# RECORD OF DECISION

# WEST LAKE LANDFILL SITE
# BRIDGETON, MISSOURI

# OPERABLE UNIT 1

**May 2008**

Prepared by
U.S. Environmental Protection Agency
Region 7
Kansas City, Kansas

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## ABBREVIATIONS

The following is a list of the abbreviations used in this document:

**GENERAL**

| | |
|---|---|
| AEC | U.S. Atomic Energy Commission |
| AOC | Administrative Order on Consent |
| AR | Administrative Record |
| ARAR | Applicable or Relevant and Appropriate Requirement |
| BRA | Baseline Risk Assessment |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| COC | Contaminant of Concern |
| CORPS | U.S. Army Corps of Engineers |
| CSR | Code of State Regulations |
| EPA | U.S. Environmental Protection Agency |
| FS | Feasibility Study |
| HI | Hazard Index |
| HQ | Hazard Quotient |
| LUST | Leaking Underground Storage Tank |
| MCL | Maximum Contaminant Level |
| MDNR | Missouri Department of Natural Resources |
| MECA | Missouri Environmental Covenants Act |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| NPL | National Priorities List |
| O&M | Operations and Maintenance |
| OU | Operable Unit |
| PRPs | Potentially Responsible Parties |
| RAO | Remedial Action Objective |
| RD | Remedial Design |
| RI | Remedial Investigation |
| RfD | Reference Dose |
| ROD | Record of Decision |
| SLAPS | St. Louis Airport Site |
| UMTRCA | Uranium Mill Tailings Radiation Control Act |

## CHEMICALS

| | |
|---|---|
| PCBs | Polychlorinated Biphenyls |
| Ra-226 | Radium-226 |
| Rn-222 | Radon-222 |
| SVOC | Semivolatile Organic Compound |
| Th-232 | Thorium-232 |
| Th-230 | Thorium-230 |
| U-238 | Uranium-238 |
| U-235 | Uranium-235 |
| U-234 | Uranium-234 |
| VOC | Volatile Organic Compound |

## UNITS OF MEASURE

| | |
|---|---|
| cm | Centimeter |
| ft\amsl | Feet Above Mean Sea Level |
| $m^2$ | Square Meter |
| pCi/g | Picocuries per gram |
| pCi/l | Picocuries per Liter |
| ppm | Parts per Million |
| mg/kg | Milligrams per Kilogram |
| mg/l | Milligrams per Liter |
| sec | Second |
| ug/l | Microgram per Liter |
| $yd^3$ | Cubic Yards |

**Record of Decision Data Certification Checklist**

The following information is included in this Record of Decision. Additional information is in the Administrative Record file for this Site.

| Site Data | Chapter |
|---|---|
| Contaminants of Concern | 7.0 |
| Baseline risk represented by the contaminants | 7.0 |
| Remedial Action Objectives | 8.0 |
| Principal Threats | 11.0 |
| Current and reasonably anticipated future land and groundwater use assumptions | 6.0 |
| Potential land and groundwater use that will be available after implementation of the remedy | 6.0 & 12.0 |
| Estimated capital, annual operation and maintenance, and total present worth costs | 12.0 |
| Key factor(s) that led to selecting the remedy | 10.0 & 12.0 |

## PART I. DECLARATION

### Site Name and Location

West Lake Landfill Site
Operable Unit 1
Bridgeton, Missouri
CERCLIS ID Number: MOD079900932

### Statement of Basis and Purpose

This Record of Decision (ROD) presents the Selected Remedy for Operable Unit 1 (OU 1) of the West Lake Landfill site (Site) in Bridgeton, Missouri. This remedy was selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. This decision is based on information contained in the Administrative Record file for the Site.

The Missouri Department of Natural Resources (MDNR), acting on behalf of the state of Missouri, accepts the Selected Remedy. See section 10.8 of the Decision Summary for MDNR's statement.

### Assessment of the Site

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

### Description of the Selected Remedy

The Site consists of the Bridgeton Sanitary Landfill (Former Active Sanitary Landfill) and several inactive areas with sanitary and demolition fill that were closed prior to state regulation. Two areas of the Site were radiologically contaminated when soils mixed with uranium ore processing residues were reportedly used as soil cover for municipal refuse in the landfill operations. The Site is divided into two OUs. OU 1 consists of the radiologically contaminated landfill areas and the area formerly described as the Ford Property, now called the Buffer Zone/Crossroad Property. OU 2 consists of the other landfill areas that are not impacted by radionuclide contaminants. The Selected Remedy for OU 2 is provided in a separate ROD. The Site does not contain principal threat wastes. See section 11.0 of the Decision Summary for an explanation of principal threat wastes.

The major components of the Selected Remedy for OU 1 are as follows:

- Install landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills, including enhancements consistent with the standards for uranium mill tailing sites, i.e., armoring layer and radon barrier

- Consolidation of radiologically contaminated surface soil from the Buffer Zone/Crossroad Property to the containment area
- Apply groundwater monitoring and protection standards consistent with requirements for uranium mill tailing sites and sanitary landfills
- Surface water runoff control
- Gas monitoring and control including radon and decomposition gas as necessary
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing long-lived radionuclides
- Long-term surveillance and maintenance of the remedy

**Statutory Determinations**

The Selected Remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate, is cost effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable.

The remedy for OU 1 does not satisfy the statutory preference for treatment as a principal element of the remedy. The contaminants are dispersed within large volumes of heterogeneous municipal refuse and demolition debris; there are no practicable treatment alternatives, and no principal threat wastes have been identified.

This remedy will result in hazardous substances, pollutants, or contaminants remaining on the Site above levels that allow for unlimited use and unrestricted exposure; therefore, a statutory review will be conducted within five years after initiation of the remedial action to ensure the remedy is or will be protective of human health and the environment.

John B. Askew
Regional Administrator

5/29/08
Date

## PART II. DECISION SUMMARY

## 1.0 SITE NAME, LOCATION, AND DESCRIPTION

The West Lake Landfill Site (Site) is located in Bridgeton, Missouri. The U.S. Environmental Protection Agency (EPA) is the lead agency, and the Missouri Department of Natural Resources (MDNR) is the supporting state agency. The EPA ID Number is MOD079900932.

The Site is on a parcel of approximately 200 acres located in the northwestern portion of the St. Louis metropolitan area (Figure 1-1). It is situated approximately one mile north of the intersection of Interstate 70 and Interstate 270 within the limits of the city of Bridgeton in northwestern St. Louis County. The Missouri River lies about two miles to the north and west of the Site. The Site is bounded on the north by St. Charles Rock Road and on the east by Taussig Road. Old St. Charles Rock Road borders the southern and western portions of the Site. The Earth City Industrial Park is adjacent to the Site on the west. The Spanish Village residential subdivision is located less than a mile to the south (Figure 1-2).

The Site consists of the Bridgeton Sanitary Landfill (Former Active Sanitary Landfill) and several inactive areas with sanitary and demolition fill that have been closed. The address of the Bridgeton Landfill is 13570 St. Charles Rock Road. The Site is divided into two operable units (OUs). OU 1 addresses two of the inactive landfill areas that are radiologically contaminated known as Area 1 and Area 2, and the area formerly described as the Ford Property, now the Buffer Zone/Crossroads Property. This Record of Decision (ROD) provides the Selected Remedy for OU 1. The other landfill areas that are not impacted by radionuclide contaminants are addressed by OU 2. OU 2 is addressed under a separate ROD.

Other facilities which are not subject to this response action are located on the 200-acre parcel including concrete and asphalt batch plants, a solid waste transfer station, and an automobile repair shop.

## 2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Site was used agriculturally until a limestone quarrying and crushing operation began in 1939. The quarrying operation continued until 1988 and resulted in two quarry pits. Beginning in the early 1950s, portions of the quarried areas and adjacent areas were used for landfilling municipal refuse, industrial solid wastes, and construction/demolition debris. These operations were not subject to state permitting because they occurred prior to the formation of MDNR in 1974. Two landfill areas were radiologically contaminated in 1973 when they received soil mixed with leached barium sulfate residues.

The barium sulfate residues, containing traces of uranium, thorium, and their long-lived daughter products, were some of the uranium ore processing residues initially stored by the Atomic Energy Commission (AEC) on a 21.7-acre tract of land in a then undeveloped area of north St. Louis County, now known as the St. Louis Airport Site (SLAPS), which is part of the St. Louis Formerly Utilized Sites Remedial Action Program managed by the U.S. Army Corps of Engineers (Corps). The radium and lead-bearing residues—known as K-65 residues—were stored in drums prior to being relocated to federal facilities in New York and Ohio.

In 1966 and 1967, the remaining residues from SLAPS were purchased by a private company for mineral recovery and placed in storage at a nearby facility on Latty Avenue under an AEC license. Most of the residues were shipped to Canon City, Colorado, for reprocessing except for the leached barium sulfate residues, which were the least valuable in terms of mineral content, i.e., most of the uranium and radium was removed in previous precipitation steps. Reportedly, 8,700 tons of leached barium sulfate residues were mixed with approximately 39,000 tons of soil and then transported to the Site. According to the landfill operator, the soil was used as cover for municipal refuse in routine landfill operations. The data collected during the Remedial Investigation (RI) are consistent with this account. Figure 2-1 is a generalized illustration of the ore processing steps, and Figure 2-2 identifies the barium sulfate residues that went to the Site.

The quarry pits were used for permitted solid waste landfill operations beginning in 1979. In August 2005, the Bridgeton Sanitary Landfill (Former Active Sanitary Landfill) stopped receiving waste pursuant to an agreement with the city of St. Louis to reduce the potential for birds to interfere with airport operations.

EPA placed the Site on the Superfund National Priorities List (NPL) in 1990. The NPL is a list of priority sites promulgated pursuant to section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended. The NPL is found in Appendix B of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

In 1993, EPA entered into an Administrative Order on Consent (AOC) with the potentially responsible parties (PRPs) for performance of the OU 1 RI/Feasibility Study (FS). Pursuant to the requirements of that order, the PRPs submitted for EPA's review and approval an RI which detailed the findings of extensive sampling and analysis on the area of OU 1 and the surrounding area. Following the RI, the PRPs submitted for EPA's review and approval an FS which evaluated the various remedial alternatives for OU 1 consistent with the requirements of the AOC and taking into account the requirements of CERCLA and the NCP. In addition, the state of Missouri was provided an opportunity for review and comment on these documents.

## 3.0 COMMUNITY PARTICIPATION

Public participation activities for the remedy selection process were carried out consistent with NCP section 300.430(f)(3). The Proposed Plan and the Administrative Record (AR) file—which contains the RI/FS and other supporting documents—were made available to the public in June 2006. The AR file was placed at Bridgeton Trails Branch of the public library which is located near the Site. The public notice on the Proposed Plan and public meeting was published in *Bridgeton/Hazelwood Journal* of the *St. Louis Post Dispatch.* Fact Sheet notices were sent to area residents, elected officials, and the media outlets.

The comment period was opened on June 14, 2006. The first public meeting was held on June 22, 2006, at the Bridgeton Community Center. At the meeting, EPA provided an overview of the Site, described the preferred alternatives for both OU 1 and OU 2, and explained the remedy selection process. Following the presentation, oral comments from the public were received.

In response to a request from the city of Bridgeton, the comment period was extended to August 14, 2006, and later extended again to October 14, 2006. Following public notice, a second public meeting was held at City Hall on September 14, 2006. All of the community concerns expressed at the first meeting were related to the proposed remedy for OU 1. Therefore, the presentation at the second meeting was more narrowly focused to address concerns with the proposed remedy for OU 1 that were identified at the first meeting. Following the presentation, oral comments from the public were received.

In response to additional requests, EPA further extended the comment period to December 29, 2006. In total, the public comment period was held open for more than six months.

Responding to ongoing community interest, EPA reopened the public comment period and held a third public meeting on March 27, 2008. This third public comment period was closed on April 9, 2008.

Written transcripts were made of all three public meetings and these are contained in the AR file. Responses to comments received at the meeting and to written comments received during the comment period are provided in the Responsiveness Summary, which is Part III of this ROD.

## 4.0 SCOPE AND ROLE OF THE RESPONSE ACTION

The Site is divided into the following areas (see Figure 4-1):

- Radiological Area 1 – This area was part of the landfill operations conducted prior to state regulation. Approximately 10 acres are impacted by radionuclides at depths ranging up to 15 feet. The radionuclides are in soil material that is intermixed with the overall landfill matrix consisting of municipal refuse.

- Radiological Area 2 – This area was also part of the unregulated landfill operations conducted prior to 1974. Approximately 30 acres are impacted by radionuclides at depths generally ranging to 12 feet, with some localized occurrences that are deeper. The radionuclides are in soil material that is intermixed with the overall landfill matrix consisting mostly of construction and demolition debris.

- Buffer Zone/Crossroad Property – This property—also known as the Ford Property—lies west of Radiological Area 2 and became surficially contaminated when erosion of soil from the landfill berm resulted in transport of radiologically contaminated soils from Area 2 onto the adjacent property.

- Closed Demolition Landfill – This area is located on the southeast side of Radiological Area 2. This landfill received demolition debris. It received none of the radiologically contaminated soil. It operated under permit with the state and was closed in 1995.

- Inactive Sanitary Landfill – This landfill is located south of Radiological Area 2 and was part of the unregulated landfill operations conducted prior to 1974. The landfill contains sanitary wastes and a variety of other solid wastes and demolition debris. It received none of the radiologically contaminated soil.

- Former Active Sanitary Landfill – This municipal solid waste landfill—known as the Bridgeton Landfill—is located on the south and east portions of the Site. The landfill is subject to a state permit issued in 1974. This landfill received none of the radiologically contaminated soil. This landfill ceased operation in 2005.

The Site has been divided into two OUs. OU 1 consists of Radiological Area 1 and Radiological Area 2 (Areas 1 and 2) and the Buffer Zone/Crossroad Property. This ROD provides the Selected Remedy for OU 1. OU 2 consists of the other landfill areas that are not impacted by radionuclides, i.e., the Closed Demolition Landfill, the Inactive Sanitary Landfill, and the Former Active Sanitary Landfill. The Selected Remedy for OU 2 is provided in a separate ROD. The OU 1 and OU 2 RODs provided the final remedies for both source control and groundwater and complete the CERCLA decision-making for the Site. The specific remedial action objectives (RAOs) are described in Section 8 of this ROD.

Section 12 of this ROD identifies the performance standards and environmental requirements for the Selected Remedy. This ROD will be followed by a Remedial Design and Remedial Action (RD/RA) process to develop specific standards for construction, monitoring, and maintenance.

## 5.0 Site Characteristics and Site Conceptual Model

This section presents a summary of the findings of the RI investigations. Sections 5.1 through 5.5 provide an overview of the Site's conditions, the investigations that were undertaken, and the nature and extent of contamination. Section 5.6 presents the Site conceptual model through discussion of the actual and potential pathways for migration and/or exposure to the Site's contaminants. Illustrations of the Site conceptual model are depicted in Figures 5-1 and 5-2. Both radionuclide and nonradionuclide contaminants have been investigated.

The following pathways have been investigated:

- Airborne transport of radon gas and fugitive dust

- Rainwater runoff transport of dissolved or suspended contaminants

- Erosion and transport of contaminated soils
- Leaching of contaminants to the underlying alluvial groundwater

## 5.1 Overview of Site Conditions and Land Use

The Site is located within the western portion of the St. Louis metropolitan area on the east side of the Missouri River. The landfill is situated approximately one mile north of the intersection of Interstate 70 and Interstate 270 within the city limits of the city of Bridgeton in northwestern St. Louis County. St. Charles Rock Road (State Highway 180) borders the landfill on the north. Taussig Road and agricultural land lie southeast of the landfill. Old St. Charles Rock Road, along with undeveloped land, borders the southern and western portions of the landfill (Figure 1-2).

The Site is an approximately 200-acre parcel containing multiple facilities. The primary facility—the Bridgeton Landfill (formerly known as the Laidlaw Landfill)—has an address of 13570 St. Charles Rock Road, St. Louis County, Missouri. The Bridgeton Landfill, referred to herein as the Former Active Sanitary Landfill, stopped receiving waste in 2005 and is now in post-closure status. Other facilities on the Site that are not the subject of the CERCLA action include the concrete and asphalt batch plants, an automotive repair shop, and a waste transfer station. The Site's layout is shown in Figure 4-1.

Land use in the area surrounding the landfill is commercial and industrial. Deed restrictions have been recorded against the entire Site to prevent residential development or groundwater use from occurring at the landfill. Additional deed restrictions have been recorded against Areas 1 and 2 to prevent construction of buildings or utility excavations in these areas. The southernmost portion of the landfill property is permitted for active sanitary landfill operations (Permit No. 118912).

The property to the north of the landfill across St. Charles Rock Road is moderately developed with commercial, retail, and manufacturing operations. The Earth City Industrial Park is located adjacent to the landfill on the west, across Old St. Charles Rock Road. The nearest residential development, Spanish Village, is located to the south of the landfill near the intersection of St. Charles Rock Road and Interstate 270 approximately .75 mile from Area 1 and 1 mile from Area 2. Mixed commercial, retail, manufacturing, and single-family residential uses are present to the southeast of the landfill.

## 5.2 Surface Features

The Site is situated on the eastern edge of the Missouri River flood plain approximately two miles east of the river. The river is separated from the area of the Site by a levee system.

Ground elevations at the Site range from approximately 450 to 500 feet; however, the topography of the Site area has been significantly altered by quarry activities in the eastern portion of the landfill and by placement of mine spoils and landfill materials in the eastern and western portion of the landfill.

Area 1 is situated on the north and western slopes of a topographic high within the landfill. Ground surface elevation in Area 1 varies from 490 feet on the south to 452 feet at the roadway near the landfill property entrance.

Area 2 is situated between a topographic high of landfilled materials on the south and east and the Buffer Zone and Crossroad Properties (former Ford Property) on the west. The highest topographic level in Area 2 is about 500 feet on the southwest side of Area 2 sloping to approximately 470 feet near the top of the landfill berm along the south side of the Ford Property. The upper surface of the berm along the western edge of Area 2 is located approximately 20 to 30 feet above the adjacent Ford Property and approximately 30 to 40 feet higher than the water surface in the flood control channel located to the southwest of Area 2. A berm on the northern portions of Area 2 controls runoff to the adjacent properties.

On the north side of Area 2 is the property referred to as the Buffer Zone/Crossroad Property (called the Ford Property in the RI). This property was previously owned by Ford Motor Credit, Inc. (Ford). Prior to 1998, Ford subdivided and sold all of its property in this area. The majority of the Ford Property was sold to Crossroad Properties LLC and has been developed into the Crossroad Industrial Park. Ford retained the 1.78 acres immediately adjacent to the western portion of the northern boundary of Area 2 referred to as the Buffer Zone. The ownership of the Buffer Zone was subsequently acquired by Rock Road Industries, Inc. (Rock Road) on behalf of the landfill owner.

### 5.2.1 Earth City Levee District

The Site borders the Earth City Levee District to the east, with the northwestern edge of the Site located about one and one third mile from the Missouri River. The Earth City Levee District is fully developed with business and industrial parks. The 1,891-acre Levee District is protected on three sides with the main levee running 2.6 miles along the eastern bank of the Missouri River. The levee system is designed to exceed the 500-year flood level and ranges from 462.03 feet above mean sea level (ft/amsl) at the south end to 459.34 ft/amsl at the north end. The 500-year flood elevations at these locations are 459.03 ft/amsl and 452.15 ft/amsl, respectively. Assuming a 500-year flood, the Missouri River would be three to seven feet below the top of the Earth City levee.

Landfilling at the Site has significantly raised the elevation of Areas 1 and 2 above the level of the former flood plain. The top elevation of the Area 2 berm is approximately 20 feet above the projected flood elevations of about 453 feet within the levee system along the river. Flooding of areas adjacent to the landfill, i.e., areas outside of the levee system, would only occur as a result of a failure of the levee system. Spreading of floodwaters into areas outside of the levee system would result in lower flood elevations than those projected to occur within the levee system. Therefore, the actual elevations of any floodwaters that may extend into areas adjacent to the landfill would be less than 453 feet. The result would be no more than a foot or two of water at the northwestern toe of the landfill. Four major flood events have occurred since the levee was completed in 1972, including the record level flood of August 1993 when the Missouri River crested at 14.6 feet above flood stage and remained above flood level for about 110 days. The flood control system functioned successfully in each case.

According to information provided on the Earth City Levee District web site, the Levee District has:

> developed a comprehensive and ongoing maintenance program whereby the entire levee system, relief wells, pump station and other mechanical and electrical systems are inspected at least annually by qualified independent contractors. The Corps inspects the levee and pump station normally on an annual basis. The District's levee and the pump station have qualified for participation in the Corp's rehabilitation assistance program for flood control projects (e.g. Public Law 84-99.) As a result of such participation, the Corps will pay 80 percent of the construction costs incurred in connection with rehabilitation of the levee or pump station resulting from flooding. Costs such as dirt are not covered by the Corps' assistance program.

## 5.3 Subsurface Features

The geology of the landfill area consists of Paleozoic-age sedimentary rocks overlying Pre-Cambrian-age igneous and metamorphic rocks. The Paleozoic bedrock is overlain by unconsolidated alluvial and loess deposits of recent (Holocene) age.

Alluvial deposits of varying thickness are present beneath Areas 1 and 2. The landfill debris varies in thickness from 5 to 56 feet in Areas 1 and 2, with an average thickness of approximately 30 feet in Area 2. The underlying alluvium increases in thickness from east to west beneath Area 1. The alluvial thickness beneath the southeastern portion of Area 1 is less than 5 feet (bottom elevation of 420 ft/amsl) while the thickness along the northwestern edge of Area 1 is approximately 80 feet (bottom elevation of 370 ft/amsl). The thickness of the alluvial deposits beneath Area 2 is fairly uniform at approximately 100 feet (bottom elevations of 335 ft/amsl).

During the RI investigations, groundwater was generally encountered in the underlying alluvium near or immediately below the base of the landfill debris. Isolated bodies of perched water were encountered in 2 of the 24 soil borings drilled in Areas 1 and 6 of the 40 borings drilled in Area 2 as part of the RI field investigations. The perched water generally occurs in small isolated units at depths varying from 5 to 30 feet below ground surface.

Monthly groundwater levels measured in various landfill wells indicate that only a very small amount of relief (less than a foot) exists in the natural alluvial water table surface. The regional direction of groundwater flow is northerly within the Missouri River alluvial valley, parallel or subparallel to the river alignment. However, the leachate collection system for the Former Active Sanitary Landfill creates a localized cone of depression that extends across the eastern half of the Site and includes the water table underlying Area 1. The approximate extent of the inward hydraulic gradient and the generalized flow direction is shown on the maps showing the groundwater sampling results (Figures 5-8 through 5-12).

Vertical hydraulic gradients were calculated using piezometer clusters. The vertical hydraulic gradients for the shallow alluvium to intermediate or deep alluvium and for deep alluvium to shallow bedrock are very small and vary from slightly downward to slightly upward.

### 5.4 Landfill Surface and Subsurface Investigations

This section describes the surface and subsurface investigation activities in the fill material including surface geophysical investigations, perched water investigation, landfill gas surveys, borehole drilling, soil sample collection and chemical analyses, downhole gamma logging, and geotechnical sampling and testing.

#### 5.4.1 Purpose and Scope of Investigation

The surface and subsurface soil and perched water investigation activities were completed to characterize the distribution and extent of radioactive and hazardous nonradioactive constituents within the landfill mass, including the various cover soils and potential perched water occurrences in Areas 1 and 2.

Investigations of the landfill soils and perched water included the following:

- Pre-screening of each soil boring location within the landfill for potential large metal obstacles and methane concentrations

- Drilling of 20 borings in Area 1 and 40 borings in Area 2 (Figure 5-3), including pre-drilling of all planed monitoring wells to be completed through areas underlain by landfill refuse

- Collection of soil samples from all of the soil borings, generally at five-foot depth intervals and performance of radiological and chemical analyses on selected soil samples from the various soil borings

- Collection of samples from four background locations potentially representative of daily cover materials and performance of radiological and chemical analyses

- Downhole radiological logging of all of the newly drilled soil borings and all existing monitoring wells and cased soil borings remaining from prior Site investigations that could be located

- Collection of selected perched water samples encountered during the soil boring activities

- Collection and laboratory testing for selected geotechnical properties of four soil samples obtained from the landfill slope at the northern edge of Area 2 above the former Ford Property.

### 5.4.2 Summary of Results

Significant observations with respect to landfill setting, radiological constituents, nonradiological constituents, and perched water based upon the data collected are described in the following subsections.

Landfill Setting

Based on the data collected, the following observations were made regarding the general Site geologic and hydrogeologic conditions and the nature and configuration of the landfill debris:

- The thickness of the landfill materials varies from 20 to 56 feet in Area 1, and 11 to 45 feet in Area 2

- Loess (silt, clay, and fine sand) materials were used to cover the landfill debris in Areas 1 and 2

- Isolated occurrences of perched water were found to be present within the landfill debris and where present, perched water was found to be of very limited extent

- Regional (continuous) groundwater generally occurs in the unconsolidated alluvial deposits present below the base of the landfill debris

Radiological Constituents

Based on the data collected, the following observations were made regarding the occurrences of radiological constituents within the landfill debris: (1) Radionuclides are dispersed in landfill deposits in Areas 1 and 2. Radiological constituents occur in soil materials that are intermixed with and interspersed in the overall matrix of landfilled refuse, debris, fill materials, and unimpacted soil. In some portions of Areas 1 and 2, radiologically impacted materials are present at or near the surface; however, the majority of the radiological occurrences are in the subsurface. (2) The primary radionuclides detected at levels above background concentrations at OU 1 are part of the uranium-238 (U-238) and uranium-235 (U-235) decay series. Isotopes from the thorium-232 (Th-232) decay series are also present above background levels but to a lesser degree. The radionuclides derive from ore processing residues with an elevated ratio of Th-230. The high relative concentration of Th-230 resulted from ore processing designed to separate out uranium and radium, leaving thorium in the residue (by-product). See Tables 5-2 through 5-6 for a summary of radionuclide occurrences in Areas 1 and 2 and the results of background sampling.

