receptor	Media	Constituents	Pathway	Total Noncarcinogen Risk HI	Total Carcinogenic Risk ELCR
Construction Worker Scenario	Soil (all sample depths)	Chemical	Ingestion	NA	NA
			Dermal	NA	NA
			Inhalation of Dust	NA	NA
			Inhalation of VOCs	NA	NA
		Radiological	Ingestion	NA	**1.5E-06**
			Inhalation of Dust	NA	1.1E-09
			External	NA	**7.5E-06**
			TOTAL	NA	**8.9E-06**
	Groundwater* (Current)	Chemical	Sum of Ingestion, Dermal Contact and Inhalation While Showering	3.7E-02	NA
		Radiological	Sum of Ingestion, Dermal Contact and Inhalation While Showering	NA	**2.5E-06**
			TOTAL	3.7E-02	**2.5E-06**
	Groundwater* (Future)	Chemical	Sum of Ingestion, Dermal Contact and Inhalation While Showering	**1.6E+00**	NA
		Radiological	Sum of Ingestion, Dermal Contact and Inhalation While Showering	NA	**2.9E-06**
			TOTAL	**1.6E+00**	**2.9E-06**
	Air*	Radiological	Inhalation	NA	2.1E-07
			TOTAL	NA	2.0E-07
Site Employee Scenario	Soil (0-2 ft bls)	Chemical	Ingestion	NA	NA
			Dermal	NA	NA
			Inhalation of Dust	NA	NA
			Inhalation of VOCs	NA	NA
		Radiological	Ingestion	NA	1.2E-07
			Inhalation of Dust	NA	4.4E-11
			External	NA	**8.3E-06**
			TOTAL	NA	**8.4E-06**
	Groundwater* (Current)	Chemical	Ingestion	3.7E-02	NA
		Radiological	Ingestion	NA	**1.5E-05**
			TOTAL	3.7E-02	**1.5E-05**
	Groundwater* (Future)	Chemical	Ingestion	**1.6E+00**	NA
		Radiological	Ingestion	NA	**1.4E-05**
			TOTAL	**1.6E+00**	**1.4E-05**
	Air*	Radiological	Inhalation	NA	9.9E-07
			TOTAL	NA	9.9E-07