Radiological Occurrences at Area 1

Radionuclides are present in the upper six inches (15 centimeter [cm]) at levels above the Uranium Mill Tailings Radiation Control Act (UMTRCA[a]) standard for surface soil (5 pCi/g over background) over approximately 50,700 square feet (1.16 acres) (Figure 5-4). Approximately 194,000 square feet (4.45 acres) have radionuclides present in the subsurface at depths ranging up to seven feet, with localized intervals present to depths of 15 feet (Figure 5-5). Subsurface occurrences of radionuclides are present in soil material that is intermixed with the overall landfill matrix of refuse, debris, and fill materials. The total volume of radiologically impacted materials and associated landfill materials is estimated to be approximately 24,400 cubic yards ($yd^3$).

[a] To assist in describing the extent of the radiologically impacted material, the soil clean-up standards set forth in the Uranium Mill Tailings Radiation Control Act (UMTRCA), 40 CFR part 192, sections 12 and 41, are used in the RI as reference levels. See section 13.2 for a description of these standards.

Radiological Occurrences at Area 2

Radionuclides are present in the upper six inches (15 cm) over approximately 468,700 square feet (10.76 acres) (Figure 5-4). An additional 17,200 square feet in the northeastern portion contain soil/sediment eroded from the surface. Radionuclide-impacted materials are present in the subsurface beneath approximately 817,000 square feet (18.76 acres) at depths of up to approximately 12 feet, with some localized deeper intervals (Figure 5-5). Subsurface occurrences of radionuclides are present in soil material that is intermixed with the overall landfill matrix of refuse, debris, fill, and nonimpacted soil materials. The total volume of radiologically impacted materials and associated landfill materials is estimated to be approximately 118,000 $yd^3$.

Radiological Occurrences on the Buffer Zone/Crossroad Property

During the RI, an additional 196,000 square feet of impacted surface soil were identified in the southern portion of what at that time was property owned by Ford (referred to as the Ford Property) located immediately west of Area 2 (see Figure 4-1). Reportedly, subsequent to completion of landfilling activities in Area 2, erosion of soil from the landfill berm resulted in transport of radiologically impacted materials from Area 2 onto the adjacent Ford Property (now Buffer Zone and Crossroad). The area was subsequently revegetated by natural processes. Low concentrations of radionuclides were found in surficial (6 to 12 inches or less) soil at the toe and immediately adjacent to the landfill berm. Since the RI, this property has been altered by AAA Trailer—a neighboring property owner. The surface soils were scraped and regraded. Gravel has been placed, and AAA Trailer uses the property to park trailers. According to AAA Trailer, all the soil that was scraped or removed was placed in the northeastern corner of the Buffer Zone, adjacent to the northwestern boundary of the Site. Native vegetation has since been reestablished over the disturbed areas. Additional soil sampling for radionuclides will be conducted as part of the RD to determine the current conditions in this area.

A more detailed discussion of the radiological occurrences in Areas 1 and 2 and on the Ford Property is present in the *Interim Investigation Results Technical Memorandum, West Lake Landfill Radiological Areas 1 and 2, January 1997,* and *Remedial Investigation Report, West Lake Landfill, Operable Unit 1, April 2000*.

Nonradiological Constituents

Based on the data collected, the following observations were made regarding the occurrences of nonradiological (priority pollutant) constituents within the landfill debris:

- In Area 1, each of the trace metals are present at concentrations above the levels found in the background soils in one or more borings. The levels of trace metals detected in area soil samples are a follows:

| **Trace Metal** | **Background Value Milligrams per Kilogram (mg/kg)** | **Range of Values Detected in Area 1 (mg/kg)** |
|---|---|---|
| Arsenic | 6.35 | 0.8 – 220 |
| Beryllium | 0.59 | <0.25 – 3.3 |
| Cadmium | <0.5 | <0.5 – 7.9 |
| Chromium | 12.83 | 3.1 – 280 |
| Copper | 17.37 | 1.0 – 230 |
| Lead | 38.42 | 2.8 – 900 |
| Mercury | 0.1 | < 0.1 – 0.17 |
| Nickel | 22.02 | 4.7 – 3600 |
| Selenium | <0.25 | 0.25 – 250 |
| Zinc | 28.2 | 16 – 120 |

- In Area 2, each of the trace metals are present at concentrations above the levels found in the background soils in one or more borings. The levels of trace metals detected in area soil samples are a follows:

| **Trace Metal** | **Background Value Milligrams per Kilograms (mg/kg)** | **Range of Values Detected in Area 1 (mg/kg)** |
|---|---|---|
| Arsenic | 6.35 | 0.7 - 35 |
| Beryllium | 0.59 | <0.25 – 2.2 |
| Cadmium | <0.5 | <0.5 – 3.4 |
| Chromium | 12.83 | 2.0 - 890 |
| Copper | 17.37 | 1.0 -360 |
| Lead | 38.42 | <0.25 – 2,200 |
| Mercury | <0.1 | <0.1 – 0.27 |
| Nickel | 22.02 | 1.3 - 682 |
| Selenium | <0.25 | 0.25 – 1.0 |
| Zinc | 28.2 | <1.0 – 1,100 |

- In Areas 1 and 2, petroleum hydrocarbons were detected. Gasoline concentrations varied from 240 to 2,600 parts per million (ppm); diesel constituents ranged from 51 to 310 ppm; and motor oil constituents ranged from 19 to 3,100 ppm.

- Volatile organic compounds (VOCs), other than petroleum hydrocarbon constituents, were detected at concentrations generally less than 1 ppm in both Areas 1 and 2.

- Semi-volatile organic compounds (SVOCs), other than petroleum hydrocarbon constituents, were detected in both Areas 1 and 2 at concentrations less than 1 ppm.

- Pesticides were generally detected at concentrations less than 0.01 ppm. Polychlorinated biphenyls (PCBs) were detected in Area 1 at concentrations between 0.033 and 2.6 ppm. PCBs in Area 2 generally varied between 0.017 and 1.6 ppm.

- Based upon the nonradiological data collected, it was concluded that the presence and distribution of these constituents is limited in extent and isolated in nature. Also, there is no correlation between occurrences of radiological and nonradiological constituents.

<u>Perched Water</u>

Based on the data collected, the following observations were made regarding the occurrences of perched water within the landfill debris:

- Distribution of perched water is of limited extent, and the various perched waters are isolated in nature (Figure 5-6).

- U-238 decay series constituents were present in each of the perched water samples and the Area 2 seep.

- No U-235 decay series constituents were detected in the perched water.

- All detected priority pollutant metals from the perched water and the Area 2 seep were below their respective maximum contaminant levels (MCLs).

- Ten halogenated and aromatic VOCs were detected in the perched water samples. Three aromatic VOCs were detected in the Area 2 seep.

- Thirteen SVOCs were detected in the perched water samples, while only two SVOCs were detected in the Area 2 seep.

- Eight pesticides were detected in the perched water samples, and PCBs were detected in two of the samples. No pesticides were detected in the Area 2 seep.

- Both the perched water and the Area 2 seep sample exhibited many of the conditions indicative of landfill leachate including: total dissolved solids concentrations ranging from 2,300 to 6,300 ppm; total suspended solids ranging from 1,500 to 6,000 ppm; chloride concentrations ranging from 510 to 1,500 ppm; chemical oxygen demand ranging from 690 to 1,400 ppm; biological oxygen demand ranging from <300 to 460 ppm; and ammonia concentrations ranging from 93 to 220 ppm.

### 5.5 Groundwater Investigation

Groundwater characterization activities were completed to assess the distribution and flow of groundwater beneath Areas 1 and 2 as well as to determine the magnitude and extent, if any, of radiological and nonradiological contaminants in the groundwater.

#### 5.5.1 Purpose and Scope of Investigation

The scope of the groundwater investigation included:

- Collection of samples from 30 existing wells for gross alpha measurement to evaluate water disposal options

- Installation of 14 new groundwater monitoring wells

- Development of 44 new and existing wells (Figures 5-7)

- Collection of five sets of groundwater samples from varying sets of wells

- Analysis of groundwater samples and split samples for a full suite of contaminants

- Slug testing of 18 wells to measure hydraulic conductivity

#### 5.5.2 Summary of Results

Based on the data collected, the following observations were made regarding the occurrences of groundwater within the landfill debris:

- Constituents in the U-238, U-235, and Th-232 decay series were detected in both upgradient background wells—S-80 and MW-107.

- Constituents in U-236, U-235, and Th-232 decay series were measured near background levels in wells at the landfill, i.e., generally below 3 picocuries per liter (pCi/l). There were minimal differences between the results obtained from the filtered and unfiltered samples.

- Six of the priority pollutant trace metals—arsenic, chromium, copper, lead, nickel, and zinc—were detected in unfiltered samples from background wells.

- Eight of the priority pollutant trace metals—arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc—were detected in the unfiltered samples from wells at the landfill. With the exception of the single detection of mercury in well D-14 (0.21 micrograms per liter [µg/l]) and a single detection of selenium in well MW-101 (38 µg/l), all of these trace metals were also detected in the background well samples. For the six trace metals detected in both background and site wells, the levels of the trace metals detected in the unfiltered samples from the wells at the landfill were similar to or less than the levels of the trace metals found in the background wells. The two exceptions were the arsenic results in six of the site wells and the nickel levels in well S-5 (arsenic 13 to 420 µg/l versus background of <0.1 to 20 µg/l and nickel 93 to 110 µg/l versus background of <0.2 to 74 µg/l). Furthermore, with the exception of arsenic and to a lesser extent nickel, the trace metals generally were not detected in the filtered samples.

- Total petroleum hydrocarbons were detected in six wells at concentrations from 0.53 to 3.5 ppm.

- Eleven VOCs including benzene, several chlorobenzene compounds, and acetone (a known laboratory contaminant) were detected in the wells at the landfill. These compounds were not detected in the background wells.

- Four SVOCs (1,4-dichlorobenzene, 4-methyl phenol, and two phthalate compounds, known laboratory contaminants) were detected in wells at the landfill. These compounds were not detected in the background wells.

- Three pesticides were detected in wells at the landfill in the November 1995 sampling episode. They were not detected during the February 1996 episode. No PCBs were detected during either sampling event.

- The hydraulic conductivity of the shallow material (average of $8 \times 10^{-3}$ centimeters per second [cm/sec]) is slightly less than average hydraulic conductivity results obtained from the intermediate and deep monitoring wells ($4 \times 10^{-2}$ cm/sec).

### 5.6 Potential Migration Pathways

This section describes the potential pathways by which radionuclides and other contaminants could migrate from Areas 1 and 2. As the primary contaminants of concern (COCs), particular emphasis is given to the potential for radionuclide migration. In some cases, actual contaminant migration was measured during the RI. In other cases, these pathways are considered to have some potential for future migration. As shown in Figure 5-1, the potential pathways are:

- Airborne transport of radon gas and fugitive dust
- Rainwater runoff transport of dissolved or suspended contaminants
- Erosion and transport of contaminated soils
- Leaching of contaminants to the underlying alluvial groundwater

### 5.6.1 Airborne Transport

Radionuclides in Areas 1 and 2 can be transported to the atmosphere either as a gas in the case of radon or as a fugitive dust in the case of the other radionuclides. Both potential pathways were evaluated based on site-specific data.

Radon Gas

Radon gas is discharged as a result of the decay of radium. The radon, like other landfill gases, will migrate upward and be discharged to the air at the surface of Areas 1 and 2. Radon flux measurements were made at 54 locations at Areas 1 and 2. Several locations gave high radon flux measurements; however, the average radon flux readings across Areas 1 and 2 were relatively low. The average radon flux for all 54 measurements is 22 pCi/square meters ($m^2s$). The standard established pursuant to the UMTRCA for allowable radon emissions from residual radioactive materials from inactive uranium processing sites [40 CFR 192.02(b)] is 20 pCi/$m^2$s. This standard applies to the average radon emissions across vast tailings piles that are considerably larger than Areas 1 and 2. Given their relatively small size, the net radon contribution to the air from Areas 1 and 2 is considered small. The radon emitted at the surface is subject to the dilution and dispersion processes active in the atmosphere and is unlikely to have an impact beyond the landfill boundaries. However, radon generation does occur and will increase over time due to ingrowth of radium. Therefore, the remedy will address this pathway.

Radon gas from Areas 1 and 2 along with other landfill gases could potentially migrate laterally in the subsurface and be captured by the landfill gas collection system on the south side of Area 1. Factoring in dispersion, the short half-life for radon (3.8 days for radon-222 [Rn-222]), the low overall radon flux from Areas 1 and 2, and the small contribution these areas would make to the gas collection system, this pathway is not expected to present a significant problem. Measurements of radon concentrations near the landfill office and in the Former Active Sanitary Landfill gas collection system did not identify significant levels of radon gas.

Methane gas measurements were performed as part of the RI field investigations. During the RI, methane levels ranging from less than one percent to as much as 45 percent were observed in the various boreholes drilled for the RI. The highest levels of methane were observed in boreholes drilled in Area 1. Lower levels of methane were observed in Area 2; however, methane concentrations greater than five percent methane concentration by volume (the lower explosive limit or LEL for methane) were observed in both Area 1 and Area 2.

Fugitive Dust

Fugitive dust monitoring was conducted at one location in Area 1 and one location in Area 2 in accordance with the approved RI/FS Work Plan. Sampling for fugitive dust monitoring was performed at locations that contained the highest or some of the highest radionuclide concentrations in surface soil samples. Results of the fugitive dust monitoring indicated that although fugitive dust emissions may be a pathway at the landfill, the levels of radionuclides detected in the samples collected during the RI indicated that it is not a significant pathway for radionuclide migration from Areas 1 and 2. Fugitive dust is not considered a significant pathway for radionuclide migration under current conditions, primarily because the surfaces of Areas 1 and 2 for the most part are vegetated, thereby reducing or preventing release of significant amounts of fugitive dust. This pathway could become a concern in the future if the Site's conditions are not monitored and maintained.

### 5.6.2 Rainwater Runoff and Transport

Radionuclides present in Areas 1 and 2 could potentially be transported to other portions of the landfill or to off-site areas with precipitation runoff from the landfill. Transport with rainwater runoff would include both dissolved phase transport and suspended phase transport within the flowing runoff water.

Water samples were obtained during storm events to assess the potential for dissolved or suspended phase transport of site contaminants in precipitation runoff. Low levels of radionuclides were detected in some of the rainwater runoff samples obtained as part of the RI.

As no standards or health-based criteria exist for rainwater runoff, the results of the analyses of these samples were compared to their respective MCLs for drinking water systems; however, as there is no expectation that any potential receptor would actually drink rainwater runoff, the MCLs are not an applicable or relevant and appropriate requirement (ARAR) for rainwater runoff. One of the rainwater runoff samples obtained from an on-site area contained radionuclides at levels slightly above the radium MCL. The analysis indicated that the total of radium-226 (Ra-226) and Ra-228 isotopes in the unfiltered sample was twice the MCL. None of the surface water samples (either dissolved or total fractions) collected from the nearest off-site surface water bodies (surface water retention and detention basins and flood control channel located adjacent to the Site) contained radionuclides at levels above the MCL.

The potential for radionuclide transport in either the dissolved phase or as suspended sediment in rainwater runoff during average storm events is likely limited by the presence of the existing vegetative cover. Therefore, dissolved phase transport in rainwater runoff does not appear to be a significant potential pathway for radionuclide migration under current conditions. Suspended sediment transport in rainwater runoff is a potential pathway for radionuclide migration within and adjacent to Areas 1 and 2; however, based on the results of the off-site sampling, it does not appear to be a significant pathway for off-site migration of radionuclides under current conditions.

Although elevated levels of radionuclides were not found in samples from off-site surface water and sediment, nonetheless rainwater runoff is considered a potential pathway for radionuclide migration from Areas 1 and 2 in the event the condition of these areas were to degrade, e.g., loss of vegetative cover. Rainwater runoff containing dissolved or suspended radionuclides could be transported from Area 1 or the southeastern portion of Area 2 into the drainage ditches at the landfill. Dissolved or suspended radionuclides could be further transported into the perimeter drainage ditch along the northeastern boundary of the landfill (southwestern side of St. Charles Rock Road). From the perimeter drainage ditch, dissolved or suspended radionuclides could potentially enter the water impoundment north of Area 2 depending upon the magnitude and duration of the rainwater runoff. Similarly, rainwater runoff containing dissolved or suspended radionuclides could be transported from the western portions of Area 2, down the landfill slope, and onto the Buffer Zone/Crossroad Property.

### 5.6.3 Soil Erosion and Sediment Transport

Radionuclides present in Areas 1 and 2 could be transported to other portions of the landfill or to off-site areas through erosional transport of soil and sediment. In order to determine if this has occurred, sediment samples were collected from various surface water diversion ditches, runoff control structures, or erosional channels located on-site and off-site.

Some of the sediment samples collected on-site contained levels of radionuclides above background. One sediment sample collected at the landfill boundary on the southern side of the access road contained Ra-226 at a level of approximately 5 pCi/g above background. The levels of radionuclides detected in off-site sediment samples were generally near or slightly above background.

Soil samples obtained from 5 of the 11 locations on the Buffer Zone/Crossroad Properties contained radionuclides at levels of 5 pCi/g or more above background. All of these samples were from the upper three to six inches of materials. Radionuclides were not detected above background levels in any of the samples obtained from the Buffer Zone/Crossroad Properties at depths of one foot or more.

Based on the results of the sediment sampling, erosion of surface soils in Areas 1 and 2 and subsequent sediment transport to the landfill access road drainage ditch has occurred and continues to occur in response to significant precipitation events. Sediment transport along the landfill access road drainage ditch into the landfill perimeter drainage ditch along St. Charles Rock Road also has occurred. The data do not indicate significant levels of contaminated sediment in the perimeter drainage ditch along St. Charles Rock Road; however, the potential exists for contaminated sediments to migrate from the interior drainage ditches to perimeter drainage ditch. To the extent that sediment transport would occur along the landfill perimeter drainage ditch, any sediment that may be transported along this pathway would accumulate in the surface impoundment north of Area 2. Previous erosional transport—slope failure or mudflow—from the western portion of Area 2 down the landfill berm resulted in transport of radionuclides onto the eastern portion of the Buffer Property and portions of the Crossroad Property located adjacent to the base of the landfill slope on the northwestern boundary of Area 2. The remedy for OU 1 will need to address this migration pathway.

### 5.6.4 Leaching to Groundwater and Groundwater Transport

The fourth potential migration pathway identified is downward migration of landfill leachate to the alluvial groundwater system and subsequent transport by the groundwater system to off-site areas. The landfill units addressed under OU 1 and OU 2 affect the same alluvial groundwater system and any potential impacts and remedial objectives will be interrelated. The following evaluation combines data collected for both OU 1 and OU 2 to present a more comprehensive look at groundwater.

To review, perched water is present at isolated locations within the landfill materials at Areas 1 and 2. The perched water exhibited many conditions indicative of landfill leachate; however, radionuclides were not generally detected except at levels consistent with background, i.e., 1 to 2 pCi/l or less.

Groundwater and Surface Water Data – General Summary

Groundwater samples obtained from a network of on-site monitoring wells over a period of years have been analyzed for a wide range of chemicals including radionuclides, trace metals, petroleum hydrocarbon constituents, VOCs, SVOCs, pesticides, and PCBs. Surface water samples have also been analyzed. Figures 5-8 through 5-12 are maps illustrating groundwater and surface water data collected as part of the Site's OU 1 and OU 2 RI/FS projects. Groundwater and surface water results for chlorobenzene, benzene, dissolved and total lead, dissolved and total arsenic, and dissolved and total radium are illustrated on these figures. These are the only constituents detected in excess of MCLs which are used as a reference level.

The locations of two known sources of groundwater contamination unrelated to the Site are also identified on the figures. PM Resources, located to the east of Area 1 across St. Charles Rock Road, produces a wide variety of animal health care products and chemicals. In addition, a Leaking Underground Storage Tank (LUST) is located at the center of the Site property. As shown by the arrows on these figures, some groundwater flows from these sources toward the Former Active Sanitary Landfill. Some of the contaminants detected as part of the OU 1 and OU 2 investigations may be attributable to these sources. Summaries regarding the nature of these facilities and the potential groundwater releases associated with these can be found in the OU 2 RI/FS documents.

The figures also include the approximate extent of the inward hydraulic gradient that has been established by pumping of about 300 millions gallons per year of groundwater/leachate at the Former Active Sanitary Landfill. The sanitary landfill has been pumping about 300 million gallons per year of leachate/groundwater for approximately 15 years and is required by state permit to maintain a significant inward hydraulic gradient throughout post-closure, which will extend for at least another 29 years.

Brief descriptions of the figures are provided below:

- Chlorobenzene: All wells and surface water locations at which chlorobenzene concentrations were below detection are shown in blue. The few isolated locations at which chlorobenzene concentrations were above detection are shown in brown along with the reported concentration. One location exceeded the chlorobenzene MCL.

- Benzene: All wells and surface water locations at which benzene concentrations were below detection are shown in blue. The few isolated locations at which benzene concentrations were above detection are shown in brown along with the reported concentration. The few benzene detections are located in the general direction of regional groundwater flow from the LUST facility. Surface water in the Earth City Stormwater Retention Pond was sampled for benzene in two locations near the wells with detectable benzene, and benzene was nondetect in the surface water samples.

- Dissolved Lead: There were no detections of dissolved lead for the sampling events shown.

- Total Lead: All wells and surface water locations at which total lead concentrations were below the lead MCL of 0.015 milligram per liter (mg/l) are shown in blue. The few isolated locations at which total lead concentrations were above the MCL of 0.015 mg/l are shown in brown along with the reported concentration. Note that the total lead MCL exceedances are isolated. Also as described above, all dissolved lead concentrations were less than detection indicating that the total lead exceedances are associated with particulates commonly entrained in unfiltered samples.

- Dissolved Arsenic: All wells and surface water locations at which dissolved arsenic concentrations were below the current arsenic MCL of 0.010 mg/l are shown in blue. The few isolated locations at which dissolved arsenic concentrations were above the current MCL of 0.010 mg/l are shown in brown along with the reported concentration. Note that the dissolved arsenic MCL exceedances are isolated spatially. Note also, the arsenic MCL was 0.050 mg/l during the RI and preparation of the Baseline Risk Assessments (BRAs) for OU 1 and OU 2. These documents reflect the standards in place at the time and therefore describe only three wells exceeding the standard of 0.050 mg/l—MW-F3, PZ-304-AS, and PZ-303-AS.

- Total Arsenic: All wells and surface water locations at which total arsenic concentrations were below the current arsenic MCL of 0.010 mg/l are shown in blue. The locations at which total arsenic concentrations were above the current MCL of 0.010 mg/l are shown in brown along with the reported concentration. Arsenic was detected in many of the samples at concentrations ranging from 0.010 to 0.420 mg/l. The elevated detections are isolated, i.e., most nearby locations are at background or nondetect. Note also that one of the farthest upgradient wells, located approximately 1,000 feet upgradient of the facility, exhibits a total arsenic MCL exceedance. The arsenic MCL was 0.050 mg/l during the RI and preparation of the BRAs for OU 1 and OU 2. These documents reflect the standards in place at the time and therefore describe only five wells exceed the standard of 0.050 mg/l—MW-F3, D-14, I-62, PZ-304-AS, and PZ-303-AS. One well yielded a total arsenic concentration equivalent to 0.050 mg/l—S-20. The arsenic detections tend to occur along roads and ditches suggesting the potential for sources other than the landfill units, e.g., herbicide application.

- Dissolved Radium: All wells and surface water locations at which dissolved radium concentrations were below the radium MCL of 5 pCi/l are shown in blue. Only one well exhibited a dissolved radium concentration above 5 pCi/l—D-6—with an activity of 5.4 pCi/l.

- Total Radium: All wells and surface water locations at which total radium concentrations were below the radium MCL of 5 pCi/l are shown in blue. Only four wells exhibited a total radium concentration above 5 pCi/l. These exceedances ranged from 5.74 pCi/l to 6.33 pCi/l. The slight exceedances are isolated spatially. Two of the four wells with total radium exceedances are located in areas that are not downgradient of either Radiological Area 1 or Radiological Area 2. One of these locations is on the opposite side of the formerly active landfill and the 250-foot-deep excavated rock quarry in which the solid waste was placed.

Conclusion

The alluvial groundwater underlying and in the immediate vicinity of Areas 1 and 2 and other landfill units have been sampled and analyzed over time. For radionuclides and metals, both filtered and unfiltered samples were analyzed to evaluate dissolved versus colloidal transport. The results generally show sporadic and isolated detections of a small number of contaminants at relatively low concentration levels. These results are not indicative of on-site contaminant plumes, radial migration, or other forms of contiguous groundwater contamination that might be attributable to the landfill units being investigated. Based on frequency of detection and concentration level relative to its MCL, arsenic is by far the most noteworthy COC found in the groundwater. However, even in the case of arsenic, no evidence of radial migration was found, i.e., the detections were not supported by immediately downgradient locations. Total arsenic was detected in many of the samples at concentrations ranging from 0.010 mg/l to 0.420 mg/l. Most results were nondetect or consistent with background. The highest levels of arsenic were detected in shallow well MW-F3 located near the southeast corner of Area 2 (see Figure 5-11). None of the wells located near shallow well MW-F3 contained elevated levels of arsenic. The second highest level of arsenic (0.049 mg/l dissolved and 0.094 mg/l total) was detected in deep well D-14 located at the southern portion of Area 1. The results from other wells in this area do not indicate a contiguous occurrence of elevated arsenic levels. It is not clear that the landfill units under investigation are the source of the arsenic in groundwater since many of the significant arsenic detections occurred near roadside drainages at the perimeter of the Site and in many cases, the detections are not clearly downgradient of the landfill units.

The groundwater results show no evidence of significant leaching and migration of radionuclides from Areas 1 and 2. Moreover, perched water from locations in Areas 1 and 2 was sampled and analyzed and elevated concentrations of radionuclides were not detected. This is the case even though the waste materials have been in place without a landfill cover for over 30 years. Significant leaching and migration of radionuclides to perched water or groundwater have not occurred despite landfilled waste materials having been exposed to worst-case leaching conditions from surface water infiltration over a period of decades.

The lack of radionuclide contamination in groundwater at the Site is consistent with the relatively low solubility of most radionuclides in water and their affinity to adsorb onto the soil matrix. This is supported by partitioning calculations presented in the RI which indicate that impacts to groundwater over time may be low. However, radionuclide and nonradionuclide contamination are present in uncovered landfill units and some of these constituents have been detected in groundwater at levels slightly exceeding MCLs. Therefore, caution is warranted regarding the potential for future leaching of contaminants to underlying groundwater and this pathway should be addressed as part of the RA at the Site.

Fate and Transport

The alluvial groundwater underlying the eastern portion of the Site, i.e., groundwater underlying Area 1 and the Former Active Sanitary Landfill, is captured by the inward hydraulic gradient created by the leachate collection system for the Former Active Sanitary Landfill. Figures 5-8 through 5-12 show the approximate extent of the inward hydraulic gradient. Bordering the Inactive Sanitary Landfill to the west and extending north of the Site is the Earth City Stormwater Retention Pond which acts as a hydraulic barrier to horizontal groundwater flow. Therefore, the potential for off-site groundwater flow under current conditions is generally limited to the western portion of the Site, i.e., groundwater underlying Area 2 and the Inactive Sanitary Landfill. Flow is predominantly horizontal and in the northeasterly direction toward the river. The groundwater contaminants in this zone have the potential to migrate with groundwater flow to off-site locations. This pathway for migration is not considered significant under current conditions because the on-site impact to groundwater from the landfill units is so limited. If groundwater monitoring data show no evidence of a contaminant plume underlying and immediately downgradient of the source material, then it is reasonable to conclude there is no contaminant plume further downgradient at some off-site location that could be attributable to the source material. For this reason, off-site groundwater investigations were not undertaken as part of the RI. However, radionuclide and nonradionuclide contamination is present in the landfill units; the potential for leaching to groundwater and off-site migration is a pathway that should be addressed as part of the remedy for the Site.

## 6.0 CURRENT AND FUTURE LAND AND RESOURCE USES

This section describes the current and reasonably anticipated land uses and current and potential groundwater uses at the Site. This assessment forms the basis for the reasonable exposure assumptions used in the risk assessment process.

### 6.1 Land Use

The Site is a 212-acre facility on which are located several solid waste disposal areas including Areas 1 and 2 and the Bridgeton Sanitary Landfill. There is also a solid waste transfer station, concrete and asphalt plants, and an automobile repair shop located on the facility.

Land use in the area surrounding the landfill is generally commercial and industrial. The property to the north of the landfill across St. Charles Rock Road is moderately developed with commercial, retail, and manufacturing operations. The Earth City Industrial Park is located adjacent to the landfill on the west and southwest, across Old St. Charles Rock Road. Spanish Village, a residential development, is located to the south of the landfill near the intersection of St. Charles Rock Road and Interstate 270, approximately .75 mile from the Site. Adjacent to the Spanish Village development is a large industrial park. Mixed commercial, retail, manufacturing, and single-family residential uses are present to the southeast of the landfill.

The Site itself is expected to remain a landfill site and any on-site commercial uses will need to be compatible with this end use. There are existing land use controls in the form of restrictive covenants executed by the property owner. Development within the Earth City Levee District, which includes all the property to the north, west, and southwest of the Site, is commercial and industrial by design and the entire 1,891 acres is 97 percent developed. Surrounding land use to the south and east is also expected to remain largely commercial/industrial. Zoning in that area is consistent with this observation. Because the surrounding area is already mostly developed, no significant changes in land use are anticipated.

### 6.2 Groundwater Use

The Site is located at the edge of the alluvial valley. Groundwater is present in both the unconsolidated materials (alluvium) and in the bedrock underlying and adjacent to the Site.

The major alluvial aquifers in the area are differentiated to include the Quaternary-age alluvium and the basal parts of the alluvium underlying the Missouri River flood plain. The major bedrock aquifers favorable for groundwater development lie at great depth. The St. Peter Sandstone aquifer lies at a depth of approximately 1,450 feet below ground surface. While of regional importance, the major bedrock aquifers are not significant to the study of the Site due to their great depths and intervening shale units. The bedrock units immediately underlying and adjacent to the Site (including the Warsaw, Salem, and St. Louis Formation) are not very favorable for groundwater development, i.e., yield less than 50 gallons per minute to wells.

Investigation during the RI confirmed there is no current groundwater use in the vicinity of the Site. The nearest registered water well is a deep bedrock well located about one mile northeast of the Site. The closest registered alluvial well is 2.5 miles south of the Site. A public water supply intake is located approximately eight miles downstream of the Site. Given the setting and the ready access to municipal drinking water supplies, use of the shallow groundwater at or near the Site is not considered to be a viable pathway for the foreseeable future. Nevertheless, based on potential yields, groundwater in the vicinity of the Site is considered potentially usable. In particular, alluvial groundwater wells completed in the Missouri River flood plain are capable of very high yields.

## 7.0 SUMMARY OF SITE RISKS

A BRA was conducted as part of the RI/FS process to examine the current and potential future effects of the contaminants on human health and the environment. The human health assessment indicates the Site does not present significant health risks under current conditions, but potential future uses of the Site could result in significant health risks. Therefore, the response action selected in this ROD is necessary to protect public health or welfare from actual or threatened releases of hazardous substances into the environment.

### 7.1 Human Health Risks

The human health risk assessment was conducted using standard EPA methods and guidance. The process evaluates a range of current and potential future exposures assuming that no controls are in place to prevent or limit exposure. It provides a basis for taking response action and identifies exposure pathways that need to be addressed by the response action.

#### 7.1.1 Identification of Contaminants of Concern

Eight radionuclides (U-238, U-235, Th-232 and their associated daughter products U-234, Th-230, Ra-226, Lead-210, and Protactinium-231) were identified as COCs based on their long half-lives. Based on Site data and toxicity screening, three trace metals (arsenic, lead, and uranium as a metal) and one PCB (Aroclor 1254) were also selected as COCs for the human health risk assessment. The radionulides in the waste material came from processed ore residues, and the ratio of Th-230 to Ra-226 is much greater than would be the case if these radionuclides were in equilibrium. Therefore, the assessment adjusted for ingrowth of Ra-226 and its eight daughters from decay of Th-230 over a 1,000-year study period. Tables 7-1 through 7-7 present a summary of the COCs and their exposure point concentrations.

### 7.1.2 Exposure Assessment

The purpose of the exposure assessment is to estimate the nature and magnitude of the potential receptors' exposure to COCs that are present at or migrating from the Site considering both current and reasonably anticipated land or resource use. Components of the conceptual Site model, e.g., exposure pathways and media, are used to perform the exposure assessment.

There are currently access controls such as fencing and limited entry that prevent the public from entering Areas 1 and 2 as well as other areas of the Site, and work practices prohibit Site workers from entering Areas 1 and 2. However, potential future human receptors could be engaged in activities that result in ongoing occupancy of Areas 1 and 2. As part of the BRA, several exposure scenarios (both current and potential) were identified or postulated and evaluated including groundskeepers working on or adjacent to Radiological Areas 1 and 2 and workers associated with other uses of Areas 1 and 2 consistent with potential future commercial/industrial uses such as future parking or open storage. The pathways by which these receptors could be exposed to contaminants present include exposure to external radiation, inhalation of radon gas or contaminated dust, dermal contact with impacted materials, or incidental ingestion of contaminated soil. The assessment used exposure assumptions and intake parameters consistent with EPA's Exposure Factors Handbook (1997). Residential use was not evaluated because it is not consistent with reasonably anticipated land use (section 6.1) and it is not consistent with a landfill remedy. A site-specific evaluation of groundwater consumption was not evaluated because there are no areas of significant off-site migration of contaminants originating from Areas 1 and 2. Some contaminants have been detected in groundwater at levels exceeding MCLs at the source, i.e., in the immediate proximity of the landfill units. However, evaluating consumption of groundwater underlying the source is not consistent with a landfill remedy.

### 7.1.3 Toxicity Assessment

This is the process of selecting appropriate toxicity values for use in estimating the potential health risks associated with exposure to the COCs. Toxicity values for both radiological and chemical COCs are identified. Consistent with EPA guidance, the assessment of radiological health risks is limited to carcinogenic effects. Carcinogenicity is assumed to be the limiting deleterious effect from low radiation doses. For the chemical contaminants, both carcinogenic and noncarcinogenic effects are evaluated. Carcinogenic slope factors for radionuclides are presented in Table 7-8. Carcinogenic slope factors for chemicals are presented in Table 7-9. For chemical noncarcinogens, health effects are assessed by comparing exposure intake to a reference dose (RfD). The RfDs for the COCs are presented in Table 7-10. The primary sources of these toxicity values are EPA's Integrated Risk Information System and EPA's Health Effects Assessment Summary Tables.

### 7.1.4 Risk Characterization

The risk characterization combines the intakes estimated in the exposure assessment with the appropriate toxicity values identified in the toxicity assessment so that cancer risks and chemical health hazards may be estimated for each of the exposure scenarios evaluated.

For carcinogens, risks are expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. These risks are generally expressed in scientific notation, e.g., $1 \times 10^{-6}$. An excess lifetime cancer risk of $1 \times 10^{-6}$ indicates a 1 in 1,000,000 chance of developing cancer from the exposure. This is referred to as "excess lifetime cancer risk" because it would be in addition to the cancer risks individuals face from other causes. For perspective, according to the 2007 American Cancer Society's Cancer Facts and Figures, the chance of an individual developing cancer from all causes is approximately 1 in 3.

For known or suspected carcinogens, EPA has determined that an acceptable level of exposure correlates to an excess lifetime cancer risk to an individual of between 1 in 10,000 ($1 \times 10^{-4}$) and 1 in 1,000,000 ($1 \times 10^{-6}$). This is known as the acceptable risk range. The calculated risks for certain potential future uses at Radiological Areas 1 and 2, as represented by the groundskeeper and a worker involved in outdoor storage, exceed the acceptable risk range. Under CERCLA, this provides a sufficient basis for taking action.

The risks associated with the noncarcinogenic toxic effects of hazardous chemicals are evaluated by comparing an exposure level or intake level to the RfD. The ratio of the intake to the RfD is called the hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD and that noncarcinogenic toxic effects are unlikely. The hazard index (HI) is generated by adding the HQs for all COCs that affect the same target organ or act through the same mechanism. An HI<1 indicates noncarcinogenic toxic effects are unlikely.

Calculated risks for most of the exposure scenarios evaluated fall within the acceptable risk range. However, calculated risks exceed the acceptable risk range for the two scenarios involving potential future workers on Area 2. The maximum exposed individual evaluated in the BRA was the hypothetical future storage yard worker for Area 2. The cancer risk estimate for this receptor is $4 \times 10^{-4}$. This is due primarily to external radiation exposure from continued ingrowth of Ra-226 and its eight daughters from decay of Th-230 over the 1,000-year study period. The findings also indicate that cancer risks from nonradiological contaminants are within the acceptable risk range and all HIs are less than one. Tables 7-11 through 7-19 present a summary of the results for each of the future exposure scenarios that were evaluated (note that the risk numbers in these tables are expressed in the alternate "E notation," e.g., $1 \times 10^{-4}$ = 1 E-4).

### 7.1.5 Uncertainties

The uncertainty analysis provides decision makers with a summary of those factors that significantly influence risk results and discusses the underlying assumptions that most significantly influence risk. This section discusses the assumptions that may contribute to over or under estimates of risk.

#### 7.1.5.1 Uncertainties Related to Environmental Sampling and Analysis

Uncertainty is always involved in the estimation of chemical concentrations. Uncertainty with respect to data evaluation can arise from many sources such as the quality and quantity of the data used to characterize the Site, the process used to select data to use in the risk assessment, and the statistical treatment of data. Errors in the analytical data may stem from errors inherent in sampling and/or laboratory procedures. One of the most effective methods of minimizing procedural or systematic error is to subject the data to a strict quality control review. This quality control review procedure helps to eliminate many laboratory errors. However, even with all data vigorously validated, it must be realized that error is inherent in all laboratory procedures.

#### 7.1.5.2 Uncertainties Related to Exposure Assessment

The exposure scenarios contribute a considerable degree of uncertainty to the risk assessment because they assume conditions that are unlikely to occur. The exposure assumptions directly influence the calculated doses (daily intakes), and ultimately the risk calculations. For the most part, site-specific data were not available and conservative default exposure assumptions were used in calculating exposure doses such as the selection of exposure routes and exposure factors, e.g., contact rate. In most cases, this uncertainty over estimates the most probable realistic exposures and therefore may over estimate risk. This is appropriate when performing risk assessments of this type so the risk managers can be reasonably assured that the public risks may not be under estimated and so risk assessments for different locations and scenarios can be compared.

#### 7.1.5.3 Uncertainties Related to Toxicity Information

RfDs and carcinogenic slope factors for the COCs were derived from EPA sources. RfDs are determined with varying degrees of uncertainty depending on such factors as the basis for the RfD no-observed-adverse-effect level versus lowest-observed-adverse-effect level, species (animal or human), and professional judgment. The calculated RfD is therefore likely overly protective and its use may result in an over estimation of noncancer risk. Similarly, the carcinogenic slope factors developed by EPA are generally conservative and represent the upper-bound limit of the carcinogenic potency of each chemical.

#### 7.1.5 Uncertainties Related to Human Health Risk Characterization

Ideally, exposure would be defined based on actual exposures or known behaviors of receptors at the Site. Often however, as in this case, conditions are controlled so that actual exposures do not occur. Therefore, it was necessary to make some assumptions about how hypothetical receptors might become exposed to the Site. This risk assessment made assumptions about exposure units (or areas) based on contaminant distribution and likely areas of exposure based on the Site's features. These assumptions add to the uncertainty inherent in the risk calculations.

Each complete exposure pathway concerns more than one contaminant. Uncertainties associated with summing risks or HQs for multiple substances are of concern in the risk characterization step. The assumption ignores the possibility of synergistic or antagonistic activities in the metabolism of the contaminants. This could result in over or under estimation of risk.

The large number of assumptions made in the risk characterization introduces uncertainty in the results. The use of numerous conservative and upper-bound assumptions will most likely lead to an over estimate of potential risks from the Site. Moreover, when evaluating risk assessment results, it is important to put the risks into perspective. For example, the background rate of cancer in the United States. is approximately 2,500 for a population of 10,000 people (Landis, et al., 1998). The results of the risk assessment must be carefully interpreted considering the uncertainty and conservatism associated with the analysis especially where site management decisions are made.

### 7.2 Ecological Risks

The BRA for OU 1 included a screening-level ecological risk assessment consistent with EPA guidance. The purpose of the screening-level risk assessment is to determine if a potential for adverse impacts to ecological receptors from exposure to COCs exists at the Site and to determine which chemicals and exposure pathways are driving the potential risk or present the greatest potential risk. There is a significant amount of uncertainty associated with the actual potential for ecological impacts. A screening-level risk assessment deals with the uncertainty by using highly conservative assumptions when estimating potential risks. In this way, sites for which there is no potential for ecological risk may be screened out from further assessment. On the other hand, if the screening-level risk assessment indicates that potential risks exist, this does not necessarily mean that site-related chemicals are impacting ecological receptors. See Table 7-20 for summary of the exposure pathways for ecological receptors.

The results of the screening-level risk assessment for OU 1 indicate that ecological receptors are potentially at risk from exposure to COCs, especially metals, in both Areas 1 and 2. The metals could adversely affect plants and soil invertebrates. Small borrowing animals may be at risk from exposure to radioactive materials in Area 2. It should be noted that both Areas 1 and 2 currently support vegetative and animal communities. There is no observable impact to the health of the plant communities.

Uptake of metals and bioaccumulation in the food chain may affect higher organisms. Based on the models used in this risk assessment, risk to ecological receptors may result from the bioaccumulation of metals in plants and earthworms. Exposure via food sources was the predominant exposure pathway for primary consumers. Exposure of predators was directly related to the concentrations of chemicals in plants and/or earthworms and the proportion of these contaminated food sources in the diet.

Selenium was the only COC for the red-tailed hawk. Exposure to all other contaminants present at the Site is not likely to have an adverse affect on this animal. Exposure to selenium was primarily the result of bioaccumulation in the food. Food accounts for over 99 percent of the exposure and the relative contributions from the various prey animals are proportional to the amount of vegetation in the prey animal's diet. The uptake of selenium in plants is likely over estimated because the bioaccumulation factor used was more representative of selenium bioaccumulating plants which are not found at the Site. The use of maximum bioaccumulation factors for prey animals is likely to have resulted in even greater over estimation of predator exposure.

Similarly, selenium was the predominant risk driver for the white-footed mouse, cottontail rabbit, and the American robin. It was one of the predominant risk drivers for the red fox and the American woodcock. The primary exposure pathway was bioaccumulation of the contaminant within the food chain, especially uptake by plants. As was previously described, the uptake of selenium in plants and bioaccumulation in prey animals is likely over estimated. See Tables 7-21 through 7-23 for a summary of the risk findings.

It should be noted that the OU 1 areas are located within a landfill operation. Some of the ecosystems present in these areas are the result of access controls and the fact that field succession has been allowed to occur. Remediation of OU 1 may significantly alter or destroy the habitats that currently exist, forcing wildlife present to migrate to other areas. The increasing commercial/industrial development of the land surrounding the Site has removed significant amounts of wildlife habitat. This process may result in a reduction in the number of larger species in the area and the reduction of the overall ability of the area to support some types of wildlife.

## 8.0 REMEDIAL ACTION OBJECTIVES

The general objective for the Selected Remedy is to protect public health and the environment by preventing actual or potential human exposure to Site contaminants and by preventing or mitigating contaminant migration. Potential pathways for human exposure are identified in section 7.1.2, and potential pathways for contaminant migration are discussed in section 5.6.

Like other areas of the Site, Areas 1 and 2 were used for solid-waste landfill disposal; however, these areas of the Site also contain substantial quantities of long-lived radionuclides mixed with the municipal solid waste and thus present conditions that are not typical of landfill sites. Generally, the principal response action for CERCLA municipal landfill sites is engineered containment in place consistent with EPA's presumptive remedy approach described below. This approach takes advantage of EPA's experience with landfill sites to streamline the Site-evaluation and remedy-selection processes. However, due to the presence of radionuclides mixed with the municipal solid waste, a more thorough Site evaluation was justified and consequently performed as part of the RI/FS. A full range of field investigations was conducted during the RI, and the range of alternatives that was evaluated included actions to remove radiologically contaminated material. Nevertheless, all remedial alternatives for OU 1 will require some measure of on-site containment of land-disposed waste material; therefore, consideration of the presumptive remedy approach for CERCLA landfills is still necessary to this remedy-selection process. The presumptive approach is described in section 8.1.

## 8.1 Presumptive Remedy Approach for CERCLA Municipal Landfills

The NCP provides the implementing regulations for CERCLA. Section 300.430(a)(iii)(B) of the NCP contains the expectation that engineering controls such as capping or other form of containment will be used for waste that poses a relatively low long-term threat or where treatment is impracticable. The preamble to the NCP identifies municipal landfills as a type of site where treatment of the waste may be impracticable because of the size and heterogeneity of the contents (55 FR 8704). Waste in CERCLA landfills usually is present in large volumes and is a heterogeneous mixture of municipal waste frequently codisposed with industrial and/or hazardous waste, which is the case here. Because treatment is usually impracticable, EPA generally considers containment to be the appropriate response action, or the "presumptive remedy" for the source areas of municipal landfill sites. Presumptive remedies are preferred technologies for common categories of sites based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. EPA has issued guidance that establishes containment as the presumptive remedy for CERCLA municipal landfills including EPA 540-F-93-035, *Presumptive Remedy for CERCLA Municipal Landfill Sites*; EPA/540/P-92-001, *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*; EPA/540F-95/009, *Presumptive Remedies: CERCLA Landfill Caps RI/FS Data Collection Guide*; EPA/540/F-96/020, *Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills,* including those that contain radioactive wastes; EPA 540/R-94/081, *Feasibility Study Analysis for CERCLA Municipal Landfill Sites;* and EPA 540-F-99-015, *Reuse of CERCLA Landfill and Containment Sites*. These documents are included in the AR file and some can be found in Appendix A to the OU 1 FS.

The general RAOs for the presumptive remedy are the following:

- Prevent direct contact with landfill contents
- Minimize infiltration and resulting contaminant leaching to groundwater
- Control surface water runoff and erosion
- Collect and treat contaminated groundwater and leachate to contain any contaminant plume and prevent further migration from the source area
- Control and treat landfill gas

These RAOs address typical migration pathways and exposures generally identified with landfills. They must be tailored to address site-specific circumstances and that analysis has been performed for OU 1. The first objective of preventing direct contact with landfill contents addresses direct exposure to contaminated soil or waste materials. For OU 1, this objective must also include prevention of exposure to gamma radiation. The second and third objectives are also appropriate for OU 1. The fourth objective is not applicable because a plume of contaminated groundwater beneath or downgradient of the disposal areas has not been identified. In addition, meeting the second objective ensures that the potential for ongoing infiltration or leaching is minimized. Similarly, long-term groundwater monitoring is a necessary component of the remedy. The fifth objective of controlling and treating landfill gas also applies and includes the need to account for potential radon gas emissions from Areas 1 and 2. The following bullets summarize the OU 1 objectives.

### 8.2 RAOs for Areas 1 and 2 of OU 1

- Prevent direct contact with landfill contents including exposure to external radiation
- Minimize infiltration and any resulting contaminant leaching to groundwater
- Control surface water runoff and erosion
- Control and treat landfill gas emissions including radon

### 8.3 RAOs for Buffer Zone/Crossroad Property

Historic erosion of the landfill berm along the north side of Area 2 resulted in deposition of radiologically impacted soil on the surface of the Buffer Zone and Crossroad Property (also known as the Ford Property). The RAOs for this property are to prevent direct contact with contaminated surface soils or to ensure contaminant levels are low enough to allow for unlimited use and unrestricted exposure.

## 9.0 DESCRIPTION OF REMEDIAL ALTERNATIVES

The following remedial components address the RAOs identified above:

- Landfill cap
- Landfill gas collection and treatment
- Institutional controls to limit land and resource use
- Long-term maintenance and groundwater monitoring to ensure the effectiveness of the RA

Construction of a proper landfill cap will attenuate gamma radiation and prevent direct contact with landfill contents. The cap will also be designed to attenuate vertical migration of radon. The cap will be designed to minimize infiltration and control surface water runoff and erosion. Based on the results of gas monitoring to be conducted during the RA, collection and control measures will be undertaken as necessary. Long-term groundwater monitoring plans and operation and maintenance (O&M) plans will be developed and implemented. All of these are conventional functions for cover systems used successfully at various landfill sites and disposal units. The specific requirements that these components must meet are established based on an analysis of ARARs.

The remedial evaluation for OU 1 includes an option involving excavation and off-site disposal of a portion of the radiologically impacted materials in Areas 1 and 2. EPA generally defines *hot spots* in landfills as discrete, accessible, and more toxic or mobile waste forms within the landfill that might compromise the integrity of the containment remedy. Typical hot spots include drums or trenches containing liquids or concentrated industrial waste. If hot spots are identified, the process provides that they be evaluated for removal and/or treatment. To be considered for excavation and treatment, hot spots should be large enough or toxic enough that remediation would significantly reduce the risk posed by the site, but small enough and accessible enough that it is reasonable to consider removal. The Site does not have any waste forms that meet this sort of criteria. However, the presence of long-lived radiological contamination makes it reasonable to evaluate excavation and off-site disposal of a portion of the waste material in conjunction with containment of the remaining waste materials and that evaluation was carried out.

Under all remedial alternatives, the Site will remain a landfill and hazardous substances will remain on-site at levels that do not allow for unlimited use and unrestricted exposure. Therefore, a periodic review of the remedy will need to be conducted at least every five years (five-year review report).

## 9.1 Area 1 and Area 2

This section describes each of the remedial alternatives that were evaluated in the FS for Areas 1 and 2.

### 9.1.1 Alternative L1 – No Action

*Estimated capital cost: $0*
*Estimated annual O&M cost: $0*
*Estimated 30-year present worth cost: $47,000*

Alternative L1 (No Action) is included as required by the NCP to serve as a baseline for comparison of the other alternatives. Under this alternative, no engineering measures will be implemented to reduce potential exposures or control potential migration from Areas 1 and 2. Similarly, no additional institutional controls and no additional fencing will be implemented to control land use, access, or potential future exposures to Areas 1 and 2. No monitoring will be conducted to identify or evaluate any potential changes that may occur to conditions at Areas 1 and 2 or to contaminant levels or occurrences. The estimated present worth cost is for performance of five-year reviews over a 30-year period.

**9.1.2 Alternative L2** – Cover Repair and Maintenance, Additional Access Restrictions, Additional Institutional Controls, and Monitoring

*Estimated capital cost: $890,000*
*Estimated annual O&M cost: $240,000 to $260,000*
*Estimated 30-year present worth cost: $3,900,000*

Under Alternative L2, the existing landfill cover in Areas 1 and 2 would be inspected and repaired. Maintenance of the landfill cover would include regular inspection and repair as necessary. Institutional controls must be implemented to limit future uses and to ensure that future uses do not impact the effectiveness or integrity of the RAs.

**9.1.3 Alternative L3** – Soil Cover to Address Gamma Exposure and Erosion Potential

*Estimated capital cost: $8,400,000*
*Estimated annual O&M cost: $20,000 to $200,000*
*Estimated 30-year present worth cost: $9,800,000*

Alternative L3 would consist of placement of a 30-inch thick soil cover over Areas 1 and 2 to reduce the potential gamma exposure to workers or others that may enter these areas in the future. Placement of additional soil cover would also reduce the potential for windblown or water erosion of surface soil containing radionuclides. Maintenance of the landfill cover would include regular inspection and repair as necessary. Institutional controls must be implemented to limit future uses and to ensure future uses do not impact the effectiveness or integrity of the RAs.