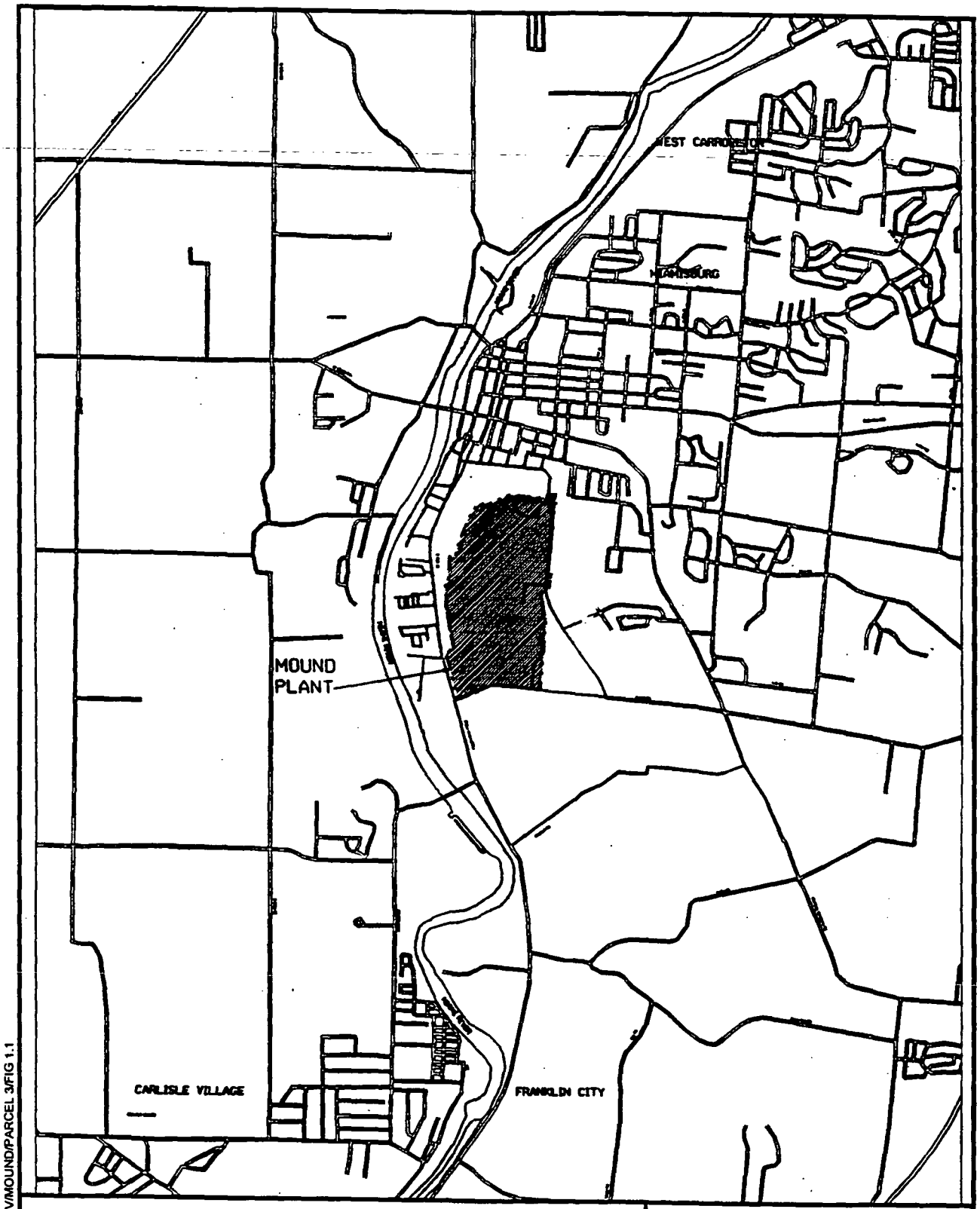
NA - Not applicable

* - RRE for groundwater and air were brought forward from the Technical Position Report for Release Block H. (DOE 1999).

Table 5.8 Overall Risk Summary

Scenario and Receptor	Overall Risk Types	Total Noncarcinogen Risk HI	Total Carcinogenic Risk ELCR
Current Construction Worker	Total	3.7E-02	1.2E-05
	Background	9.6E-05	5.3E-07
	Incremental	3.7E-02	1.2E-05
Future Construction Worker	Total	1.7E+00	1.3E-05
	Background	3.1E-02	5.3E-07
	Incremental	1.6E+00	1.2E-05
Current Site Employee	Total	3.7E-02	2.4E-05
	Background	7.6E-05	2.5E-06
	Incremental	3.7E-02	2.4E-05
Future Site Employee	Total	1.6E+00	2.6E-05
	Background	3.1E-02	2.5E-06
	Incremental	1.6E+00	2.3E-05

FIGURES



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Release Block 3

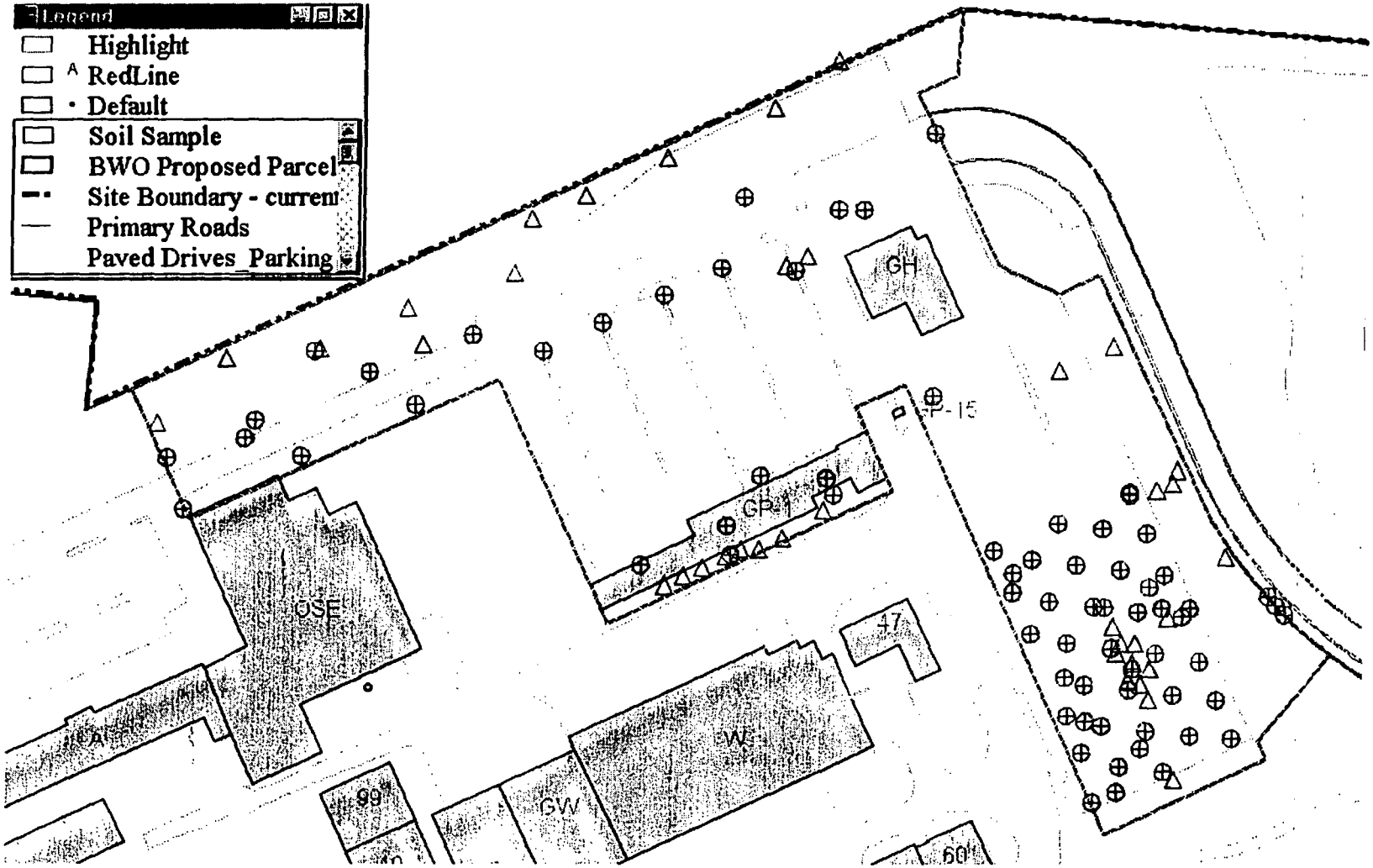
Release Block 3 Area Map

Miamisburg, Ohio

SAIC
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
COLUMBUS, OHIO

DRAWN	DATE	SCALE	PROJECT NO.	FIGURE NO.
LMA	02-14-00	NOT KNOWN	04-2358-003	1.1

ARCVIEW T:/GOV/MOUND/PARCEL 3/FIG 1.1



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W E
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Release Block 3