**9.1.4 Alternative L4** – Regrading of Areas 1 and 2 (minimum slope of two percent) and Installation of a Subtitle D Cover System

Soil fill option to achieve minimum slope of two percent:

*Estimated capital costs: $21,800,000*
*Estimated annual O&M costs: $15,000 to $200,000*
*Estimated 30-year present worth costs: $23,100,000*

Cut/fill existing materials option to achieve minimum slope of two percent:

*Estimated capital costs: $20,500,000*
*Estimated annual O&M costs: $15,000 to $200,000*
*Estimated 30-year present worth costs: $21,700,000*

Alternative L4 would consist of placing additional soil or inert fill material (nonputrescible construction and demolition debris such as concrete or asphalt rubble) or soil over Areas 1 and 2 to increase the final grades to achieve a minimum slope angle of two percent. Alternatively, the existing waste material and soil in these areas could be regraded (cut and filled) to achieve a minimum slope of two percent. Portions of the landfill berm that contain slopes greater than 25 percent would be regraded through placement of additional material or cutting and filling of existing material to reduce the slope angles to 25 percent subject to physical constraints associated with the location of the toe of the landfill relative to the property boundary. Upon completion of the landfill regrading, a new landfill cover would be constructed over these areas. Design and construction of the landfill cover would include a rubble/rock armor layer to minimize biointrusion and erosion potential and increase the longevity of the landfill cover. Surface drainage diversions, controls, and structures would also be designed and constructed as necessary to route storm water runoff off of Areas 1 and 2 to the permitted storm water drainage systems. The landfill cover would be routinely inspected and maintained to ensure the long-term integrity of the cover. Landfill gas monitoring/management and long-term groundwater monitoring would be required. Institutional controls must be implemented to limit future uses and to ensure future uses do not impact the effectiveness or integrity of the RAs.

The landfill cover and post-closure care and monitoring would at a minimum meet the relevant and appropriate requirements found in the MDNR solid waste landfill regulations [10 CSR 80-3.010(17)] and the UMTRCA standards for control of residual radioactive materials (40 CFR part 192).

**9.1.5 Alternative L5** – Regrading of Areas 1 and 2 (minimum slope of five percent) and Installation of a Subtitle D Cover System

Soil fill option to achieve minimum slope of five percent:

*Estimated capital costs: $24,600,000*
*Estimated annual O&M costs: $15,000 to $200,000*
*Estimated 30-year present worth costs: $25,800,000*

Cut/fill existing materials option to achieve minimum slope of five percent:

*Estimated capital costs: $19,900,000*
*Estimated annual O&M costs: $15,000 to $200,000*
*Estimated 30-year present worth costs: $21,100,000*

Alternative L5 would consist of placing additional soil or inert fill material (nonputrescible construction and demolition debris such as concrete or asphalt rubble) over Areas 1 and 2 to increase the final grades to achieve a minimum slope angle of five percent specified in the MDNR regulations [10 CSR 80-3.010(17)] and [10 CSR 80-4.010(17)] for final cover for operating municipal solid waste or construction and demolition landfills. Alternatively, the existing waste material and soil in these areas could be regraded (cut and filled) to achieve a minimum slope of five percent. Portions of the landfill berm that contain slopes greater than 25 percent would be regraded through placement of additional material or cutting and filling of existing material to reduce the slope angles to 25 percent subject to physical constraints associated with the location of the toe of the landfill relative to the property boundary. Upon completion of the landfill regrading, a new landfill cover would be constructed over these areas. Design and construction of the landfill cover would include a rubble/rock layer to minimize biointrusion and erosion potential. Surface drainage diversions, controls, and structures would also be designed and constructed as necessary to route storm water runoff off of Areas 1 and 2 to the permitted storm water drainage systems. The landfill cover would be routinely inspected and maintained to ensure the long-term integrity of the cover. Landfill gas monitoring/management and long-term groundwater monitoring would be required. Institutional controls must be implemented to limit future uses and to ensure future uses do not impact the effectiveness or integrity of the RAs.

The landfill cover and post-closure care and monitoring would at a minimum meet the relevant and appropriate requirements found in the MDNR solid waste landfill regulations [10 CSR 80-3.010(17)] and the UMTRCA standards for control of residual radioactive materials (40 CFR part 192).

**9.1.6 Alternative L6** – Excavation of Material with Higher Levels of Radioactivity from Radiological Area 2 and Regrading and Installation of a Subtitle D Cover System

With soil fill option to achieve minimum slope:

*Estimated capital costs: $75,000,000*
*Estimated annual O&M costs: $15,000 to $200,000*
*Estimated 30-year present worth costs: $76,000,000*

Because the radiologically contaminated soils are distributed widely in the landfill waste material, there are no areas that represent discrete hot spots. Nonetheless, this alternative was developed to evaluate excavation of some accessible portion(s) of the landfill material containing relatively higher concentrations of radiologically contaminated material.

Alternative L6 consists of excavation of a portion of the radiologically impacted materials in Area 2 that contain levels of radioactivity that are higher than those found in other portions of Area 2 along with the installation of an engineered landfill cover. Area 2 generally has higher concentrations of radionuclides and higher comparative risk estimates than Area 1. As part of the development of this alternative, excavation of all of the radiologically impacted material above reference levels (see footnote on page 10) was initially evaluated (OU 1 FS, Appendix B). This assessment indicated that over 250,000 $yd^3$ of in situ material (including over 130,000 $yd^3$ of radiologically impacted materials and approximately 120,000 $yds^3$ of overburden waste materials and soil) would have to be excavated. Substantial quantities of the radiologically impacted materials are located at depths of 10 to 20 feet below ground surface. The action would involve extensive waste handling and characterization, numerous health and safety challenges, water and dust management problems, time-intensive labor, transportation and decontamination issues, etc. The uncertainties are large and costs would exceed $150 million. Even if such excavations were implemented, these areas would remain landfills and it would not alleviate the need to install proper cover systems including long-term monitoring and post-closure care. Given the large scale of the excavations and the unfavorable trade-offs in protectiveness, implementability, and cost, wholesale excavation is not considered a practicable solution. Therefore, this alternative was developed to evaluate excavation and removal of a smaller volume (a portion) of the radiologically impacted materials from Area 2 which contains relatively higher levels of radionuclides.

For purposes of developing this alternative, the activity levels of individual radionuclides and gamma levels measured in the downhole (borehole) gamma logs were reviewed to identify those materials with levels of radioactivity that were higher than those found in other portions of Area 2. The purpose of this effort was to identify subarea(s) within Area 2 that are substantially smaller than the entire extent of Area 2 but that may contain relatively higher levels of radiological contamination. For purposes of developing and evaluating this alternative, the subareas were defined as areas containing individual radionuclides with activity levels above 1,000 pCi/g or gamma readings above 500,000 counts per minute. These levels were used for evaluation purposes and do not reflect a correlation with any health standards. Under this alternative, these subarea(s) would be excavated and shipped for commercial disposal.

Under one scenario, all of these materials (construction and demolition debris, household and commercial refuse, radiologically impacted soil, and unimpacted soil) would be shipped off-site for disposal at a licensed, commercial, low-level radioactive waste disposal facility. After applying a bulking factor appropriate for municipal refuse, the total volume of material (waste plus soil) to be shipped and disposed at a licensed, commercial, low-level radioactive waste disposal facility was estimated to be approximately 85,000 $yd^3$.

As an alternative to shipping all of the excavated material (construction and demolition debris, commercial and household refuse, radiologically impacted soil, and unimpacted soil) for off-site disposal, the excavated material could be sorted and screened to separate out the soil—both impacted and unimpacted—fraction from the debris and refuse. After applying assumptions on soil fraction, the volume of segregated soil for transport and disposal was estimated at 21,250 $yd^3$. This approach decreases the volume for commercial disposal but increases the waste handling that would be necessary.

In addition to the selective excavation component described above, Alternative L6 would also include backfilling of the selective excavation with soil or inert fill material, regrading and construction of an upgraded landfill cover as described under Alternative L4 or L5, as well as the additional access restriction and institutional controls.

### 9.2 Buffer Zone/Crossroad Property (Ford Property) Alternatives

Historic erosion of the landfill berm along the north side of Area 2 resulted in deposition of radiologically impacted soil on the surface of the Buffer Zone and Crossroad Property (also known as the Ford Property). This section describes the remedial alternatives that were evaluated in the FS.

### 9.2.1 **Alternative F1** – No Action

Alternative F1 (No Action) is included as required by the NCP to serve as a baseline for comparison of the other alternatives. Under this alternative, no engineering measures will be implemented to reduce potential exposures to the radiologically impacted soil in the Buffer Zone and Crossroad Property. Similarly, no new institutional controls and no additional fencing will be implemented to control land use, access, or potential future exposures to the Buffer Zone and Crossroad Properties. No long-term monitoring will be conducted to identify or evaluate any potential changes that may occur to conditions in the Buffer Zone or Crossroad Property or to contaminant levels or occurrences in this area.

### 9.2.2 **Alternative F2** – Institutional and Access Controls

*Estimated capital cost: $210,000*
*Estimated annual O&M cost: $6,000 to $14,000*
*Estimated 30-year present worth cost: $290,000*

Alternative F2 entails the use of institutional and access controls on the Buffer Zone and Crossroad Property to prohibit residential and other land uses that could result in human exposure to the contaminated soils. Alternative F2 would include additional soil sampling to assess the current conditions of the surface soil in Lot 2A2 and the Buffer Zone.

### 9.2.3 **Alternative F3** – Capping and Institutional and Access Controls

*Estimated capital cost: $340,000*
*Estimated annual O&M cost: $6,000 to $14,000*
*Estimated 30-year present worth cost: $420,000*

Alternative F3 includes construction of a cap consisting of a minimum six-inch thick gravel layer, asphalt or other form of pavement, or another form of surface preparation installed over the Crossroad Property to prevent direct contact with the radiologically impacted soil. Installation of gravel or pavement over the surface of the Crossroad Property is consistent with the currently intended use of the property for outdoor storage of tractor trailers. Installation of a gravel cover or pavement would prevent direct contact by workers with the radiologically impacted soil. Alternative F3 would include additional soil sampling to assess the current conditions of the surface soil in Lot 2A2 and the Buffer Zone. Alternative F3 would also include access and institutional controls to control land use.

### 9.2.4 **Alternative F4** – Soil Excavation and Consolidation in Area 2

*Estimated capital cost: $600,000*
*Estimated annual O&M cost: $0*
*Estimated present worth cost: $600,000*

Alternative F4 entails excavation of the radiologically impacted soil from the Buffer Zone and/or Crossroad Property and consolidation of the radiologically impacted soil on the surface of Area 2. The soil would be excavated to remediation goals that support unlimited use and unrestricted exposure. Upon completion of excavation, verification sampling would be performed followed by backfilling and regrading of the area and replacement of the gravel cover.

## 10.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

This section summarizes the comparative analysis of alternatives. The alternatives must be evaluated against the nine evaluation criteria provided in the NCP. The nine evaluation criteria fall into three categories: threshold criteria, primary balancing criteria, and modifying criteria. The first two criteria described below are the threshold criteria. To be eligible for selection, an alternative must meet the threshold criteria, i.e., be protective of human health and the environment and comply with ARARs. The next five criteria are the primary balancing criteria. These criteria are used to assess the relative advantages and disadvantages of each alternative. The last two are the modifying criteria. These allow for consideration of state and community issues and concerns.

### 10.1 Overall Protection of Human Health and the Environment

This criterion addresses whether the alternative provides adequate protection of human health and the environment and how well the risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, and/or institutional controls.

All of the alternatives for OU 1, except the No Action alternative, would protect human health and the environment by limiting potential exposure to the Site's contaminants through engineering means and land use controls. Due to the required engineering controls, the landfill cover alternatives (Alternatives L3, L4, L5, and L6) offer much more reliable protection than Alternative L2, which is more reliant on land use controls. The more sophisticated design of multi-layered landfill cover with infiltration barrier (Alternatives L4, L5, and L6) would provide greater overall protection than the soil cover (Alternative L3).

All of the alternatives for the Buffer Zone/Crossroad Property, except Alternative F1 (No Action), are protective of human health and the environment.

## 10.2 Compliance with ARARs

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that RAs at CERCLA sites attain legally ARARs unless such ARARs are waived under CERCLA section 121(d)(4).

The principal ARARs for Areas 1 and 2 are the closure and post-closure care requirements for Missouri solid waste landfill rules, supplemented by standards developed under the UMTRCA to further address the radiological component. See section 13.2 for a full description. Alternatives L4, L5, and L6 will comply with all ARARs. Alternatives L2 and L3 do not meet the basic cover design requirements found in the Missouri Solid Waste Rules for sanitary landfills (10 CSR 80-3.010). Since Alternatives L2 and L3 do not meet this threshold criterion, these alternatives are not evaluated further.

All of the alternatives for the Buffer Zone/Crossroad Property, except Alternative F1 (No Action), will meet ARARs.

## 10.3 Long-Term Effectiveness and Permanence

This refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time.

Each of the landfill cover alternatives—Alternatives L4, L5, and L6—provide engineered containment in conjunction with long-term monitoring, maintenance, and land use control designed to be effective over the long term. Long-term site management plans and institutional controls will be made as robust and durable as possible. Long-term groundwater monitoring is effective in verifying the remedy is performing as required and groundwater is protected. While not anticipated, even with the loss of institutional control, the landfill cover will passively prevent potential contaminant migration and human exposures for an indefinite period. Removing a portion of the contaminated material prior to capping, as in Alternative L6, may not decrease calculated risks because the exposure point concentrations used in risk assessment are based on arithmetic mean and not maximum concentrations. In theory, however, Alternative L6 provides a greater measure of long-term effectiveness than the other alternatives in the event the remedy is compromised because it involves excavation and removal of a portion of the radiologically contaminated material. Note this judgment applies only to the Site and assumes there would be no impact to the disposal facility that would receive the excavated waste material.

By moving the contamination from the Buffer Zone/Crossroad Property to the landfill, the excavation alternative—Alternative F4—provides the greatest level of long-term effectiveness and permanence among the alternatives.

## 10.4 Reduction of Toxicity, Mobility, or Volume of Contaminants Through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

None of the alternatives for OU 1 will reduce the toxicity, mobility, or volume of the waste material through treatment technology. Occurrences of radionuclides within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout the overall, heterogeneous matrix of municipal refuse, construction and demolition debris, and other nonimpacted soil materials. Consequently, excavation of the radiologically impacted materials for possible ex situ treatment techniques is considered impracticable. In addition, the heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within the overall solid waste matrix make in situ treatment techniques impracticable.

None of the alternatives for the Buffer Zone/Crossroad Property will reduce toxicity, mobility, or volatility through treatment technologies.

## 10.5 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during implementation of the remedy.

During the construction period, all of the alternatives will result in additional local truck traffic and pose some physical hazards for workers. Alternative L6 ranks lower than the capping only alternatives in this category because it is more difficult and time consuming to construct. Alternative L6 poses increased physical hazards to workers due to the increased level of personal protective equipment, extensive waste excavation and handling, and increased truck traffic. The extensive excavation and handling of contaminated materials also present greater potential for human exposures and contaminant migration than Alternatives L4 and L5 over the near term. Due to the extensive work with contaminated materials, Alternative L6 would involve more complicated and time-consuming work place practices, e.g., dust suppression, use of respirators, decontamination zones, water management issues, and extensive work place monitoring. Alternative L6 would take at least a year or two longer to design and construct than Alternatives L4 and L5.

All of the action alternatives for the Buffer Zone/Crossroad Property would be effective over the near term and generate no significant adverse impacts. There is no great difference in effectiveness between the alternatives over the near term.

## 10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

All of the cover materials for Alternatives L4, L5, and L6 are readily available and the technologies have been generally proven through application at other landfills. Design and construction of a landfill cover are not expected to pose any great implementability challenges. The waste excavation and disposal component of Alternative L6 is expected to pose some implementability challenges. There are significant additional construction challenges associated with the excavation and handling of contaminated materials, e.g., the management of fugitive dust, water management and treatment, waste handling, sorting and sampling, equipments decontamination, and the need for higher level personal protective equipment like respirators. The feasibility of Alternative L6 rests on more assumptions and greater uncertainties than the capping only alternatives. It is not certain, for example, that discrete portions of waste material consisting of a disproportionately greater share of the radionuclide content could be located and recovered. There is no clear pathway for commercial disposal of this material, i.e., commercial disposal facilities for radiological waste do not accept municipal sanitary waste. The degree of sorting and/or processing that would be necessary to meet acceptance criteria is not known. In addition, the handling of putrescible waste in proximity to Lambert Airport may not be permitted by agreement (recorded as negative easement on the entire Site) with the city of St. Louis and state regulations.

All of the action alternatives for the Buffer Zone/Crossroad Property are implementable although Alternatives F2 and F3 could be more difficult to carry out than F4 because they may require institutional controls involving property owned by a third party.

### 10.7 Cost

This assessment compares the capital and O&M costs of each alternative. These study estimate costs are intended to allow gross comparisons but are not expected to have a high degree of accuracy.

All of the landfill cover alternatives will have similar construction and annual maintenance costs. The big distinction among the alternatives is due to the excavation and disposal component of Alternative L6. The excavation and disposal of approximately 85,000 $yd^3$ of waste was estimated to add about $50 million in capital costs. This estimate uses a unit disposal rate for debris of $353 per $yd^3$, but actual pricing factors for this sort of material are not certain. Thirty-year present worth costs are estimated using a seven percent discount rate. A thirty-year period is used for the purpose of comparative cost analysis and is not related to the expected duration of the remedy. The cost estimates for Alternatives L4, L5, and L6 are summarized below.

The engineering alternatives for the Buffer Zone/Crossroad Property (Alternatives F3 and F4) involve modestly greater capital costs than the land use control alternative (Alternative F2). Soil excavation (Alternative F4) costs the most to construct but has the advantage of having no annual costs.

**Cost Estimates for Alternatives L4, L5, and L6**

| | Alternative L4 – Installation of Landfill Cover (2% slope) | Alternative L5 – Installation of Landfill Cover (5% slope) | Alternative L6 – Excavation of Some Waste & Installation of Landfill Cover |
|---|---|---|---|
| **Capital Cost** | $21.8 million | $24.6 million | $75 million |
| **Annual O&M** | $15,000 to $200,000 | $15,000 to $200,000 | $15,000 to $200,000 |
| **Present Worth (7% Discount)** | $23.1 million | $25.8 million | $76.0 million |

## 10.8 State Acceptance

MDNR assists EPA in its oversight role and provides review and comment on Site documents. MDNR provided the following statement describing state acceptance:

> The Missouri Department of Natural Resources has reviewed the Record of Decision for Operable Unit 1 and Operable Unit 2 (OU 1 and OU 2) of the West Lake Landfill. Generally speaking, everyone would want all sites remediated to levels that provide unencumbered use. The department's goal of remediation to unencumbered use aligns with the National Contingency Plan's objective. For West Lake Landfill, however, the department accepts remediation that provides containment and isolation of contaminants from human receptors and the environment as the most reasonable option given the circumstances, as defined in the selected remedies for OU 1 and OU 2. The department recognizes the hazards associated with excavation into a former solid waste landfill, and has determined that the risks associated with this option to on-site workers and nearby citizens, outweigh the risks of containment in place.
>
> The department also recognizes the need for long-term care and monitoring for containment in place and insists that a robust and durable stewardship plan be implemented to address this aspect. In order to achieve this, the state has applicable standards, which are relevant and appropriate for:
>
> - closure and long-term care of all portions of the Site,
> - monitoring and control of gas generated in the waste deposits,
> - monitoring of groundwater, and
> - continued removal of leachate from the formerly active sanitary landfill.

> The department must remain a partner in the development of the remedial design, stewardship plan, and implementation of these aspects for this Site to ensure that the Selected Remedy remains protective of human health and the environment into the future. To reiterate, the department would support actions that move the Site closer to unencumbered use (recognizing the Site is a landfill), should future events occur that would change the current administrative process.

### 10.9 Community Acceptance

Many community activists, local officials, and others expressed a preference for moving the radiologically contaminated waste to another disposal facility. Common concerns included the Site being located in a flood plain and protection of the water supply. Many who live and work in proximity to the Site expressed a preference for managing the waste in place. A common concern was that excavation might result in a release of contaminated dust. All significant public comments and EPA responses are provided in the Responsiveness Summary attached to this ROD.

## 11.0 PRINCIPAL THREAT WASTES

Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur. For example, drums or trenches with hazardous liquids or volatile wastes would generally be considered principal threat wastes. The NCP establishes the expectation that treatment will be used to address the principal threats posed by the Site wherever practicable [section 300.430(a)(1)(iii)(A)]. The hazardous substances at OU 1 are dispersed in a heterogeneous mix of municipal solid waste. No principal threat wastes have been identified.

## 12.0 SELECTED REMEDY

The Selected Remedy for OU 1 is to contain Areas 1 and 2 using a cover system consistent with Alternative L4. Any contaminated soil on the adjacent Buffer Zone/Crossroad Property will be consolidated within Areas 1 or 2 prior to installation of the cover consistent with Alternative F4. Long-term groundwater monitoring, institutional controls, inspection, maintenance, and periodic reviews are also required.

### 12.1 Summary of the Rationale for the Selected Remedy

The information developed during the RI/FS and prior field investigations indicates that the waste materials, including the radiological contamination, can be safely managed in place using conventional landfill methods consistent with Alternatives L4 and L5. The remedy will apply capping technologies routinely used in government and the industry for disposal of a variety of wastes including hazardous, nonhazardous, and radiological wastes. By virtue of removing some of the contamination prior to capping, Alternative L6 offers some greater theoretical measure of long-term protection over the capping only alternatives in the event the remedy is compromised at some point in the future; however, this advantage is small compared to the disadvantages, e.g., greater potential for human exposures and increased physical hazards during the implementation phase. Also, this advantage in long-term protection does not account for any impact to the other landfill that would receive the material. Cost and implementability considerations also work against Alternative L6. The difference between Alternatives L4 and L5 is the sloping requirements for the cover. The lower sloping requirements of Alternative L4 take advantage of the low potential for differential settlement to offer a design that will be less subject to erosion and should enhance longevity. In short, Alternative L4 provides the best balance of trade-offs when evaluated against the nine criteria.

With respect to the Buffer Zone/Crossroad Property, the evaluation of alternatives points to consolidation under the landfill cover (Alternative F4) as the most straightforward and effective solution. Also, it is anticipated that construction of the landfill cover will require the toe of the landfill berm to be regraded and extended over the impacted area on the Buffer Zone/Crossroad Property so there are fewer practical options for this property than were evaluated in the FS.

## 12.2 Description of the Selected Remedy

The major components of the Selected Remedy for OU 1 are as follows:

- Installation of landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills including enhancements consistent with the standards for uranium mill tailing sites, i.e., armoring layer and radon barrier

- Consolidation of radiologically contaminated surface soil from the Buffer Zone/Crossroad Property to the containment area

- Application of groundwater monitoring and protection standards consistent with requirements for uranium mill tailing sites and sanitary landfills

- Surface water runoff control

- Gas monitoring and control, including radon and decomposition gas, as necessary

- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing long-lived radionuclides

- Long-term surveillance and maintenance of the remedy

Prior to construction of the landfill cover, the areas will be brought up to grade using placement of inert fill and regrading of existing material as determined in the RD. Final grades will achieve a minimum slope of two percent.

The landfill berm around Area 2 will be regraded through placement of additional clean fill prior to placement of the landfill cover resulting in an estimated 100 lateral feet of additional material between the current landfill toe and the toe at completion of the RA. In this area, the landfill is built over the geomorphic flood plain that is now protected by the Earth City Levee. In the unlikely event of levee failure during a 500-year flood event, the lowermost two feet of the toe of the landfill cover at the northwestern end of the Site could be impacted by the water. The Site is over a mile from the river and no high energy water would be expected. The flood protection needs of the toe of the landfill will be evaluated in design and appropriate bank protection methods will be used, e.g., rock rip rap apron. The vertical height of the flood protection feature will include a margin of safety over the 1993 flood level. Figure 12-1, showing a conceptual cross-section of the Selected Remedy, indicates the approximate flood level at the toe of the landfill.

Any radiologically contaminated soil on the Buffer Zone/Crossroad Property will be consolidated in the area of containment (Areas 1 or 2) prior to placement of fill material or construction of the cover. It is anticipated that construction of the landfill cover will require the toe of the landfill berm to be regraded and extended over the impacted area on the Buffer Zone/Crossroad Property. Although the extent of contamination on the Buffer Zone/Crossroad Property is thought to be minor, the precise nature and extent of contaminated soil is uncertain. Gamma scans and soil sampling will be used to support the RD and document the existing conditions. Any soil outside the footprint of the landfill will meet remediation goals that support unlimited use and unrestricted exposure and will be subject to verification sampling. Any excavation of contaminated material will include dust suppression and work place monitoring to ensure there is no release of fugitive dust.

The landfill cover, gas control, runoff control, long-term groundwater monitoring, and post-closure inspection and maintenance will at a minimum meet the relevant and appropriate requirements found in the Missouri Solid Waste Rules for sanitary landfills. Consistent with the requirements for uranium mill tailing sites, the landfill cover will also incorporate a rubble or rock armoring layer to minimize the potential for biointrusion and erosion and increase longevity. The landfill cover will also be designed to provide protection from radioactive emissions, i.e., gamma radiation and radon. See section 13.2 for a description of the ARARs. Figure 12-2 shows a conceptual cross-section of a sanitary landfill cover that has been augmented to include a crushed concrete or rock biointrusion layer. Figure 12-3 plots the cover thickness necessary to shield a person on the surface of the cover from gamma exposure.

Surface drainage diversions, controls, and structures will be designed and constructed to expeditiously route storm water runoff to the water drainage systems which are presently subject to state National Pollution Discharge Elimination System permits.

Landfill gas characterization during the RI indicated the sporadic presence of decomposition gases, e.g., methane, and radon. Radon gas needs only to be detained for a few days until it decays to its solid progeny, and a landfill cover designed to act as a diffusion barrier is generally sufficient to control radon. However, decomposition gases must be handled differently. Typically, gas generation in municipal solid waste increases for the first five or six years after placement in the landfill and then declines thereafter. Because these areas have been inactive for 30 years, decomposition gas generation is relatively low and expected to decline. However, even at low generation rates, placement of the landfill cover creates the potential for these gases to be trapped and accumulate under the cover. To prevent pressure build up under the landfill cover and/or lateral migration, gas control systems may be required. Gas control measures may involve passive venting or active collection. The need for and nature of the gas control measures will be evaluated and defined as part of the RD. The plans for the control and/or treatment of landfill gas will consider the presence of radon and be developed accordingly.

The landfill cover system will be routinely inspected and maintained to ensure the integrity of the remedy over time. In addition to surveillance of the physical remedy, the periodic site inspections will include administrative functions such as monitoring of institutional controls and coordination with key stakeholders, including the Earth City Levee District regarding management of the flood control system. See section 5.1 for a description of the levee maintenance program.