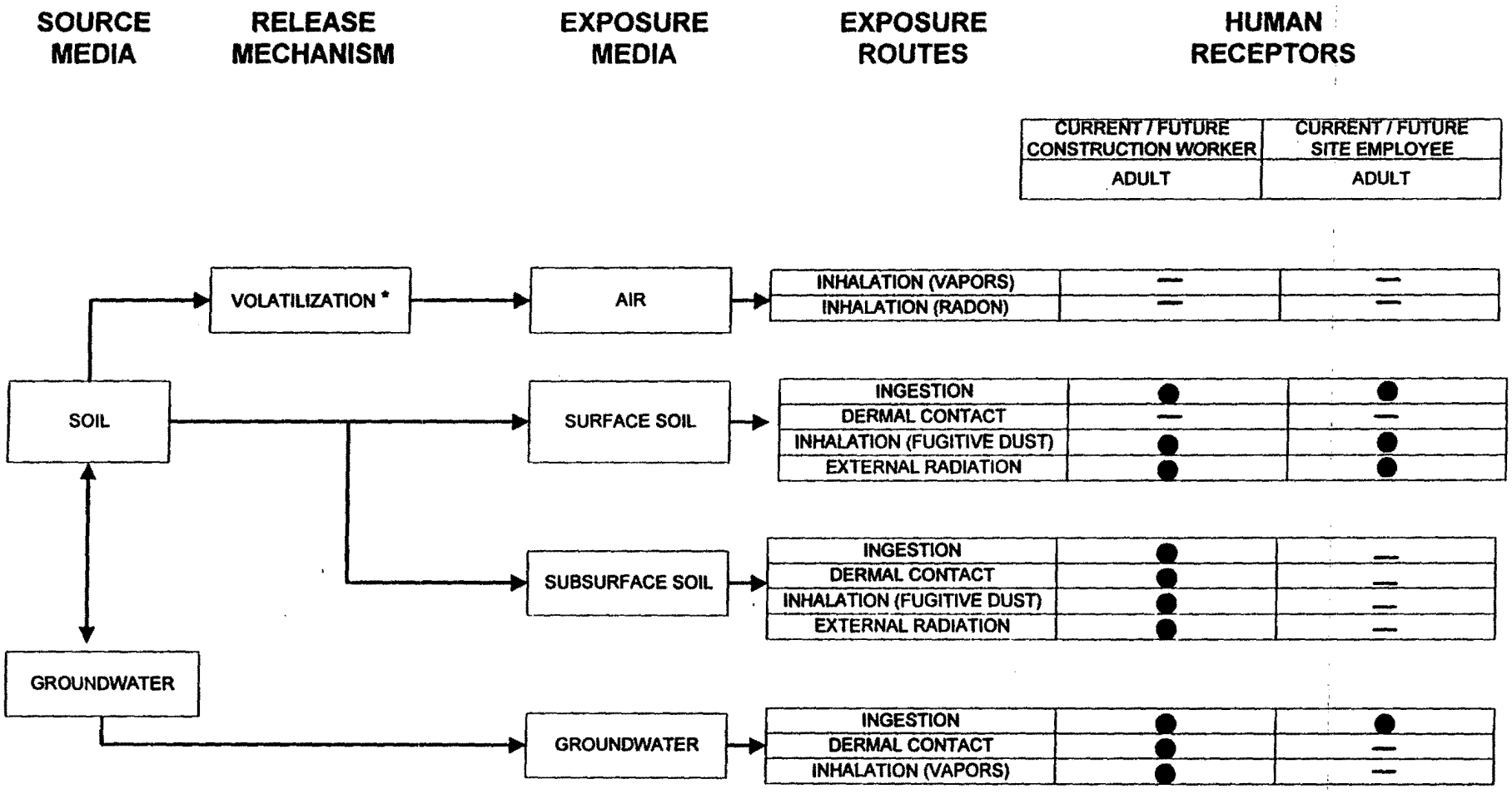
Release Block 3 Area Map

Miamisburg, Ohio

SAIC SCIENCE APPLICATIONS INTERNATIONAL CORPORATION COLUMBUS, OHIO

DRAWN	DATE	SCALE	PROJECT NO.	FIGURE NO.
LMA	03-14-03	NOT KNOWN	04-2358-003	1.1

ARCVIEW T:/COM/MOUND/PARCEL 3/FIG 1.2



● COMPLETE PATHWAY EVALUATED QUANTITATIVELY

○ COMPLETE PATHWAY EVALUATED QUALITATIVELY

— INCOMPLETE PATHWAY, NOT EVALUATED

* NO VOLATILE COPCs IN AREA

Figure 3.1
Conceptual Site Model for the Release Block 3 RRE

APPENDIX A

EVALUATION OF GROUNDWATER EXPOSURE FOR MOUND RREs

A1.1 EVALUATION OF POTENTIAL CUMULATIVE EXPOSURE – GROUNDWATER

Potential exposure to contaminants originating from outside Release Block 3 that may reach a receptor in the release block are termed potential cumulative exposures. Potential cumulative risk due to exposure to groundwater at the Mound facility are reported in the Release Block 3 Summary Tables 5.5 through 5.7. This appendix explains how describes the step taken to estimate the potential future concentration of contaminants in the Mound Plant Production Wells.

For Release Block 3, groundwater was assessed using the technique established in the RRE report for Release Block H (DOE, 1997c). This method assumes both current and future exposure to groundwater. Current groundwater exposures were estimated using data collected from the Mound Plant Production Wells up through 1994. The Mound Plant Production wells are finished in the Great Miami Buried Valley Aquifer (BVA). The concentration of contaminants in future groundwater was estimated using a model that assumes all contaminants currently detected in the Bedrock Aquifer of the Mound Plant property migrate to the BVA. Contaminant concentrations detected in the Bedrock Aquifer were added to the current contaminant concentrations detected in the Mound Plant Production Wells to estimate potential future exposures.

This technique was designed to represent the most conservative (worst-case) future scenario possible. To estimate future contaminant concentrations in the Mound Production Wells a topographic map of the bedrock surface underlying the Mound facility was used to divide the bedrock surface into 20 areas termed "flow tubes." Flow tubes were delineated based on drainage patterns suggested by the topography of the bedrock surface. Although several of the flow tubes do not appear to contribute to the BVA directly, they were considered to contribute to the BVA to make the future scenario as conservative as possible.

The maximum concentration of each analyte for any of the wells within a flow tube was assumed to be representative of the contamination within the flow tube. The maximum contaminant concentration was multiplied by the volume of water per unit time that flow within each flow tube to determine the mass of each contaminant that is contributed to the BVA production wells. The maximum concentration of each analyte from each flow tube was applied to the total flow of each tube to determine a mass of contaminant entering the BVA per year. The contaminant mass from each flow tube was summed to estimate the total mass of each contaminant contributed by the bedrock aquifer to the BVA per year. The total mass of each contaminant was then divided by an assumed Mound Plant water use of 50,000 gallons per day to obtain the theoretical concentration of the contribution of all bedrock contaminants.

Table A.1. Summary Table of All Current Groundwater Contaminants Detected in BVA Production Wells

Groundwater contaminants above detection limits	Maximum Concentration	BVA background	G.V. for Construction Worker	G.V. for Site Employee	Carried through RRE?	Reason
ORGANICS (mg/L)						
Acetone	0.012	--	10[1]	10[2]	No	Conc.< G.V.
Bromodichloromethane	0.0037	--	0.0045[3]	0.0046[4]	No	Conc.< G.V.
2-Butanone	0.041	--	53[1]	61[1]	No	Conc.< G.V.
Chloroform	0.0022	0.0005	0.024[3]	0.047[4]	No	Conc.< G.V.
1,1-Dichloroethane	0.0035	--	9.5[1]	10[2]	No	Conc.< G.V.
1,1-Dichloroethene	0.0017	--	--	--	Yes	No screening values
1,2-Dichloroethene	0.0047	--	2.0[2]	2.0[2]	No	Conc.< G.V.
1,2-cis-Dichloroethene	0.0021	0.0010	2.0[2]	2.0[2]	No	Conc.< G.V.
1,2-trans-Dichloroethene	0.003	--	2.0[2]	2.0[2]	No	Conc.< G.V.
Dichloromethane-Methylenen chloride	0.0098	--	0.038[3]	0.038[3]	No	Conc.< G.V.
Isophorone	0.010	--	0.3[3]	0.3[4]	No	Conc.< G.V.
Tetrachloroethene	0.002	--	0.46[1]	1.0[2]	No	Conc.< G.V.
1,1,1-trichloroethane	0.0018	0.0007	--	--	Yes	Conc. > background
Trichloroethene	0.0046	--	0.024[3]	0.026[4]	No	Conc. < G.V.
Trichlorofluoromethane	0.0025	--	26[1]	31[2]	No	Conc. < G.V.
1,1,2-trichloro-1,2,2-trifluoroethane	0.0087	--	--	--	Yes	No screening values
Inorganics (mg/L)						
Alkalinity	335	--	--	--	No	Water Quality Parameter
Aluminum	0.0737	0.0375	--	--	No	Water Quality Parameter
Ammonia	0.58	0.162	--	--	No	Water Quality Parameter
Barium	0.0884	0.3102	7.1[1]	7.2[1]	No	Conc. < G.V.
Cadmium	0.0077	--	0.051[1]	0.051[2]	Yes	Conc. > G.V.
Calcium	126	111	--	--	No	Water Quality Parameter
Chloride	133	106	0.51[1]	0.51[2]	No	Water Quality Parameter
Chromium (total)	0.0249	0.0061	--	--	No	Conc. < G.V.
Copper	0.593	0.0012	--	--	Yes	Conc. > background
Dissolved Solids	719	603	--	--	No	Water Quality Parameter
Fluoride	0.18	0.419	--	--	No	Water Quality Parameter
Iron	0.780	4.065	--	--	No	Conc. < background
Lead (soluble)	0.040	0.0101	--	--	Yes	Conc. > background

Table A.1. Summary Table of All Current Groundwater Contaminants Detected in BVA Production Wells

Groundwater contaminants above detection limits	Maximum Concentration	BVA background	G.V. for Construction Worker	G.V. for Site Employee	Carried through RRE?	Reason
Magnesium	39.6	40.43	--	--	No	Conc. < background
Manganese	0.0248	0.2296	0.51[1]	0.51[2]	No	Conc. < G.V.
Nitrate/Nitrite	4.9	5.349	--	--	No	Conc. < background
Nitrate	2.55	--	--	--	No	Water Quality Parameter
Nitrite	0.066	--	--	--	No	Water Quality Parameter
Nitrogen	0.62	0.324	--	--	No	Water Quality Parameter
Organic Carbon	1.1	1.987	--	--	No	Conc. < background
Phosphate	0.22	0.231	--	--	No	Conc. < background
Potassium	3.8	4.461	--	--	No	Conc. < background
Silver	0.0242	--	0.51[1]	0.51[2]	No	Conc. < G.V.
Sodium	82.4	62.43	--	--	No	Water Quality Parameter
Sulfate	83.0	142.7	--	--	No	Conc. < background
Suspended Solids	8.0	26.44	--	--	No	Conc. < background
Vanadium	0.0244	0.0171	0.71[1]	0.72[2]	No	Conc. < G.V.
Zinc	0.0577	0.1196	31[1]	31[2]	No	Conc. < G.V.
RADIONUCLIDES (pCi/L)						
Actinuim-227	0.335	--	1.34[4]	0.26[4]	Yes	Conc. > Site Employee G.V.
Bismuth-210	0.39	--	--	--	Yes	No screening values
Plutonium-239/240	2.0	0.125	2.5[4]	0.51[4]	Yes	Conc. > Site Employee G.V.
Radium-226	0.4	0.996	2.74[4]	0.54[4]	No	Conc. < background
Strontium-85	25	--	--	--	No	Short half-life, single detect
Strontium-90	0.3	0.975	14[4]	2.9[4]	No	Conc. < G.V.
Thorium-228	2.17	0.779	3.5[4]	0.69[4]	Yes	Conc. > Site Employee G.V.
Thorium-230	1.99	0.289	21[4]	4.3[4]	No	Conc. < G.V.
Thorium-232	0.1	--	24[4,5]	0.69[4,5]	No	Conc. < G.V.
Tritium	7200	1485	11000[3]	2200[4]	Yes	Conc. > Site Employee G.V.
Uranium-234	8.14	0.792	18[4]	3.6[4]	Yes	Conc. > Site Employee G.V.
Uranium-238	8.25	0.688	13[4]	2.6[4]	Yes	Conc. > Site Employee G.V.