The O&M Plan will be developed and submitted for approval as part of the RD/RA process. The O&M Plan will cover all the long-term remedy management functions including groundwater monitoring plans, site inspection, maintenance and repair, institutional control monitoring and enforcement, five-year reviews, notification and coordination, community relations, health and safety, emergency planning, activity schedules, reporting, etc. In practice, the O&M Plan may be developed as a compilation of more focused plans.

#### 12.2.1 Groundwater Monitoring Objectives

One of the primary objectives of the Selected Remedy is to protect groundwater from any ongoing or future impacts from Areas 1 and 2. The landfill cover over Areas 1 and 2 will be designed and constructed to shed water and minimize the potential for precipitation to infiltrate the waste materials. Therefore, the cover is expected to further reduce the potential for migration of contaminants from Areas 1 and 2 to the shallow groundwater underlying the Site. A long-term groundwater monitoring program will be established to demonstrate the Selected Remedy performs as required over the post-closure period. The plan will have a groundwater monitoring component and a detection monitoring component. Statistical evaluation of groundwater data will be used to assess groundwater quality and identify long-term trends. Statistically significant deterioration in groundwater quality with time as a result of contaminant migration from Areas 1 and 2 shall be cause to reevaluate the remedy.

Monitoring plans requiring specific monitoring locations, sampling frequencies, parameters, sampling and analysis procedures, and evaluation approach will be developed and submitted as part of the O&M Plan in the RD/RA process. The program may be optimized with time based on the monitoring results, e.g., monitoring locations or the list of analytes may be adjusted to increase effectiveness or efficiency. Monitoring plans and groundwater protection standards will be consistent with the requirements found in the Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings

(40 CFR 192 Subparts A and B) and the Missouri Solid Waste Rules for Sanitary Landfills [10 CSR 80-3.010 (11)].

#### 12.2.2 Institutional Controls

The Site will need to be used in ways consistent with it being a landfill site. Land use restrictions must be implemented for OU 1 to limit future uses and to ensure future uses do not impact the effectiveness or integrity of the RA, taking into consideration the presence of long-lived radionuclides. The restrictions must be maintained until the remaining hazardous substances are at levels allowing for unlimited use and unrestricted exposure. Due to the presence of long-lived radionuclides at OU 1, the restrictions will need to be maintained indefinitely. These restrictions do not apply to activities related to the implementation, maintenance, or repair of the remedy.

The following use restrictions apply within the boundary of the cover system(s) for Areas 1 and 2:

- Prevent development and use for residential housing, schools, childcare facilities, or playgrounds

- Prevent development and use for industrial or commercial purposes such as manufacturing, offices, storage units, parking lots, or other facilities that are incompatible with the function or maintenance of the landfill cover

- Prevent construction activities involving drilling, boring, digging, or other use of heavy equipment that could disturb vegetation, disrupt grading or drainage patterns, cause erosion, or otherwise compromise the integrity of the landfill cover or manage these activities such that any damage to the cover is avoided or repaired

- Prevent the use of all groundwater underlying these areas

- Provide for access necessary for continued maintenance, monitoring, inspections, and repair

For nondisposal areas of the Site, any new or existing structures for human occupancy shall be assessed for methane and/or radon gas accumulation and mitigative engineering measures, such as foundation venting, should be employed as necessary.

Property use restrictions at the Site will be implemented through the placement of institutional controls. The specific institutional control design and implementation strategy will be a component of the RD planning process following release of the OU 1 ROD by EPA. Where appropriate, multiple mechanisms or a *layered* approach will be used to enhance the effectiveness of the institutional control strategy. Access controls such as fences and gates may also be used to support the use restrictions.

At the Site, the affected properties are privately owned and the use restrictions must be maintained for an indefinite period of time. Therefore, proprietary controls will be used because they generally run with the land and are enforceable. The Missouri Environmental Covenants Act (MECA), which is based on the Uniform Environmental Covenants Act, was recently enacted. MECA specifically authorizes environmental covenants and authorizes the state to acquire property interests. Specifically designed to support use restrictions at contaminated sites, an environmental covenant pursuant to MECA is the preferred instrument to be used at the Site.

The Site has been listed by MDNR on the State's Registry of Confirmed, Abandoned, or Uncontrolled Hazardous Waste Disposal Sites in Missouri (Uncontrolled Sites Registry). The registry is maintained by MDNR pursuant to the Missouri Hazardous Waste Management Law, Mo.Rev.Stat. section 260.440. Sites listed on the registry appear on a publicly available list. A notice is filed with the County Recorder of Deeds and notice must be provided by the seller to any potential buyers of the property.

The O&M Plan will contain procedures for surveillance, monitoring, and maintenance of the institutional controls. The O&M Plan will provide for notice to EPA and/or the state of any institutional control violations, planned or actual land use changes, and any planned or actual transfers, sales, or leases of property subject to the use restrictions.

#### 12.2.3 Estimated Remedy Costs

*Estimated capital costs: $21,800,000*
*Estimated annual O&M costs: $15,000 to $200,000*
*Estimated 30-year present worth costs: $23,100,000*

A breakdown of the estimated capital costs for regrading and cover installation is provided in Table 12-1. The variation in annual O&M costs reflects the variation in the frequency of groundwater monitoring activities assumed for the near years as compared to the far years. Also, the CERCLA five-year review occurs every five years. The total present worth cost uses a discount rate of 7 percent for the duration of the 30-year evaluation period.

The 30-year evaluation period is used to allow for cost comparisons only and has nothing to do with the expected duration of the remedy. The use of a 30-year period for present worth analysis of remedy costs is not intended to imply a limit on monitoring and maintenance requirements. Monitoring and maintenance activities are expected to be required for essentially as long as the waste materials remain in place. The need for and scope of continued monitoring and maintenance both within and beyond 30 years will be subject to ongoing evaluation as part of the five-year review process.

The cost estimates are based on the best available information regarding the anticipated scope of the remedy and unit rates. Changes in the cost elements will occur as new information is collected during the design and construction phase.

### 12.3 Expected Outcomes of the Selected Remedy

As a result of the Selected Remedy for OU 1, Areas 1 and 2 will remain dedicated to permanent disposal of sanitary waste mixed with radiologically contaminated soil. This use is consistent with current and reasonably anticipated future use for the Site. As such, the Site may be used in ways that are consistent with it being a closed landfill site, i.e., uses that do not interfere with the function or maintenance of the landfill cover system. See section 12.2.2 for a description of the use restrictions.

## 13.0 STATUTORY DETERMINATIONS

Under CERCLA section 121(b) and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs, are cost effective, and utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. In addition, CERCLA includes a preference for treatment that reduces volume, toxicity, or mobility as a principal element. The following sections discuss how the Selected Remedy meets these statutory requirements.

### 13.1 Protection of Human Health and the Environment

The Selected Remedy will protect human health and the environment through the use of engineered containment, long-term surveillance and maintenance, and institutional controls on land and resource use. The landfill cover will eliminate potential risks from exposure to external gamma radiation, inhalation or ingestion of contaminated soils or other wastes, dermal contact with contaminated soils or other wastes, radon gas emissions, and wind dispersal of fugitive dust. The cover will prevent users of the Site from exposure to external radiation primarily through shielding and increasing the distance to the radiation source, i.e., the cover materials will be of more than sufficient thickness and design to attenuate gamma radiation. For normal soils, the depth of cover required for gamma radiation shielding is on the order of 60 cm. Figure 12-3 plots the effect of cover thickness on dose rates for Areas 1 and 2. The cover materials will also be of sufficient thickness and design to retard or divert the vertical migration of radon. The landfill cover acts as a diffusion barrier allowing time for the decay of the relatively short-lived Rn-222 gas (half-life for Rn-222 is 3.8 days) during migration through the pore spaces of the cover soil. Radon is continually produced from the radium source, but need only be detained in the cover materials for a few days before it decays to its progeny thereby eliminating any significant radon emissions. The radon may also be intentionally vented or diverted to a gas control system. The potential for direct contact with waste materials is eliminated by placing a barrier (multi-layer landfill cover including biointrusion layer) between the waste materials and any potential receptors. Likewise, there is no potential for the generation of fugitive dust from the waste material as long as the barrier remains in place. The multi-layer cover will also be designed to prevent infiltration of surface water that might cause leaching of contaminants to the groundwater. This is typically accomplished by promoting surface drainage and using a hydraulic barrier, e.g., compacted clay liner meeting stringent permeability requirements. These are all conventional functions for landfill cover technologies widely used by government and industry to address similar circumstances. Long-term maintenance of the cover and monitoring of the groundwater will ensure the Selected Remedy functions as intended. Institutional controls will ensure that land and resource uses are consistent with permanent waste disposal. The use restrictions consider the presence of radionuclides.

### 13.2 Compliance with ARARs

The Selected Remedy will comply with all ARARs as identified below.

<u>Missouri Solid Waste Rules for Sanitary Landfills</u>

Under the Resource Conservation and Recovery Act Subtitle D, a state may promulgate more stringent regulations for landfills in that state, provided that the EPA approves of the state's regulations. Missouri is an approved state for providing regulations for landfills. Missouri promulgated its regulations in 1997 (22 Mo Reg 1008, June 2, 1997) and they became effective July 1, 1997. The Missouri Solid Waste Rules establish closure and post-closure requirements for existing sanitary landfills that close after October 9, 1991. Although not applicable to the closure of Areas 1 and 2, the requirements described below are considered relevant and appropriate and therefore will be met.

The MDNR regulations require cover to be applied to minimize fire hazards, infiltration of precipitation, odors and blowing litter, control gas venting and vectors, discourage scavenging, and provide a pleasing appearance [10 CSR 80-3.010(17)(A)]. This final cover shall consist of at least two feet of compacted clay with a coefficient of permeability of $1 \times 10^{-5}$ cm/sec or less overlaid by at least one foot of soil capable of sustaining vegetative growth [10 CSR 80-3.010(17)(C)(4)]. Placement of soil cover addresses the requirements for minimization of fire hazards, odors, blowing litter, control of gas venting, and scavenging. Placement of clay meeting the permeability requirement addresses the requirement for minimization of infiltration of precipitation. Placement of soil and establishment of a vegetative cover meet the requirement of providing for a pleasing appearance. The final cover prevents users of the Site from coming into contact with the waste material.

The MDNR landfill regulations also contain minimum and maximum slope requirements. Specifically, these regulations require the final slope of the top of the sanitary landfill shall have a minimum slope of five percent [10 CSR 80-3.010(17)(B)(7)]. MDNR regulations also require that the maximum slopes be less than 25 percent unless it has been demonstrated in a detailed slope stability analysis that the slopes can be constructed and maintained throughout the entire operational life and post-closure period of the landfill. Even with such a demonstration, no active, intermediate, or final slope shall exceed 33.33 percent. The objective of these requirements is to promote maximum runoff without excessive erosion and to account for potential differential settlement. Because landfilling of Areas 1 and 2 was completed approximately 30 years ago, most compaction of the refuse has taken place and differential settlement is no longer a significant concern. The five percent minimum sloping requirement is greater than necessary and may not be optimal in this case. Therefore, the five percent minimum sloping requirement is not considered appropriate. Sloping specifications would be designed to promote drainage and reduce infiltration of precipitation while minimizing the potential for erosion. It is anticipated that a two percent slope would be sufficient to meet drainage requirements while resulting in a lower potential for erosion or slope failure. This approach should increase the life of the cover and overall longevity of the remedy compared to a steeper slope which would be subject to increased erosion potential. The maximum sloping requirements would be met.

The requirements for decomposition gas monitoring and control in 10 CSR 80-3.010(14) are considered relevant and appropriate and will be met. The number and locations of gas monitoring points and the frequency of measurement will be established in RD submittals to be approved by EPA and the state. In the event landfill gas is detected at the landfill boundaries above the regulatory thresholds, appropriate gas controls will be implemented.

The requirements for a groundwater monitoring program in 10 CSR 80-3.010(11) are considered relevant and appropriate. The monitoring program must be capable of monitoring any ongoing or potential impact of the landfill on underlying groundwater. The monitoring program will enable the regulatory agencies to evaluate the need for any additional requirements.

The substantive MDNR landfill requirements for post-closure care and corrective action found in 10 CSR 80-2.030 are also considered relevant and appropriate. These provisions provide a useful framework for O&M and corrective action plans. These substantive provisions require post-closure plans describing the necessary maintenance and monitoring activities and schedules. These requirements will be used in addition to EPA CERCLA policy and guidance on developing robust O&M and long-term monitoring plans.

<u>Environmental Protection Standards for Uranium and Thorium Mill Tailings</u>

The Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192 Subpart B) provide standards for land and buildings contaminated with residual radioactive materials from inactive uranium processing sites. The standards were developed pursuant to UMTRCA. Although not applicable, some of the regulations that provide for closure performance standards are considered relevant and appropriate to the Selected Remedy for OU 1. Specifically, to address longevity considerations, 40 CFR 192.02(d) requires that each disposal site "shall be designed and stabilized in a manner that minimizes the need for future maintenance." For UMTRCA tailings piles, the longevity consideration has often been addressed through placement of a rock armoring layer over the upper surface of the tailings pile capping system. To address longevity considerations for OU 1 and long-term hazards relating to disruption of the disposal site by natural phenomena, the Selected Remedy will use a hybridized cover system incorporating a rock or concrete rubble layer to restrict biointrusion and erosion into the underlying landfilled materials.

Three chemical-specific standards of 40 CFR part 192 are considered relevant and appropriate to RAs for OU 1. First, UMTRCA standards state that control of residual radioactive materials and their listed constituents shall be designed to provide reasonable assurance that release of Rn-222 from residual radioactive material to the atmosphere will not exceed an average release rate of 20 pCi/$m^2$s [40 C.F.R. §192.02 (b)(1)]. For inactive sites, this standard can be satisfied alternatively by providing reasonable assurance that releases of Rn-222 from residual radioactive material to the atmosphere will not increase the annual average concentration of Rn-222 in air at or above any location outside the disposal site by more than one-half of a picocuries per liter [40 CFR §192.02(b)(2)]. The Selected Remedy will ensure the radon emission standard promulgated under UMTRCA is met through placement of clean fill material and construction of the landfill cover. The landfill cover system will be designed appropriately to take into consideration maximum future radon generation.

Secondly, the Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192 Subparts A and B) establishes concentration limits for groundwater protection. Based on the presence of radioactive materials in OU 1 and the potential for leaching to groundwater, the groundwater protection standards [40 CFR 192.02(c)(3) and (4)] and monitoring requirements (40 CFR 192.03) of the UMTRCA regulations are relevant and appropriate and must be met.

Third, the soil standards found in the Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192 Subpart B) are relevant and appropriate requirements for the cleanup of any radiologically impacted soil that may be present on the Buffer Zone/Crossroad Property. These soil standards address the cleanup of soil contaminated with radium. These standards are:

> The concentration of Ra-226 (or Ra-228) in land averaged over any area of 100 $m^2$s shall not exceed the background level by more than: (1) 5 pCi/g, averaged over the first 15 cm of soil below the surface; and (2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.

Guidance on the use of these soil standards for CERCLA site cleanups is contained in *Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites* (OSWER Directive 9200.4-25, February 12, 1998).

<u>National Emissions Standards for Hazardous Air Pollutants</u>

The National Emissions Standards for Hazardous Air Pollutants (NESHAP) includes standards for Rn-222 emissions to ambient air from designated uranium mill tailings piles that are no longer operational. Specifically, Rn-222 emissions from inactive uranium mill tailings piles should not exceed 20 pCi/$m^2$s (40 CFR 61 Subpart T). OU 1 is not a designated uranium mill tailings site and this requirement is not applicable. However, a portion of the waste materials in OU 1 do emit radon; therefore, the Rn-222 NESHAP is considered to be relevant and appropriate. The Selected Remedy will ensure the radon emission standard is met through placement of clean fill material and construction of the landfill cover. The RD evaluation will account for maximum future radon generation.

Clean Water Act

The Clean Water Act sets standards for ambient water quality and incorporates chemical-specific standards including federal water quality criteria and state water quality standards. The substantive requirements for storm water runoff are relevant and appropriate.

Safe Drinking Water Act

The 40 CFR part 141 establishes primary drinking water regulations pursuant to section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Public Law 93-523) and related regulations applicable to public water systems. These MCLs apply to public drinking water systems. Missouri regulations (10 CSR 60-4.010, et seq) also establish MCLs for public drinking water systems. Consistent with the NCP, MCLs are considered relevant and appropriate to all potentially usable groundwater.

The following are construction-related regulatory requirements:

Missouri Radiation Regulations for Protection Against Ionizing Radiation

The Missouri Radiation Regulations for Protection Against Ionizing Radiation (19 CSR 20-10.040) contain chemical-specific standards that address radiation protection. These regulations define maximum permissible exposure limits for specific radionuclides in air at levels above background inside and outside of controlled areas. These requirements are considered applicable during implementation of any RA. Specifically, these regulations would require perimeter air monitoring during implementation of any RA that may be undertaken at OU 1. Site health and safety plans will address worker protection consistent with these requirements.

Missouri Well Construction Code

MDNR has promulgated regulations pertaining to the location and construction of water wells. The Well Construction Code (10 CSR 23-3.010) prohibits the placement of a well within 300 feet of a landfill. These rules should provide protection against the placement of wells on or near the Site.

The regulations on monitoring well construction (10 CSR 23-4) will apply to the construction of new or replacement monitoring wells.

Missouri Storm Water Regulations

The Missouri regulations governing storm water management at construction sites are set out in 10 CSR 20-6.200. A disturbance of greater than one acre and the creation of a storm water point source during construction of the remedy would trigger these requirements.

### 13.3 Cost Effectiveness

A cost-effective remedy is one whose "costs are proportional to its overall effectiveness" [NCP §300.430(f)(1)(ii)(D)]. The Selected Remedy is considered cost effective because it provides a high degree of effectiveness and permanence at a reasonable cost. Based on evaluations performed as part of the RI/FS, the more expensive option of off-site commercial disposal would not lead to appreciable increases in effectiveness and, in fact, may introduce unnecessary risks.

### 13.4 Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable

The Selected Remedy represents the maximum extent to which permanent solutions and treatment are practicable. Treatment to reduce toxicity, mobility, or volume is not practicable because most contaminants within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout the overall, heterogeneous matrix of municipal refuse, construction and demolition debris, and other nonimpacted soil materials. Consequently, excavation of the radiologically impacted materials for possible ex situ treatment techniques is considered impracticable. Similarly, the heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within the overall solid waste matrix make in situ treatment techniques impracticable.

The information indicates that the waste materials can be effectively managed in place over the long term using conventional landfill methods. Excavating and shipping the material for remote disposal would also be effective over the long term, but this approach has the disadvantages of greater potential for human exposures and increased physical hazards during the implementation phase.

### 13.5 Preference for Treatment as a Principal Element

The Selected Remedy does not satisfy the preference for treatment as a principal element. For the reasons described in the previous section, no effective or practicable treatment options are available.

### 13.6 Five-Year Review Requirements

CERCLA §121(c) and NCP §300.430(f)(5)(iii)(C) require a periodic review, commonly called a five-year review, if the RA results in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure. Therefore a statutory five-year review is required under the Selected Remedy for OU 1. The review evaluates whether the remedy remains protective of human health and the environment.

### 13.7 Significant Changes from the Proposed Plan

The Selected Remedy is not significantly changed from the preferred alternative in the Proposed Plan. A majority of the concerns expressed during the public comment periods were related to the potential for groundwater contamination from the radionuclides disposed in Areas 1 and 2 and the potential for adverse impacts to the Site as a result of it being located in a former flood plain. This ROD includes some clarifications intended to address these concerns. Clear groundwater monitoring objectives and remedy performance standards (section 12.2.1) ensure the remedy will remain protective of groundwater. An examination of the potential impacts to the Site as a result of a levee failure indicates that flood waters would not have a significant impact on the Site. The flood protection needs of the toe of the landfill will be evaluated in design and appropriate bank protection methods will be used, e.g., rock rip rap apron. See the Responsiveness Summary (Part III of this ROD) for additional explanations on these subjects.

## 14.0 REFERENCES

Auxier & Associates, Inc., 1998. Baseline Risk Assessment, West Lake Landfill Operable Unit 1, March.

Engineering Management Support, Inc., 2000. Remedial Investigation Report, West Lake Landfill, Operable Unit 1, April.

Engineering Management Support, Inc., 2006. Feasibility Study Report, West Lake Landfill, Operable Unit 1, May.

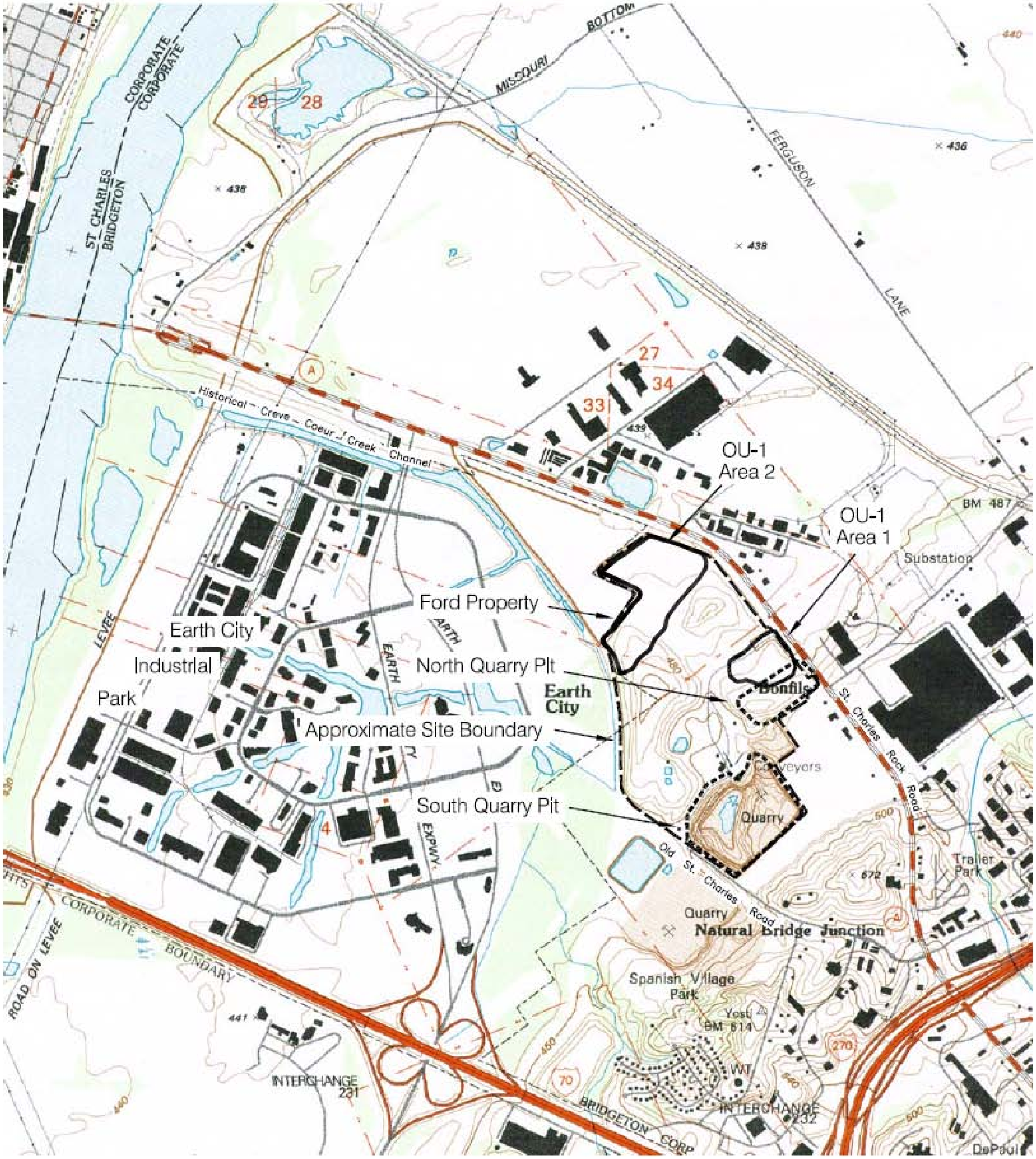
Herst & Associates, Inc., 2005. Remedial Investigation Report, West Lake Landfill Operable Unit 2, September.

Herst & Associates, Inc., 2006. Feasibility Study Report, West Lake Landfill Operable Unit 2, June.

# FIGURES

## FIGURE 1-1 SITE LOCATION


★ **Site Location**




Source: St. Charles, MO USGS
7.5' Quadrangle, 1994

2000 0 2000
SCALE IN FEET

N

**FIGURE 1-2**

**Site Vicinity Map**

West Lake Landfill OU-1 Feasibility Study

EMSI Engineering Management Support, Inc.