Notes:

-- Indicates background or guideline values not available. The more restrictive G.V was used to determine which contaminants were carried through the RRE.

1 Hazard Quotient for ingestion, dermal and inhalation. (Decision made on 0.1 X G.V.)

Table A.1. Summary Table of All Current Groundwater Contaminants Detected in BVA Production Wells

2 Hazard Quotient for ingestion only. (Decision made on 0.1 X G.V.)
3 Total Risk 10-6 for ingestion, dermal, and inhalation.
4 Total Risk 10-6 for ingestion only.
5 Guideline values from thorium-228+D.

Table A.2. Summary Table of All Future Groundwater Contaminants Assumed to be in Production Wells with Input from the Bedrock Aquifer

Groundwater Contaminants Above DetectionLimits	Maximum Concentration	BVA Background	G.V. for Construction Worker	G.V. for Site Employee	Carried throug h RRE?	Reason
ORGANICS (mg/L)						
Acetone	0.0129	--	10[1]	10[2]	No	Conc.< G.V.
Benzene	0.0001	--	0.0087[3]	0.0099[4]	No	Conc.< G.V.
Benzoic acid	0.071	--	400[1]	410[2]	No	Conc.< G.V.
Bromodichloromethane	0.0037	--	0.0045[3]	0.0046[4]	No	Conc.< G.V.
2-Butanone	0.0543	--	53[1]	61[1]	No	Conc.< G.V.
Carbon tetrachloride	0.0000135	--	0.002[3]	0.0022[4]	No	Conc.< G.V.
Chloroform	0.0022	0.0005	0.024[3]	0.047[4]	No	Conc.< G.V.
1,1-Dichloroethene	0.0035	--	9.5[1]	10[2]	No	Conc.< G.V.
1,1-Dichloroethene	0.0017	--	--	--	Yes	No Screening Values
1,2-Dichloroethene	0.0050	--	2.0[2]	2.0[2]	No	Conc.< G.V.
1,2-cis-Dichloroethene	0.0023	0.0010	2.0[2]	2.0[2]	No	Conc.< G.V.
1,2-trans-Dichloroethene	0.0032	--	2.0[2]	2.0[2]	No	Conc.< G.V.
Bis (2-ethylhexyl)phthalate	0.0153	0.0084	0.019[3]	0.02[3]	No	Conc.< G.V.
Isophorone	0.0100	--	0.3[3]	0.3[4]	No	Conc.< G.V.
4-Methylphenol	0.0004	--	0.48[1]	0.51[2]	No	Conc.< G.V.
Tetrachloroethene	0.0021	--	0.46[1]	1.0[2]	No	Conc.< G.V.
1,1,1-Trichloroethane	0.0065	0.0007			Yes	Conc. > Background
Trichloroethene	0.0050		0.024[3]	0.026[4]	No	Conc. < G.V.
Trichlorofluoromethane	0.0025	--	26[1]	31[2]	No	Conc. < G.V.
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.0087	--	--	--	Yes	No Screening Values
Toluene	0.0002	--	16[1]	20[2]	No	Conc. < G.V.
Xylenes (total)	0.000043	--	200[2]	200[2]	No	Conc. < G.V.
Inorganics (mg/L)						
Antimony	0.0008	0.0006	0.041[1]	0.041[2]	No	Conc. < G.V.
Barium	0.0884	0.3102	7.1[1]	7.2[1]	No	Conc. < G.V.
Beryllium	0.0001	--	0.000066[3]	0.000067[4]	Yes	Conc. > G.V.
Bismuth	0.0016	--	--	--	Yes	No Screening Values
Cadmium	0.0077	--	0.051[1]	0.051[2]	Yes	Conc. > G.V.
Chromium	0.4961	0.0061	0.51[1]	0.51[2]	Yes	Conc. > G.V.
Cobalt	0.0039	--	--	--	Yes	No Screening Values
Copper	0.5964	0.0012	--	--	Yes	Conc. > Background
Cyanide	0.0001	--	2.0[1]	2.0[2]	No	Conc. < G.V.
Iron	0.78	4.065	--	--	No	Conc. < Background
Lead (soluble)	0.04	0.0101	--	--	Yes	Conc. > Background
Lithium	0.0036	0.0557	--	--	No	Conc. < Background