FIGURE 2-1

# Pitchblende Ore Processing

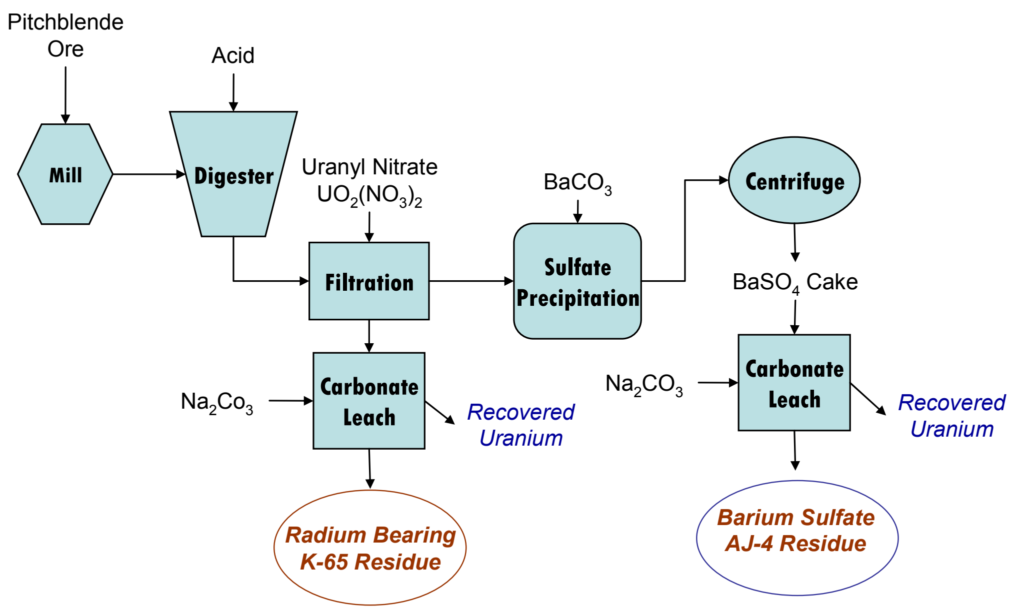


FIGURE 2-2

# Ore Processing Residues

**K-65 Residue**
**(Gangue Lead Cake)**

- $ThO_2$, $RaSO_4$, and $PbSO_4$
- 600 mg radium per ton residue
- 0.2% uranium

**AJ-4 Residue**
**(Barium Sulfate Cake)**

- Leached $BaSO_4$ with small amounts of $RaSO_4$
- $4 \times 10^{-9}$ g $RaSO_4$ / g residue (~3 mg radium per ton of residue)
- 0.1% uranium

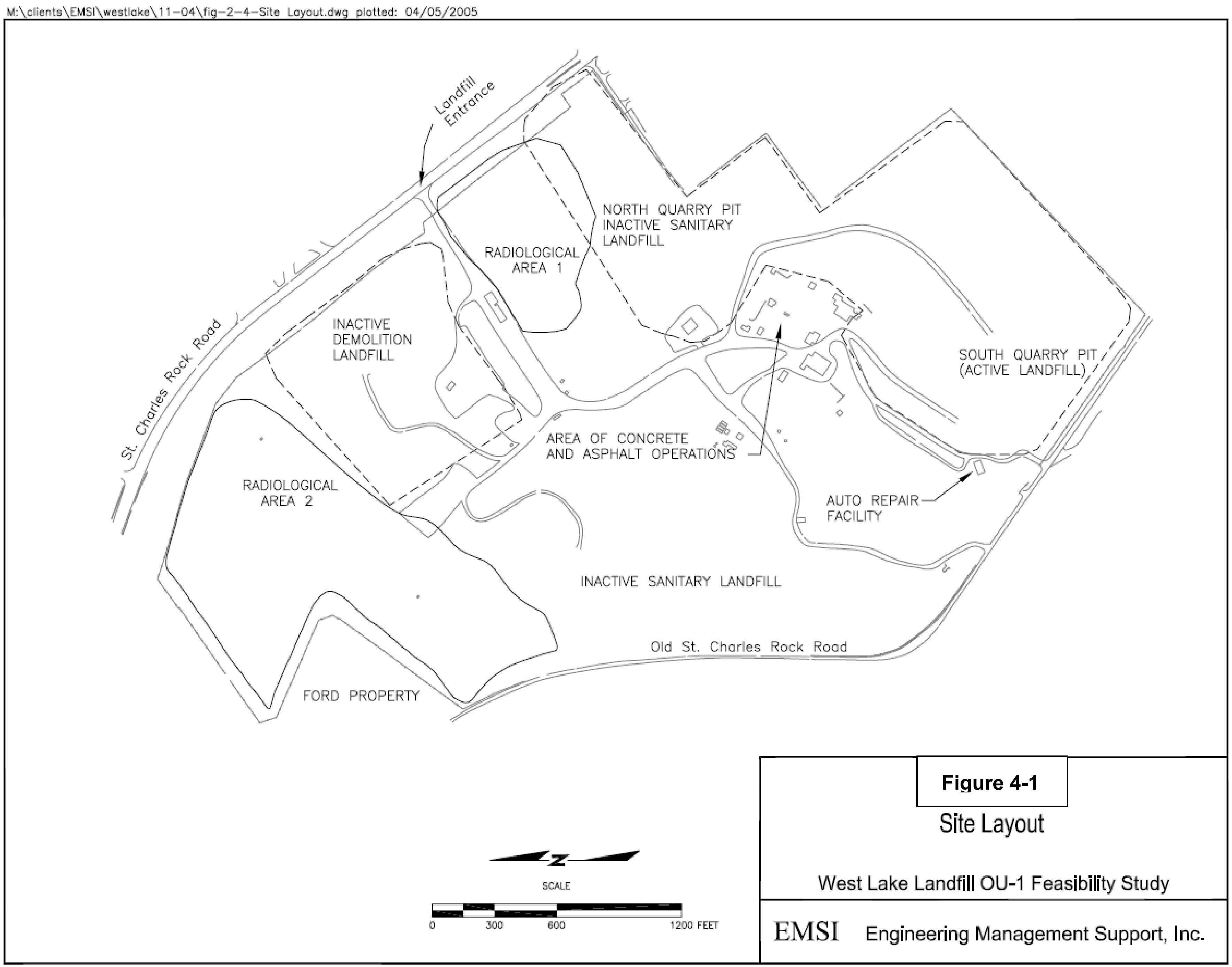
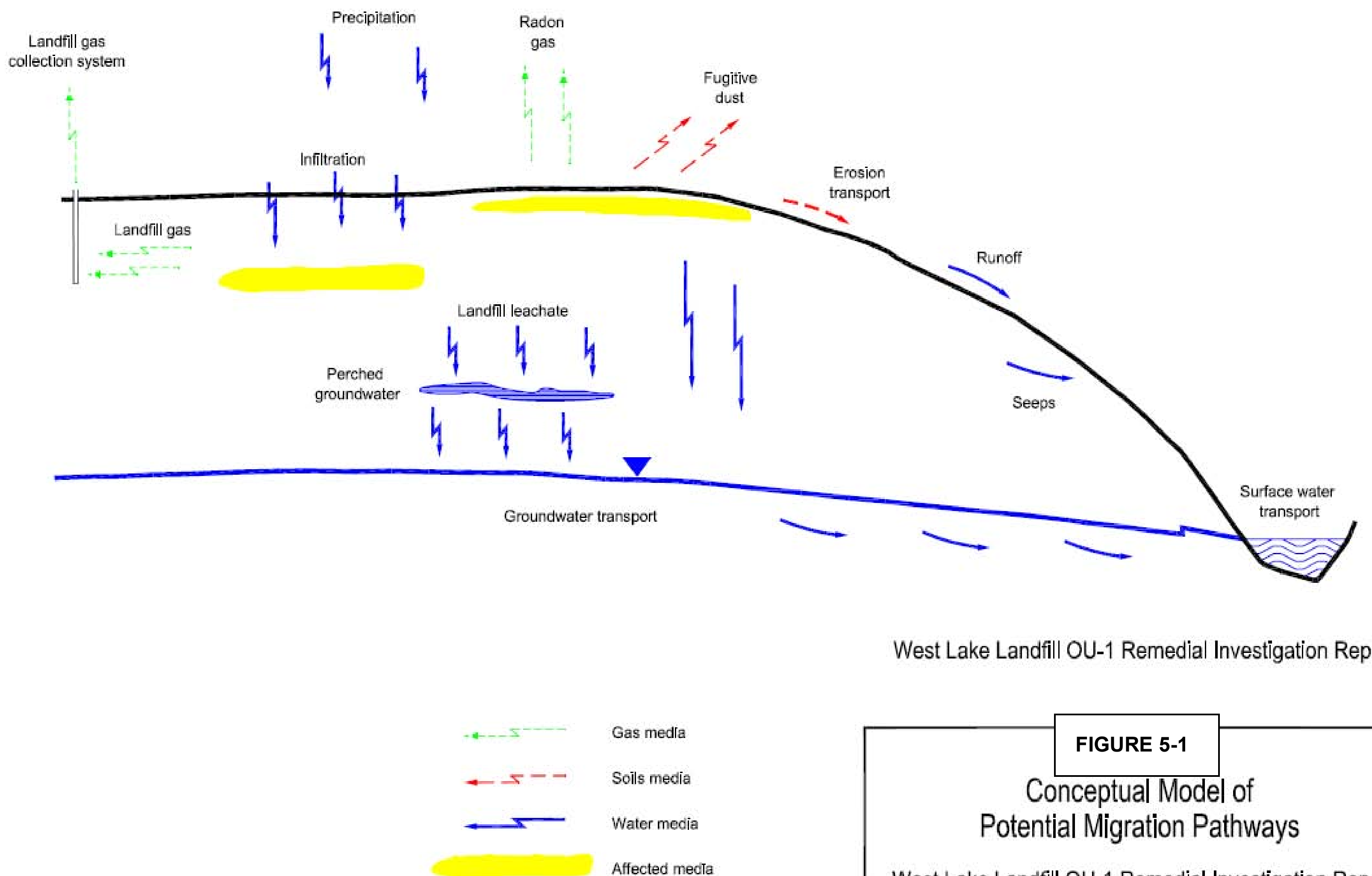



**Figure 4-1**

Site Layout

West Lake Landfill OU-1 Feasibility Study

EMSI Engineering Management Support, Inc.




West Lake Landfill OU-1 Remedial Investigation Report

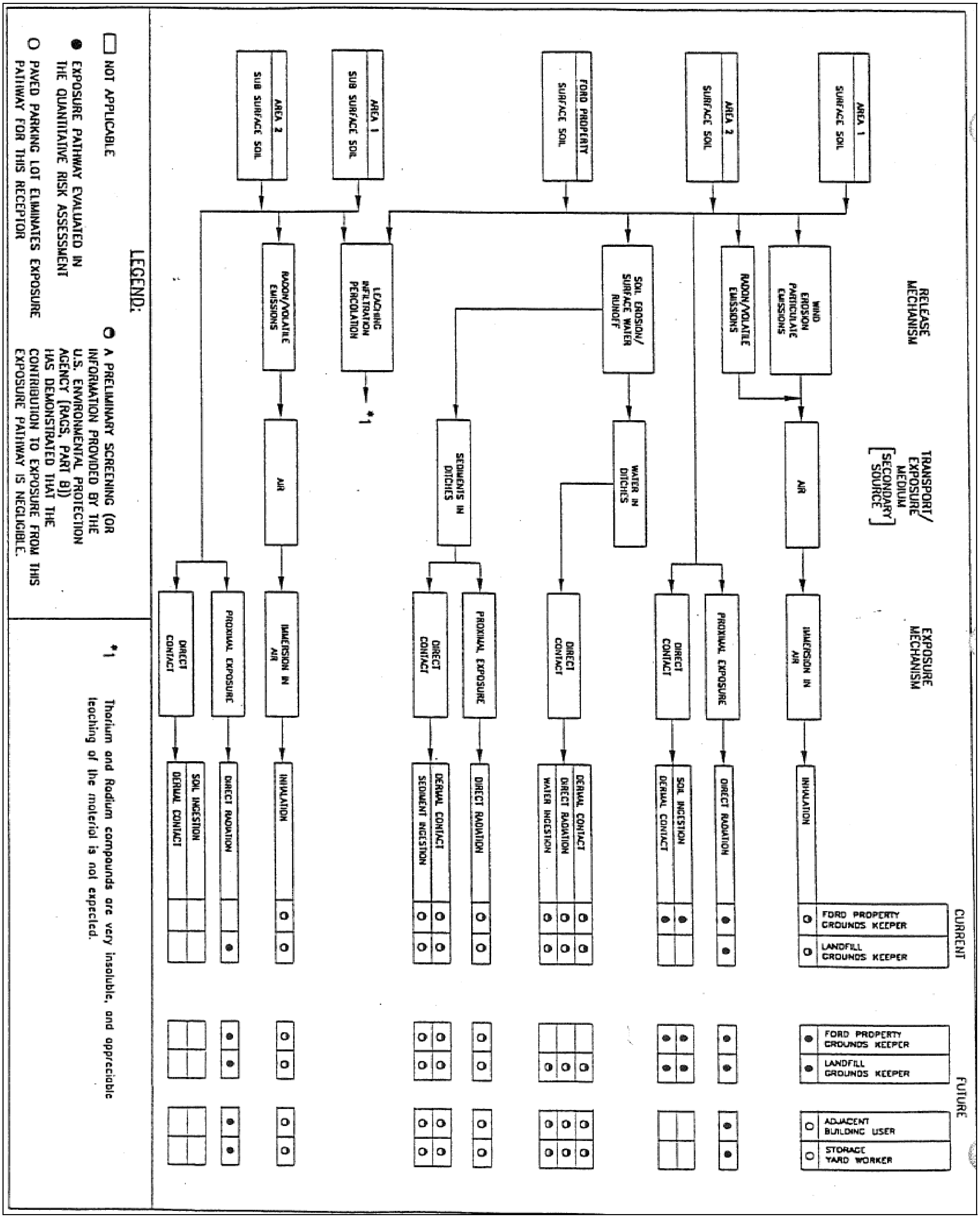
**FIGURE 5-1**

Conceptual Model of
Potential Migration Pathways

West Lake Landfill OU-1 Remedial Investigation Report

EMSI Engineering Management Support, Inc.

# FIGURE 5-2 CONCEPTUAL SITE MODEL



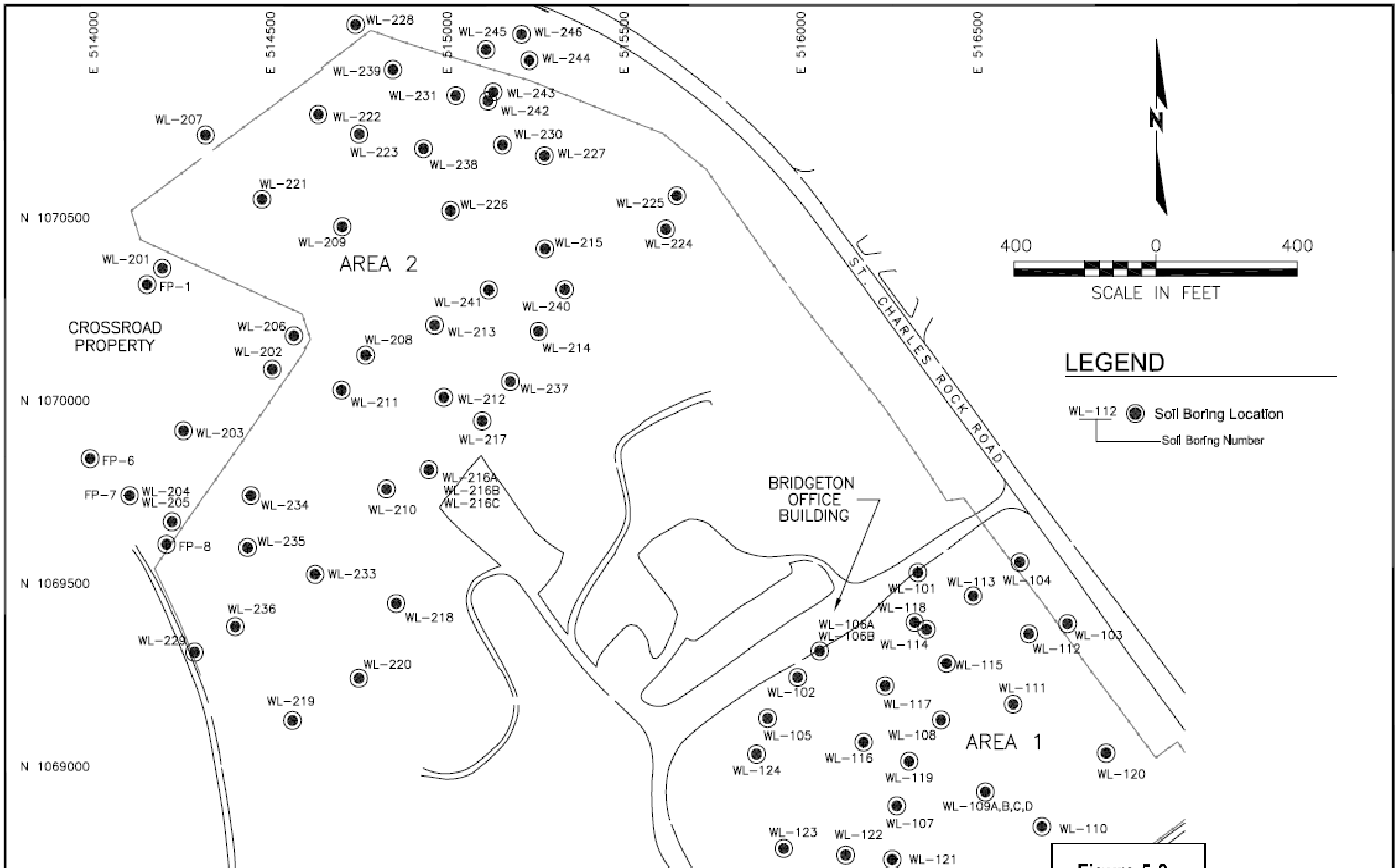



Figure 5-3

Area 1 and 2
Soil Boring Locations

West Lake Landfill OU-1 Remedial Investigation Report

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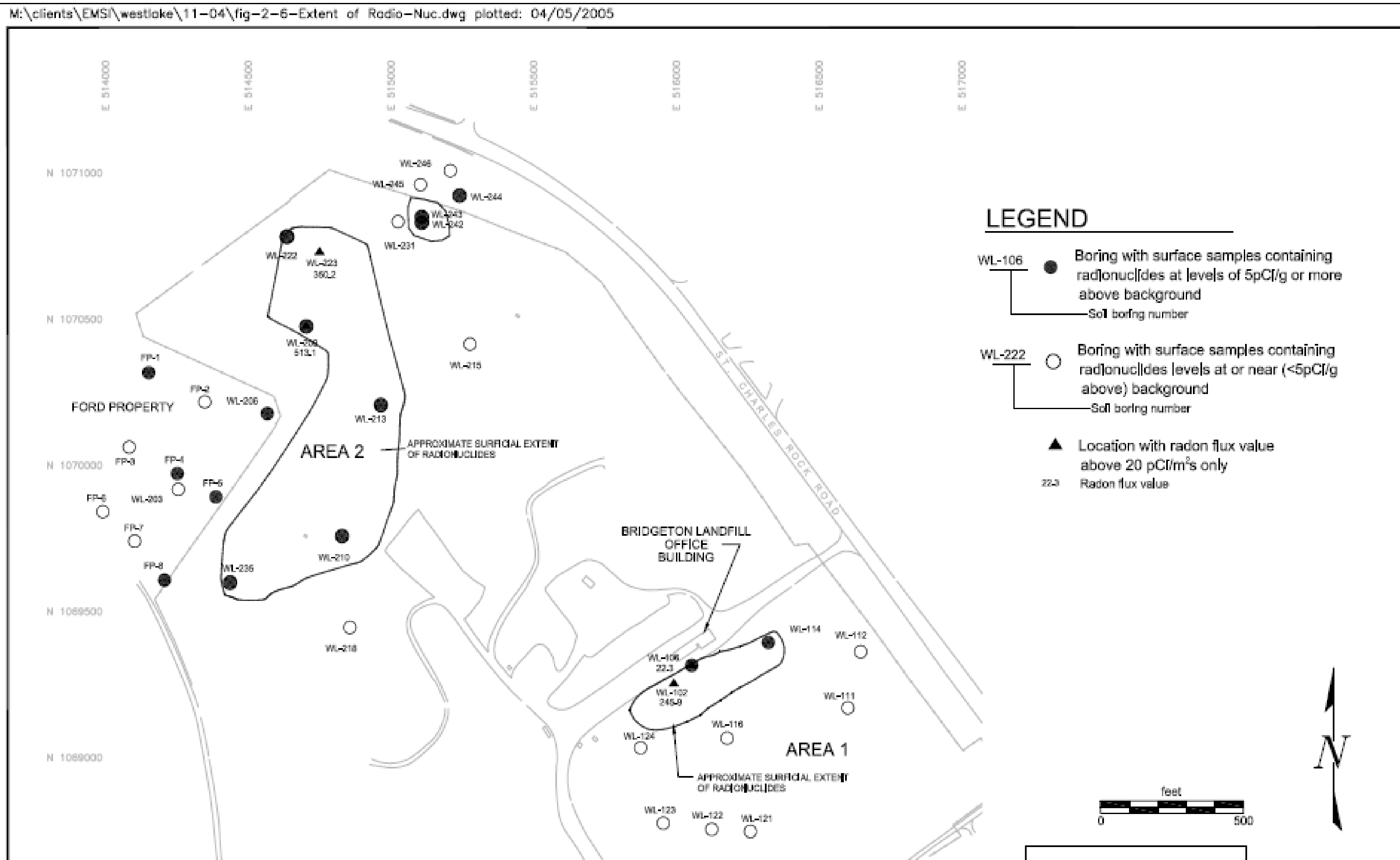


**Figure 5-4**

Approximate Extent of Radionuclide Impacted Materials at the Landfill Surface

West Lake Landfill OU-1 Feasibility Study

EMSI Engineering Management Support, Inc.

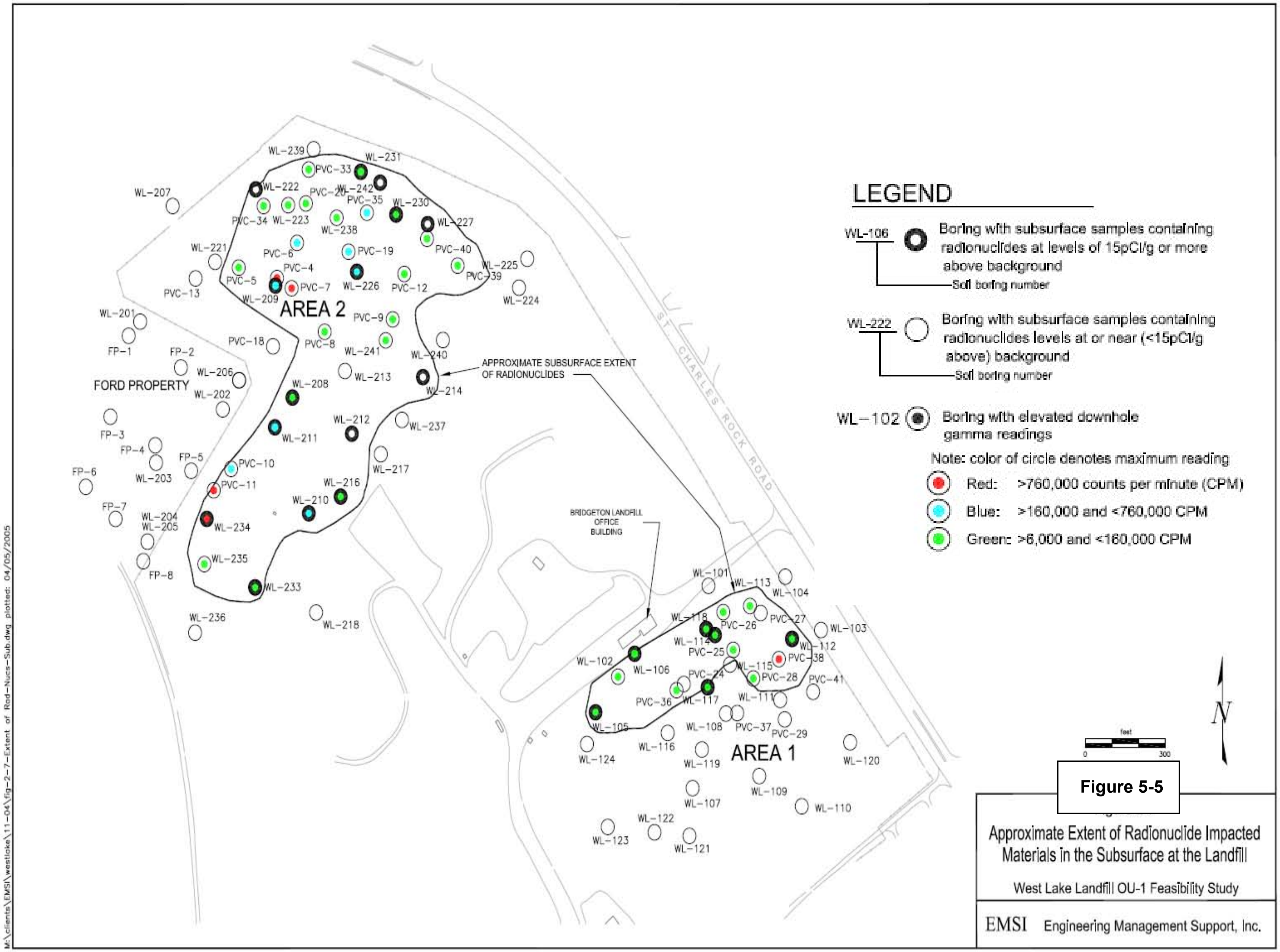


**Figure 5-5**

Approximate Extent of Radionuclide Impacted Materials in the Subsurface at the Landfill