Table A.2. Summary Table of All Future Groundwater Contaminants Assumed to be in Production Wells with Input from the Bedrock Aquifer

Groundwater Contaminants Above DetectionLimits	Maximum Concentration	BVA Background	G.V. for Construction Worker	G.V. for Site Employee	Carried throug h RRE?	Reason
Magnesium	43.974	40.428	--	--	No	Water Quality Parameter
Manganese	0.0248	0.2296	0.51[1]	0.51[2]	No	Conc. < G.V.
Molybdenum	0.0096	0.0056	--	--	Yes	Conc. > Background
Nickel	0.1003	0.0350	2.0[1]	2.0[2]	No	Conc. < Background
Phosphate	0.3664	0.231	--	--	No	Water Quality Parameter
Potassium	6.0034	4.461	--	--	No	Water Quality Parameter
Silver	0.0242	--	0.51[1]	0.51[2]	No	Conc. < G.V.
Vanadium	0.028	0.0171	0.71[1]	0.72[2]	No	Conc. < G.V.
Zinc	0.0577	0.1196	31[1]	31[2]	No	Conc. < G.V.
RADIONUCLIDES (pCi/L)						
Actinium-227	0.335	--	1.34[4]	0.26[4]	Yes	Conc. > Site Employee G.V.
Bismuth-210	0.39	--	--	--	Yes	No Screening Values
Plutonium-238	0.0034	0.087	2.7[4]	0.54[4]	No	Conc. < G.V.
Plutonium-239,240	2.0199	0125	2.5[4]	0.51[4]	Yes	Conc. > Site Employee G.V.
Radium-226	0.6402	0.996	2.7[4]	0.54[4]	No	Conc. < Background
Strontium-85	25	--	--	--	No	Short Half-Life, Single Detect
Strontium-90	0.3121	0.975	14[4]	2.9[4]	No	Conc. < G.V.
Thorium-228	2.17	0.779	3.5[4]	0.69[4]	Yes	Conc. > Site Employee G.V.
Thorium-230	2.0645	0.289	21[4]	4.3[4]	No	Conc. < G.V.
Thorium-232	0.1422	--	24[4,5]	0.69[4,5]	No	Conc. < G.V.
Tritium	10427	1485	11000[4]	2200[4]	Yes	Conc. > Site Employee G.V.
Uranium-233	0.0002	--	18[4]	3.6[4]	No	Conc. < G.V.
Uranium-234	8.14	0.792	18[4]	3.6[4]	Yes	Conc. > Site Employee G.V.
Uranium-235	0.0036	0.045	17[4]	3.4[4]	No	Conc. < G.V.
Uranium-235,236	0.0003	--	17[4]	3.4[4]	No	Conc. < G.V.
Uranium-238	8.25	0.688	13[4]	2.6[4]	Yes	Conc. > Site Employee G.V.

Notes:

-- Indicates background or guideline values not available. The more restrictive G.V was used to determine which contaminants were carried through the RRE.

1 Hazard Quotient for ingestion, dermal and inhalation. (Decision made on 0.1 X G.V.)

2 Hazard Quotient for ingestion only. (Decision made on 0.1 X G.V.)

3 Total Risk 10^6 for ingestion, dermal, and inhalation.

4 Total Risk 10^6 for ingestion only.

5 Guideline values from thorium-228+D.

Table A.3 Current Groundwater Contaminants Carried Through RRE

Groundwater Constituents	Maximum Concentration	Screening Concentration (either background or G.V.)	Reason for carrying through RRE
ORGANICS (mg/L)			
1,1-Dichloroethene	0.0017	--	No Background or G.V. Available
1,1,1-Trichloroethane	0.0018	0.0007[3]	Conc. > Background; No G.V. Available
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.0087	--	No Background or G.V. Available
INORGANICS (mg/L)			
Cadmium	0.0077	0.051[1]	Conc. > G.V; No Background Available
Copper	0.593	0.0012[3]	Conc. > Background; No G.V. Available
Lead	0.040	0.0101[3]	Conc. > Background; No G.V. Available
RADIONUCLIDES (pCi/l)			
Actinium-227	0.335	0.26[2]	Conc. > G.V; No Background Available
Bismuth-210	0.39	--	No Background or G.V. Available
Plutonium-239/240	2.0	0.125[3]	Conc. > Background; No G.V. Available
Tritium	7200	1485[2]	Conc. > Background; No G.V. Available
Uranium-234	8.14	0.792[2]	Conc. > Background; No G.V. Available
Uranium-238	8.25	0.688[3]	Conc. > Background; No G.V. Available