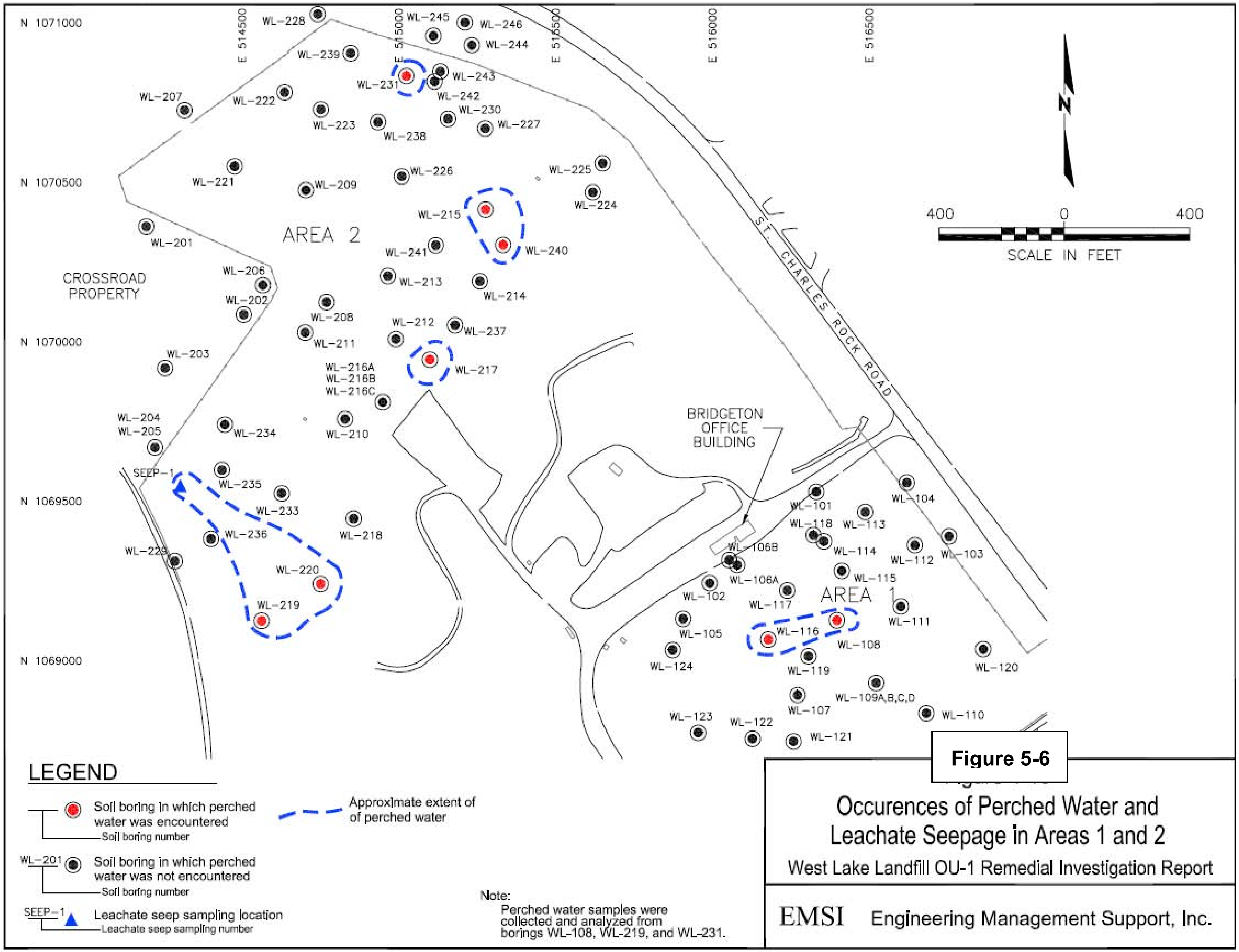


**Figure 5-6**

Occurences of Perched Water and Leachate Seepage in Areas 1 and 2

West Lake Landfill OU-1 Remedial Investigation Report

M:\clients\EMSI\westlake\2005\Fig2-9_Monitoring Wells.dwg plotted: 08/09/2005

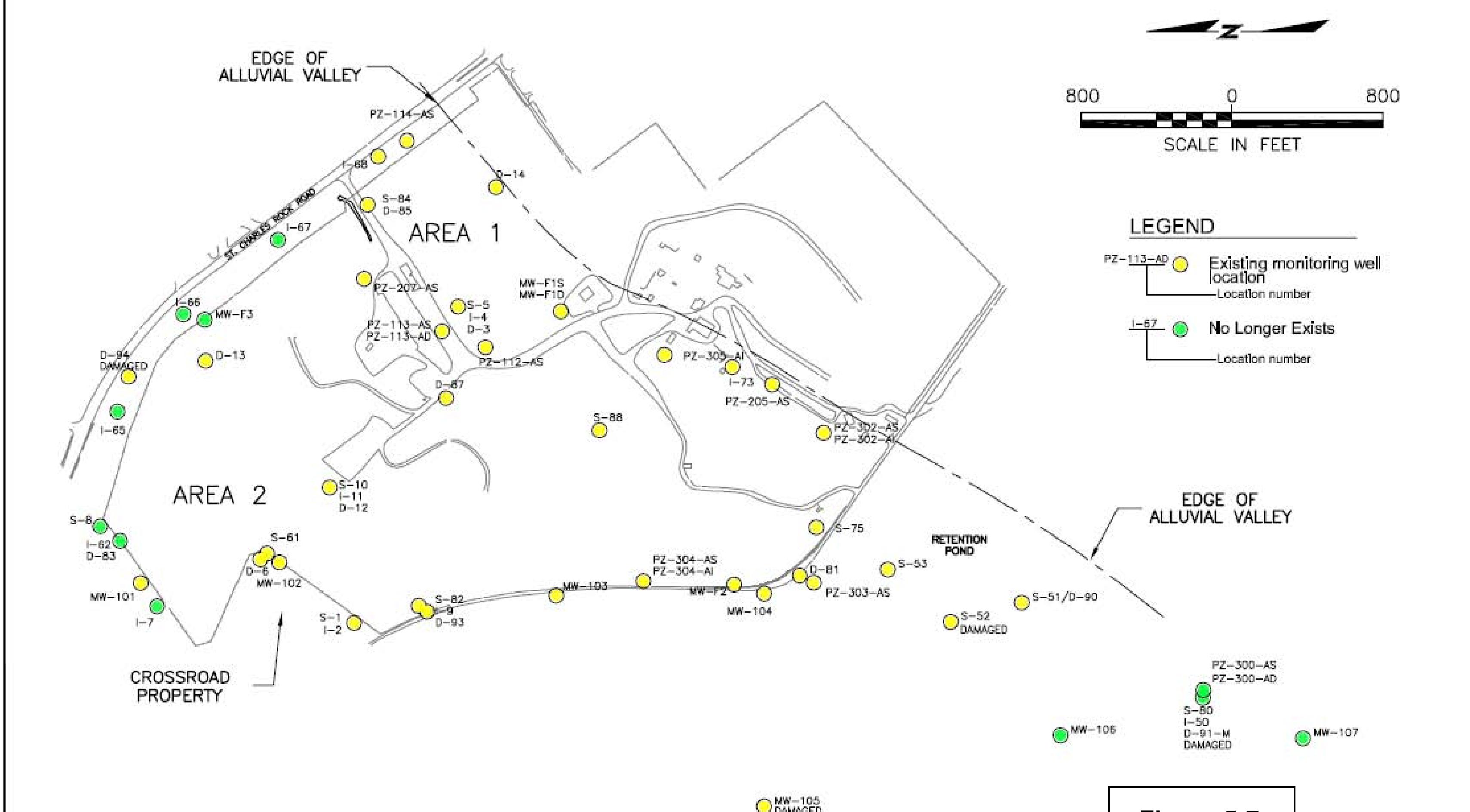


**Figure 5-7**

## Groundwater Monitoring Well Locations

West Lake Landfill OU-1 Feasibility Study

EMSI Engineering Management Support, Inc.

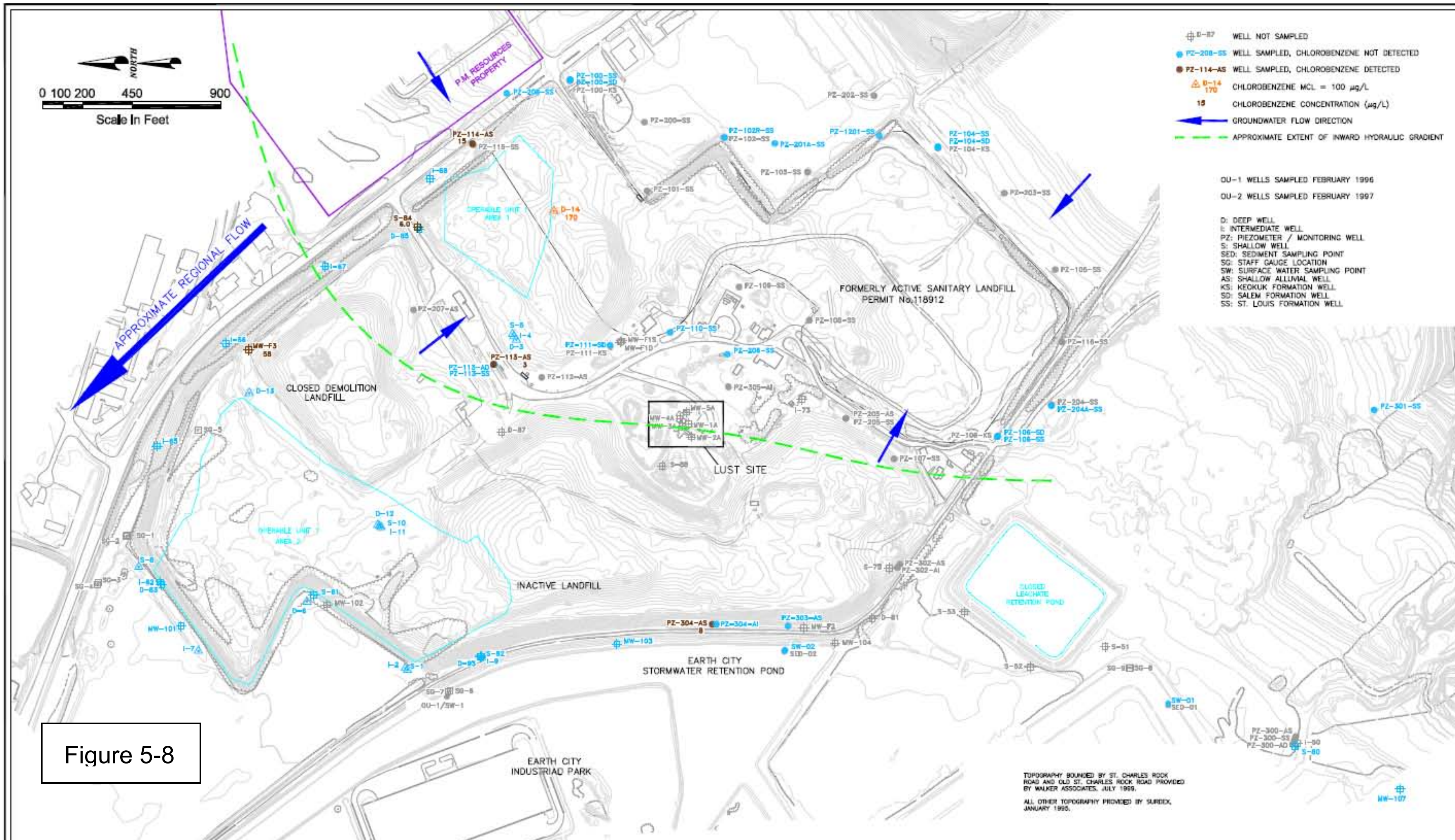


Figure 5-8

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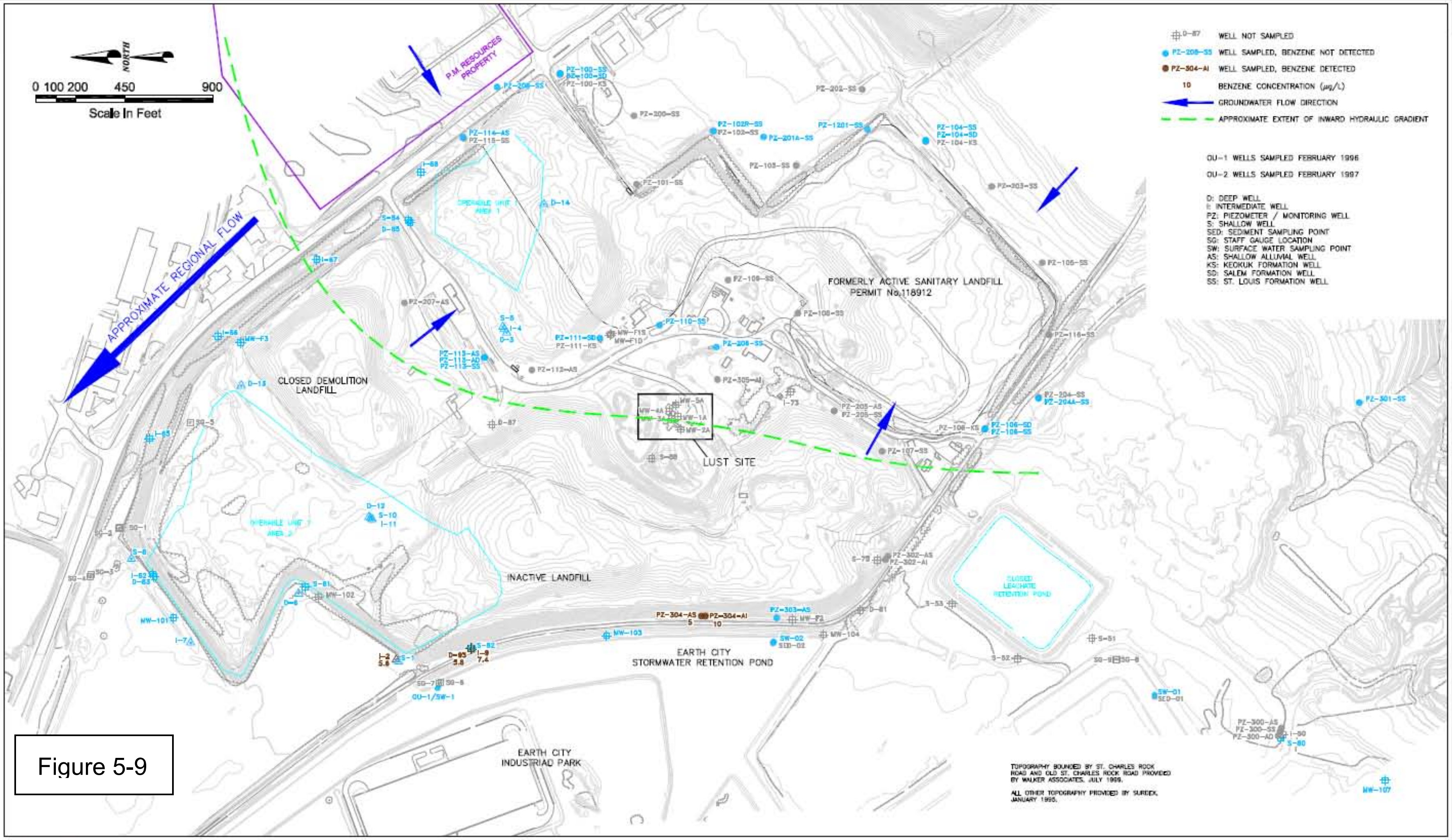
Fax (636) 939-9757

West Lake Landfill
Bridgeton, Missouri

Groundwater and Surface Water Chlorobenzene Results

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Groundwater and Surface Water
Benzene Results

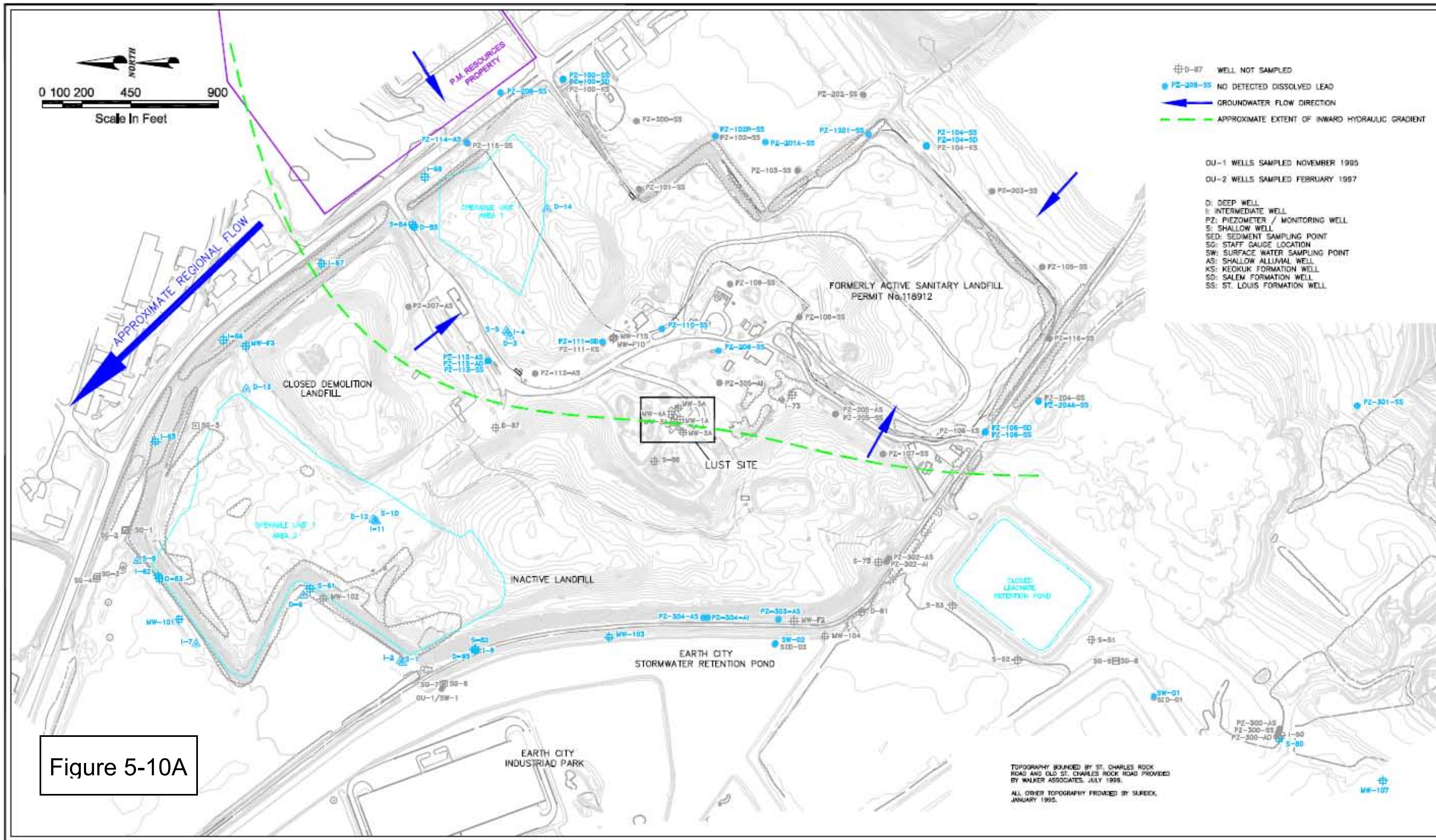


Figure 5-10A

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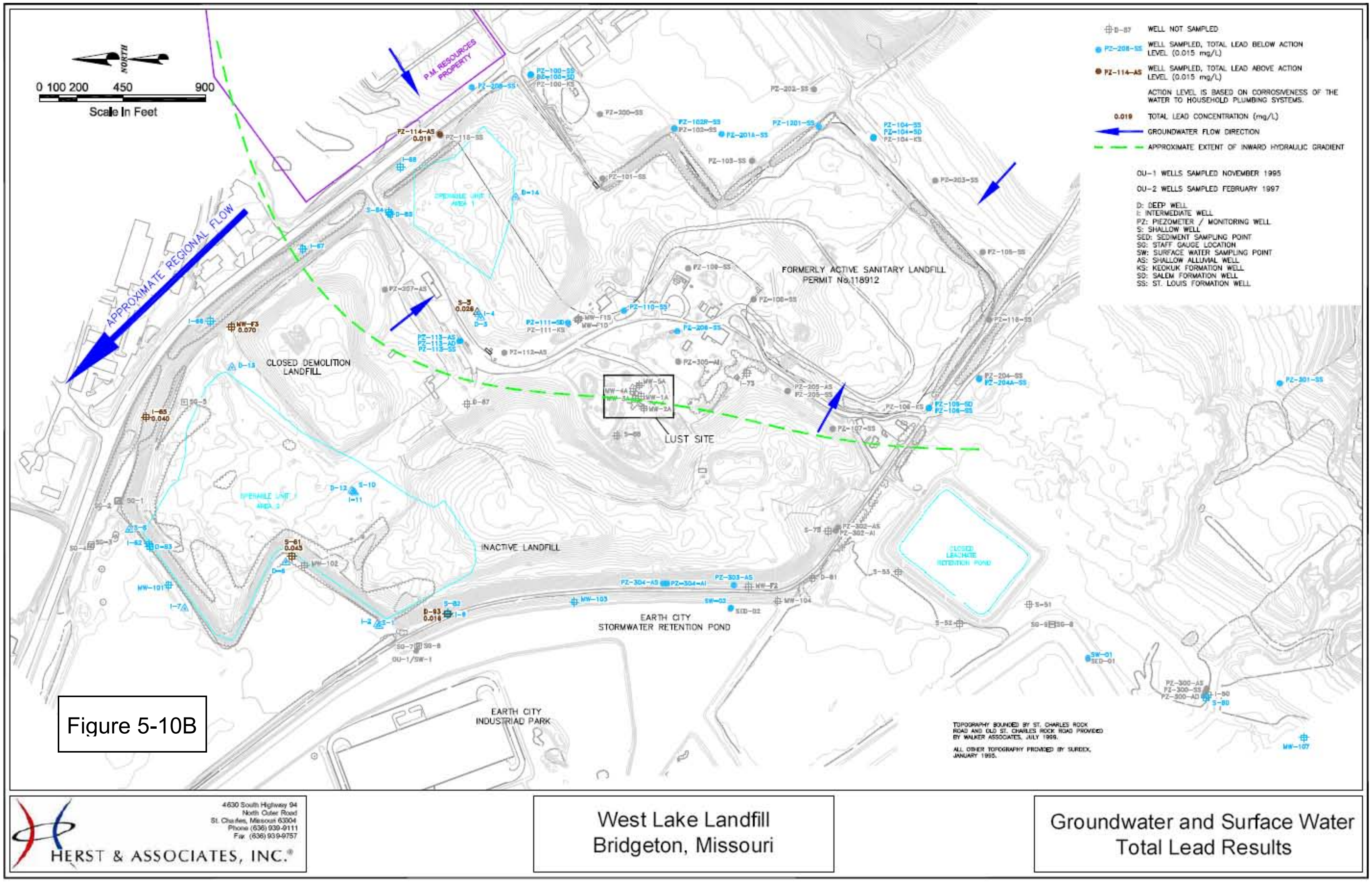
Dissolved Lead Results



NORTH
0 100 200 450 900
Scale In Feet
APPROXIMATE REGIONAL FLOW
P.M. RESOURCES PROPERTY
CLOSED DEMOLITION LANDFILL
FORMERLY ACTIVE SANITARY LANDFILL PERMIT No.118912
LUST SITE
INACTIVE LANDFILL
EARTH CITY STORMWATER RETENTION POND
EARTH CITY INDUSTRIAD PARK
WELL NOT SAMPLED
WELL SAMPLED, TOTAL LEAD BELOW ACTION LEVEL (0.015 mg/L)
WELL SAMPLED, TOTAL LEAD ABOVE ACTION LEVEL (0.015 mg/L)
ACTION LEVEL IS BASED ON CORROSIVENESS OF THE WATER TO HOUSEHOLD PLUMBING SYSTEMS.
0.019 TOTAL LEAD CONCENTRATION (mg/L)
GROUNDWATER FLOW DIRECTION
APPROXIMATE EXTENT OF INWARD HYDRAULIC GRADIENT
OU-1 WELLS SAMPLED NOVEMBER 1995
OU-2 WELLS SAMPLED FEBRUARY 1997
D: DEEP WELL
I: INTERMEDIATE WELL
PZ: PIEZOMETER / MONITORING WELL
S: SHALLOW WELL
SED: SEDIMENT SAMPLING POINT
SG: STAFF GAUGE LOCATION
SW: SURFACE WATER SAMPLING POINT
AS: SHALLOW ALLUVIAL WELL
KS: KEOKUK FORMATION WELL
SD: SALEM FORMATION WELL
SS: ST. LOUIS FORMATION WELL
TOPOGRAPHY BOUNDED BY ST. CHARLES ROCK ROAD AND OLD ST. CHARLES ROCK ROAD PROVIDED BY WALKER ASSOCIATES, JULY 1996.
ALL OTHER TOPOGRAPHY PROVIDED BY SURDEX, JANUARY 1995.
Figure 5-10B
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Fax (636) 939-9757
HERST & ASSOCIATES, INC.®
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Bridgeton, Missouri
Groundwater and Surface Water
Total Lead Results

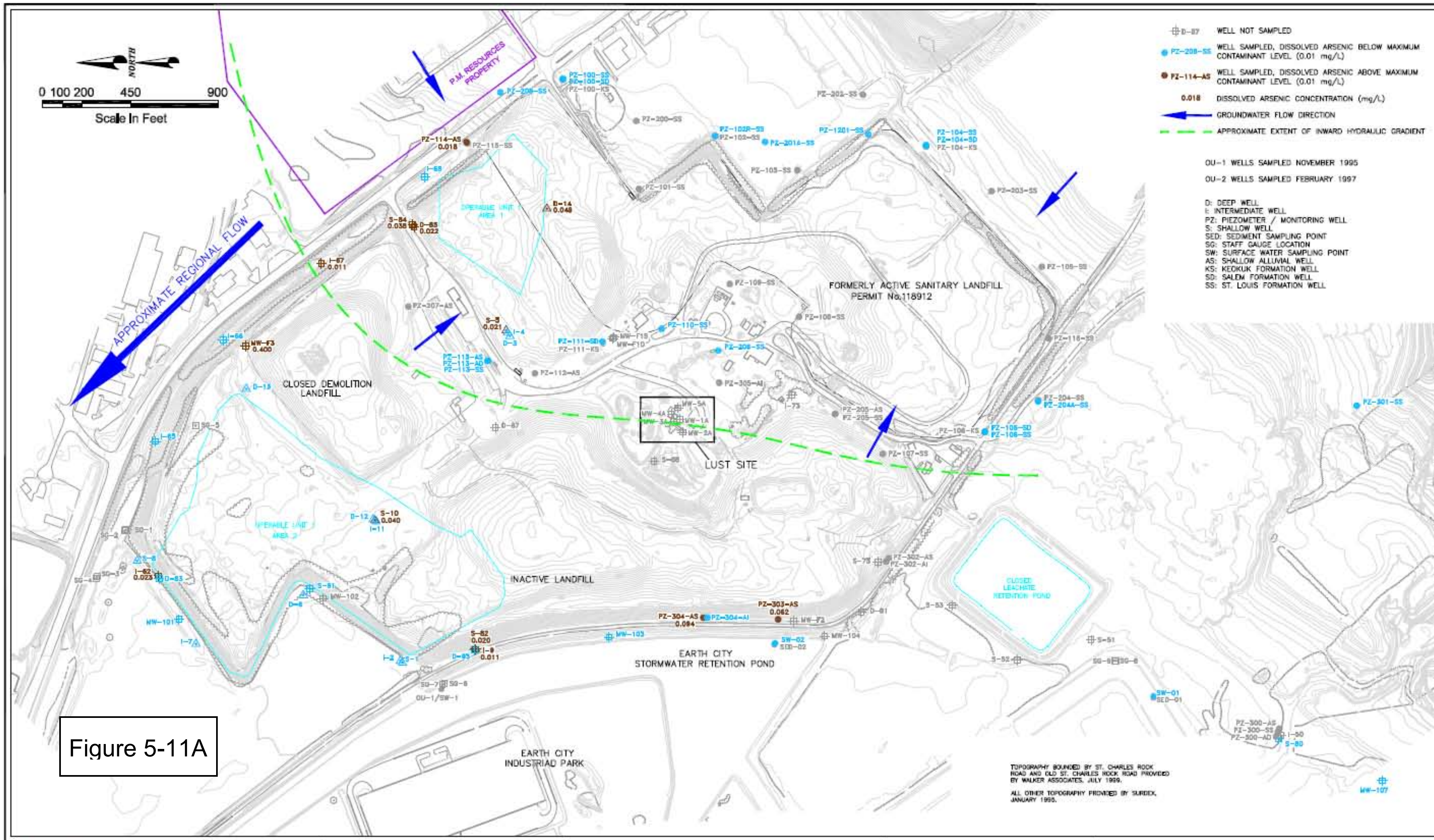


Figure 5-11A

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Groundwater and Surface Water
Dissolved Arsenic Results