1 Hazard Index for Ingestion, + Dermal + Inhalation. (Decision made on 0.1 X G.V.)
2 Total Risk 10^6 for ingestion only.
3 Background Value.

Table A.4 Future Groundwater Contaminants Carried Through RRE

Groundwater Constituents	Maximum Concentration	Screening Concentration (either background or G.V.)	Reason for carrying through RRE
ORGANICS (mg/L)			
1,1-Dichloroethene	0.0017	--	No Background or G.V. Available
1,1,1-Trichloroethane	0.0065	0.0007[4]	Conc. > Background; No G.V. Available
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.0087	--	No Background or G.V. Available
INORGANICS (mg/L)			
Beryllium	0.0001	6.6E-05[3]	Conc. > G.V
Bismuth	0.0016	--	No Background or G.V. Available
Cadmium	0.0077	0.051[1]	Conc. > G.V; No Background Available
Chromium	0.4961	0.0061[4]	Conc. > Background; No G.V. Available
Cobalt	0.0039	0[4]	Conc. > Background; No G.V. Available
Copper	0.5964	0.0012[4]	Conc. > Background; No G.V. Available
Lead	0.04	0.010[4]	Conc. > Background; No G.V. Available
Molybdenum	0.0096	0.0056[4]	Conc. > Background; No G.V. Available
RADIONUCLIDES (pCi/l)			
Actinium-227	0.335	0.26[2]	Conc. > G.V; No Background Available
Bismuth-210	0.39	--	No Background or G.V. Available
Plutonium-239/240	2.020	0.125[4]	Conc. > Background and G.V.
Tritium	10427	1485[4]	Conc. > Background and G.V.
Uranium-234	8.14	0.792[4]	Conc. > Background and G.V.
Uranium-238	8.25	0.688[4]	Conc. > Background and G.V.

1 Hazard Index for Ingestion, + Dermal + Inhalation. (Decision made on 0.1 X G.V.)
2 Total Risk 10^6 for Ingestion Only.
3 Total Risk 10^6 for Ingestion +Dermal + Inhalation.
4 Background Value.

APPENDIX B

EVALUATION OF AIR EXPOSURE FOR MOUND RREs

A1.1 EVALUATION OF POTENTIAL CUMULATIVE EXPOSURE – AIR

Potential exposure to contaminants originating from outside Release Block 3 that may reach a receptor in the release block are termed potential cumulative exposures. This appendix presents potential cumulative exposures that may come from air.

Airborne contaminant concentrations were measured at the Mound Facility in 1994 during various site restoration activities (DOE, 1994). Both radiological and non-radiological data were collected. It is assumed that the measured concentrations would represent an upper-bound air concentration. These data are shown in Table A1-1. Risks due to inhalation of the radionuclides by construction workers and site employees were calculated and are also presented in Table A1-1.

The calculated risks attributable to the potential upper-bound exposure of airborne contaminants would total 2.0E-07 for the construction worker and 9.8E-07 for the site employee. Note that the potential exposures and associated risks are based on the assumption of long-term consumption of this upper-bound concentration that was measured during site restoration activities.

Table A1-1 Concentration of Radionuclides in Air in 1994 (EG&G Mound Applied Technologies- Mound Site Environmental Report for Calendar Year 1994, pg. 4-15 to 4-17) MLM-3814

Radionuclide	Maximum Concentration* (μCi/mL)	Risks to Construction Worker*	Risks to Site Employees**
Tritium oxide (H-3)	7.54 ± 4.61E-12	1.8E-08	9.0E-08
Plutonium-238	259.65 ± 289.58E-18	1.75E-07	8.8E-07
Plutonium-239/240	3.50 ±2.75E-18	2.5E-09	1.2E-08
Total		2.0E-07	9.8E-07

* Error limits are estimates of the standard error of the estimated means at the 95% confidence level. Values given are from the location on the site with the highest concentration (based on the average of two or more samples).

** Calculated risks assumed that the maximum concentration shown here was the C_{air} value needed for the calculation of risk by inhalation for construction workers and site employees.