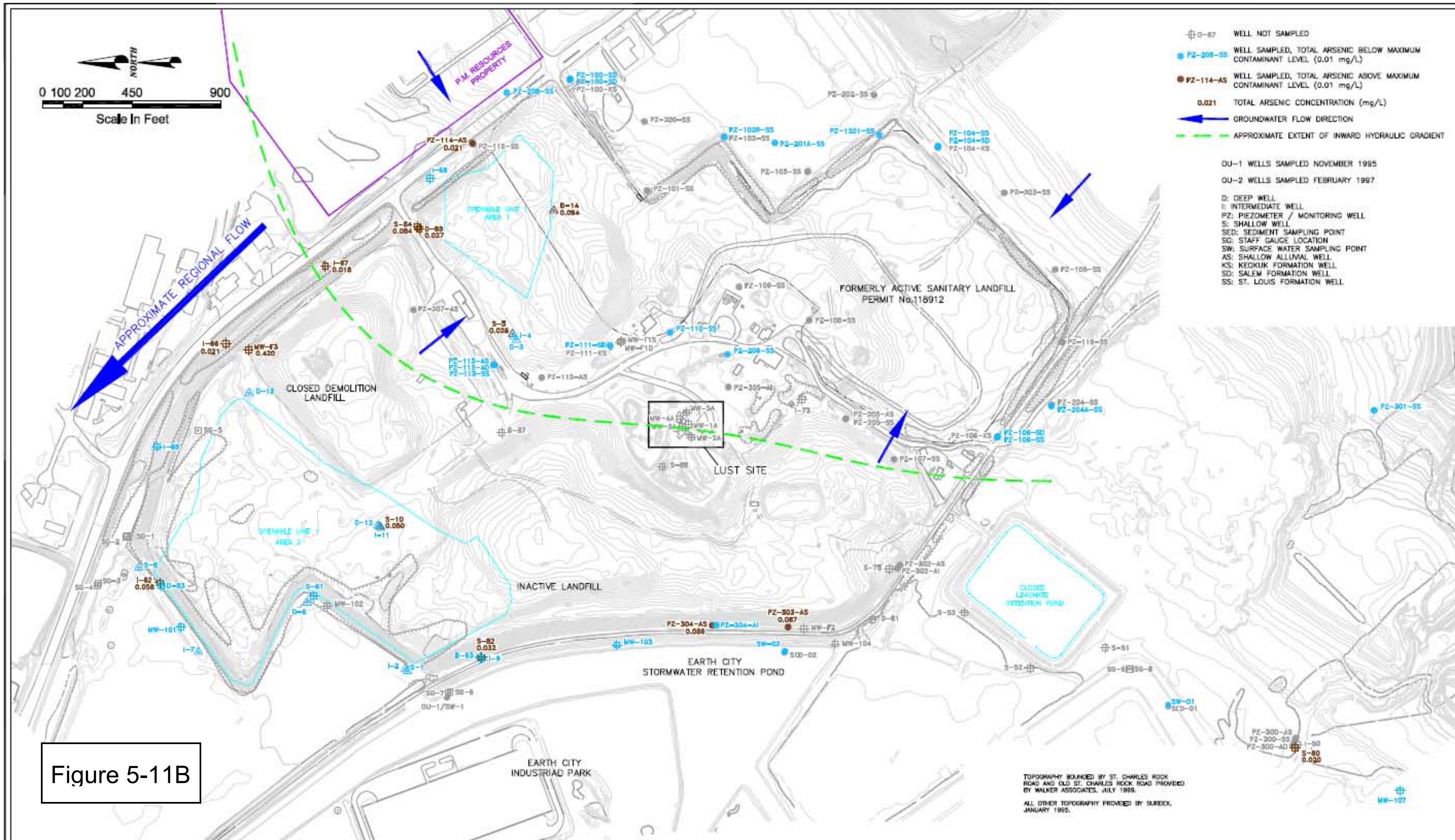


Figure 5-11B

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Groundwater and Surface Water
Total Arsenic Results

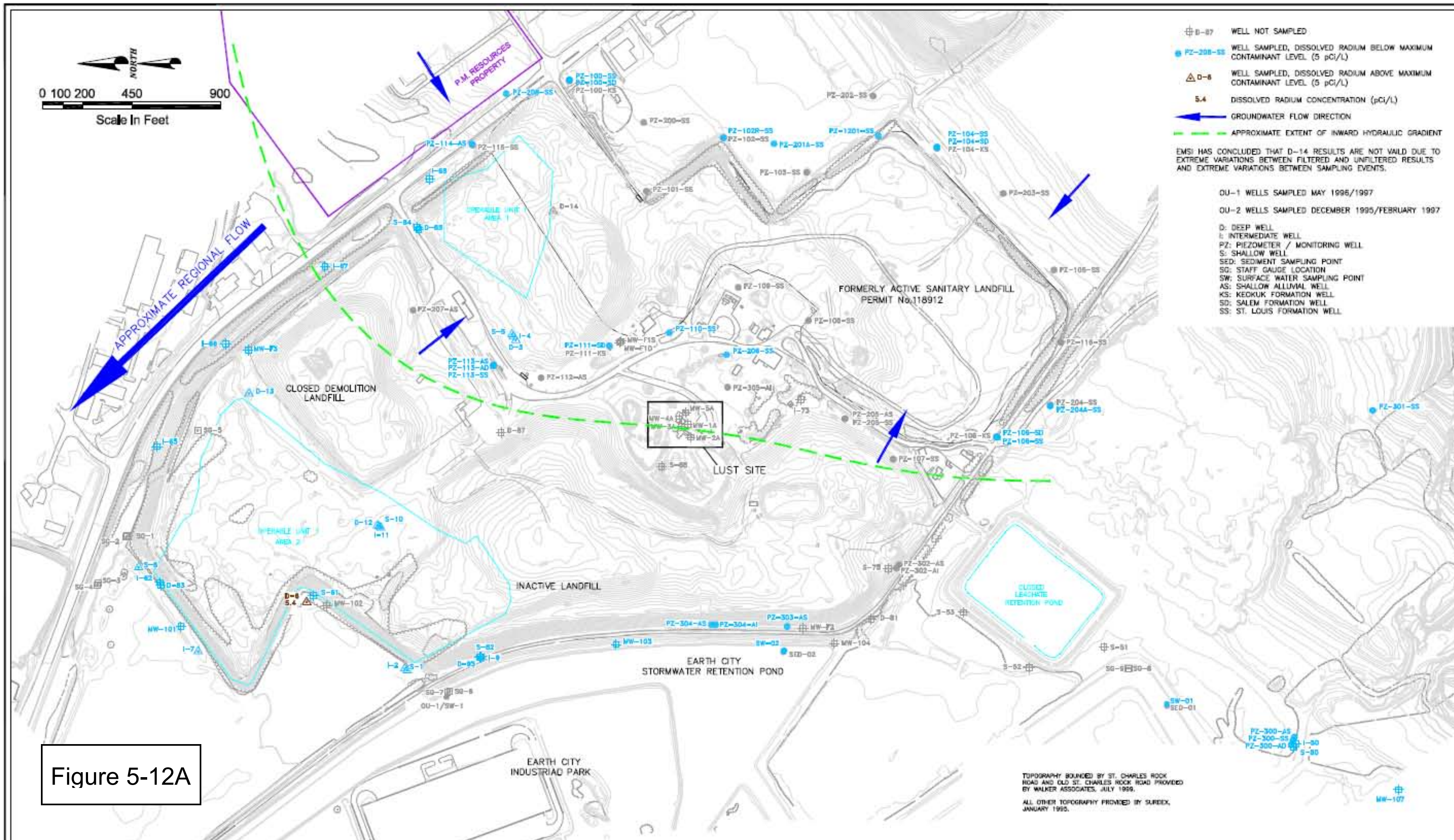


Figure 5-12A

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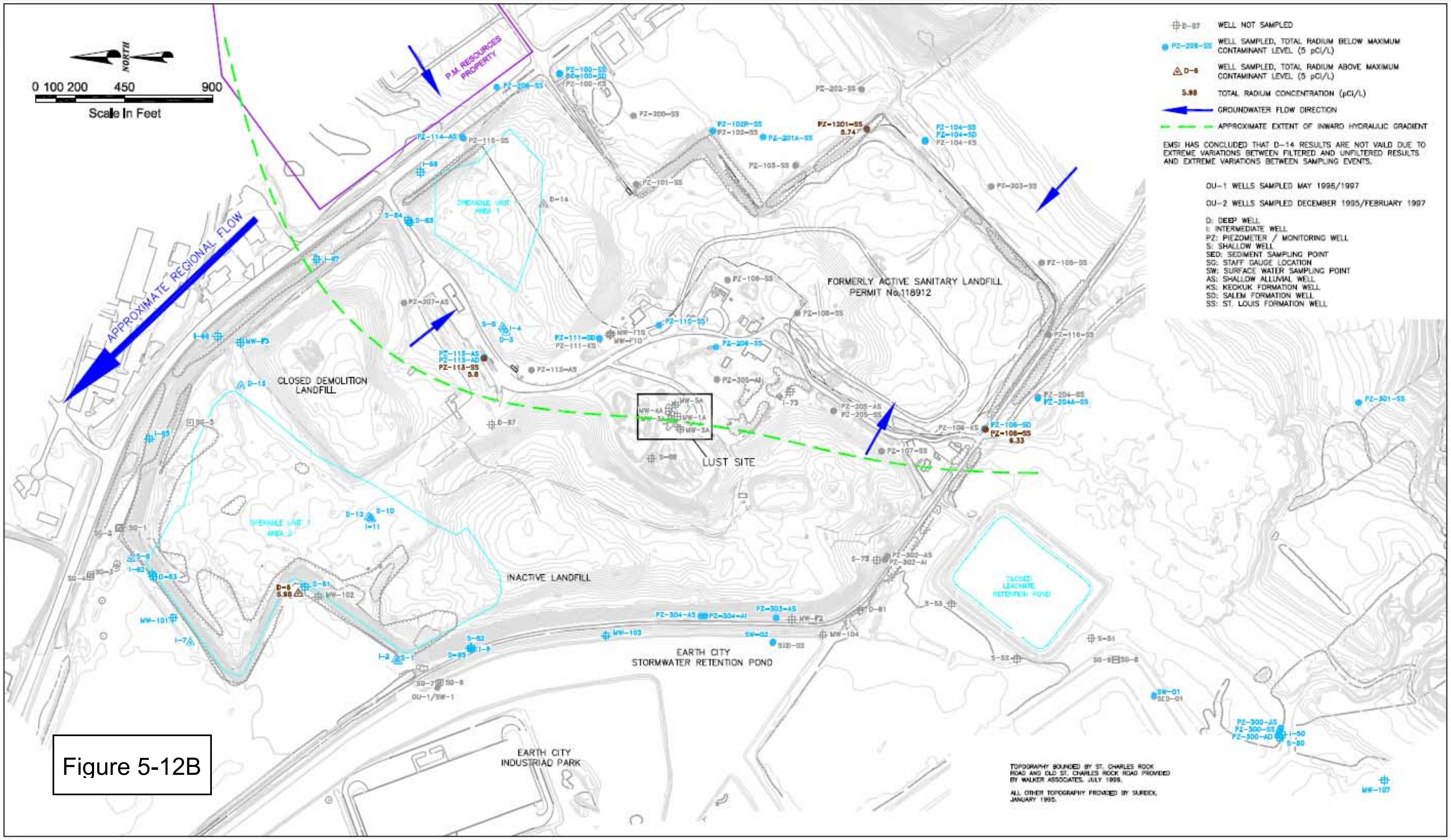
Dissolved Radium Results

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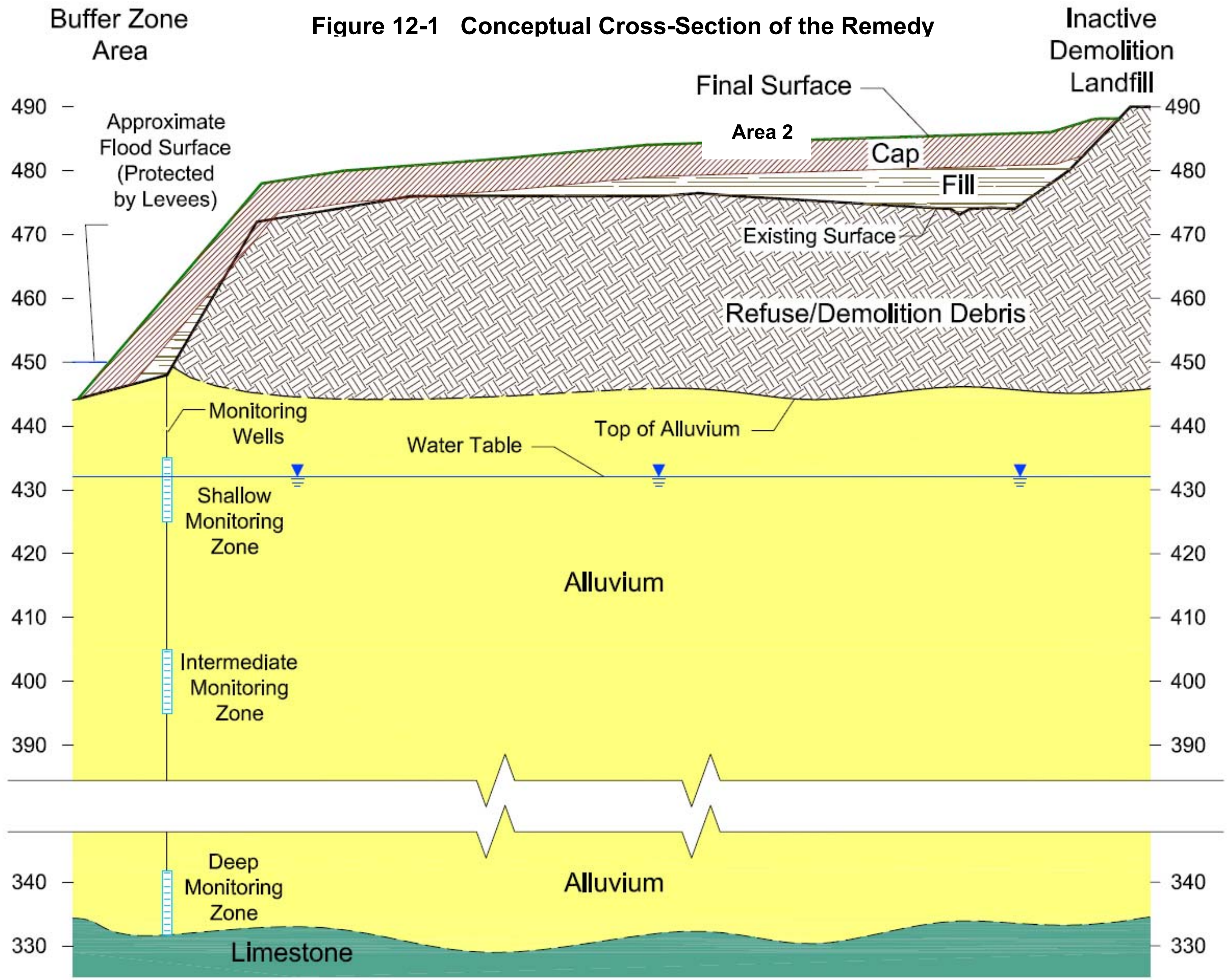
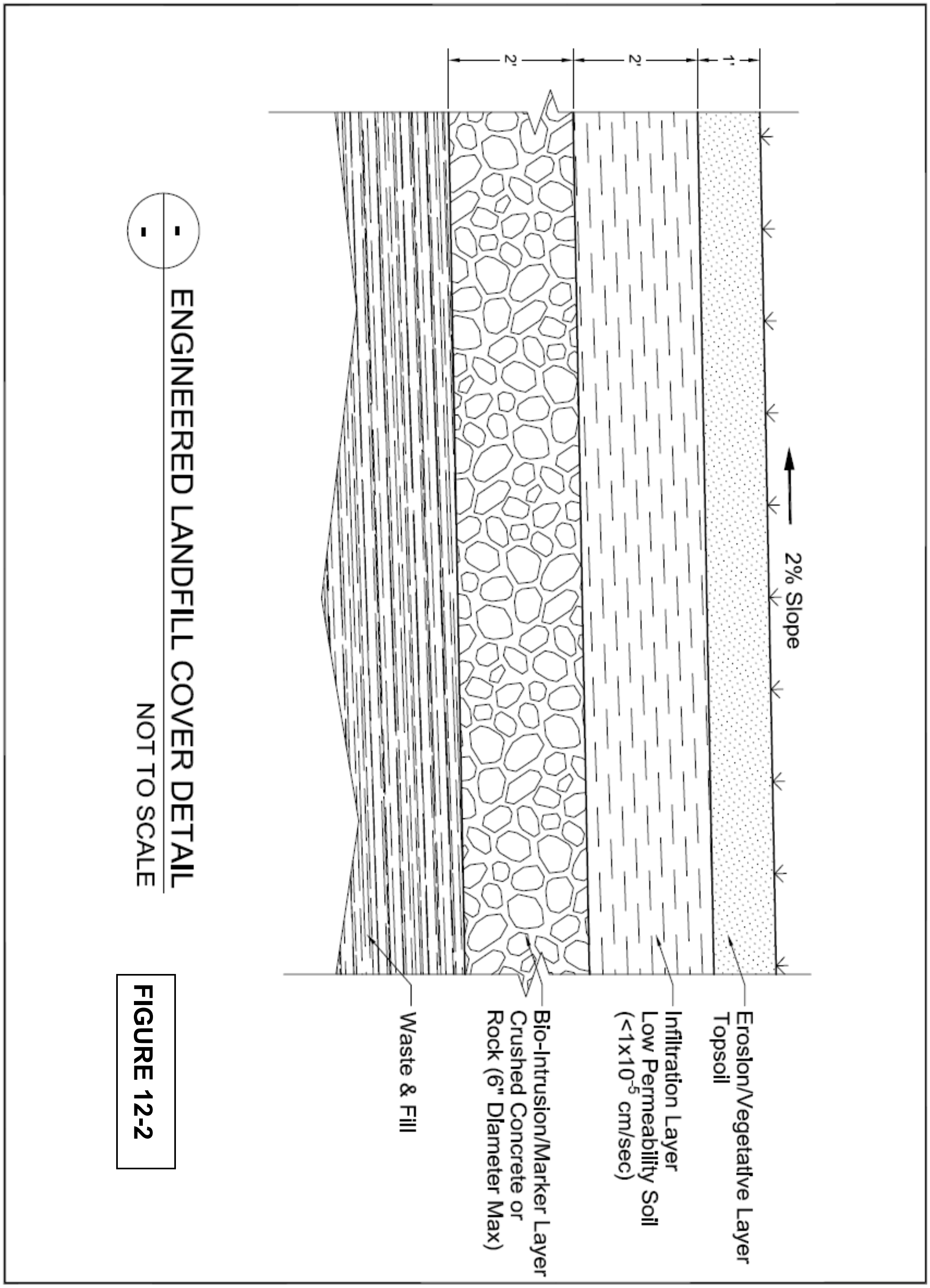
Groundwater and Surface Water
Total Radium Results

**Figure 12-1 Conceptual Cross-Section of the Remedy**





2'
2'
1'
2% Slope
Erosion/Vegetative Layer
Topsoil
Infiltration Layer
Low Permeability Soil
(<1x10-5 cm/sec)
Bio-Intrusion/Marker Layer
Crushed Concrete or
Rock (6" Diameter Max)
Waste & Fill
ENGINEERED LANDFILL COVER DETAIL
NOT TO SCALE
FIGURE 12-2

M:\clients\EMSI\westlake\4-04\fig-4-4.dwg plotted: 04/05/2005

**Effect of Cover Thickness on Dose Rates for Areas 1 and 2**
**95% UCL on Mean (8 h/w x 26 w/y = 208 h/y)**

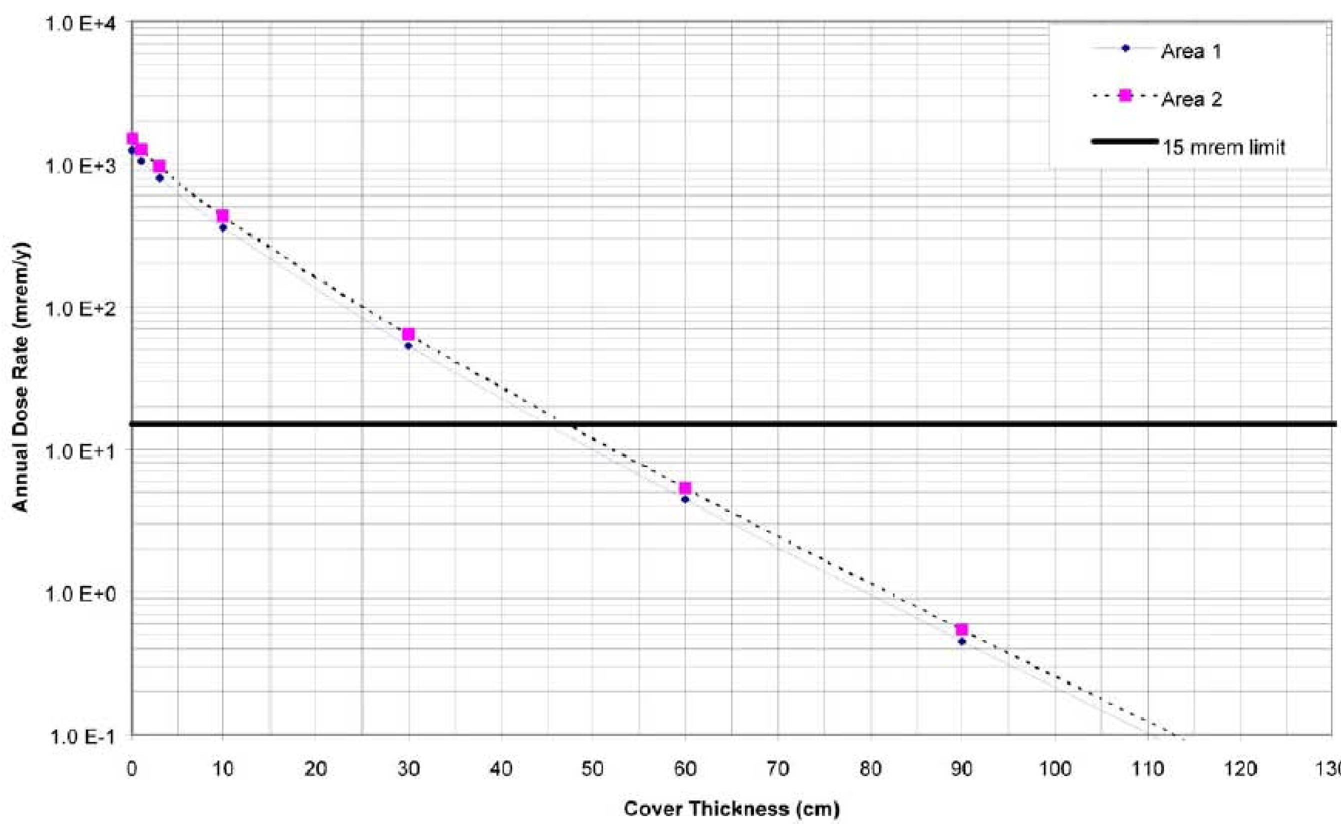



**Figure 12-3**

Cover Thickness Necessary For Protection
Of Groundskeeper Working In
Areas 1 and 2

West Lake Landfill OU-1 Feasibility Study

EMSI Engineering Management Support, Inc.

TABLES

Table 5-1 Summary of Constituents Detected in Groundwater – OU 1 RI

| Chemical | Maximum Detected Concentration (ug/l) | Drinking Water Standards (ug/l) | No. of Wells Chemical Detected Above MCL |
|---|---|---|---|
| Radionuclides | | | |
| Radium (total) | 8 | 5 | 2 |
| Uranium (total) | 9 | 30 | 0 |
| Trace Metals | | | |
| Arsenic | 420 / 400 | 50 / 10 | 4 |
| Chromium | 62 / 22 | 100 | 0 |
| Copper | 76 / 0 | 1,000 | 0 |
| Lead | 70 / 8 | 15 | 0 |
| Nickel | 93/ 110 | NA | 0 |
| Selenium | 38 | 50 | 0 |
| Zinc | 330 / 77 | 5,000 | 0 |
| Volatile Organic Compounds | | | |
| Benzene | 11 | 5 | 3 |
| Toluene | 13 | 1,000 | 0 |
| Ethyl Benzene | 16 | 700 | 0 |
| Xylenes | 51 | 10,000 | 0 |
| Chlorobenzene | 170 | NA | 0 |
| 1,2-Dichlorobenzene | 8 | 600 | 0 |
| 1,4-Dichlorobenzene | 50 | 75 | 0 |
| Cis-1,2-Dichloroethylene | 34 | 70 | 0 |
| 1,1-Dichloroethane | 8 | NA | 0 |
| Acetone | 68 | NA | 0 |
| Semi-volatile Organic Compounds | | | |
| 1,4-Dichlorobenzene | 38 | 75 | 1 |
| 4-Methylphenol | 290 | NA | 0 |
| Di-n-octylphthalate | 13 | NA | 0 |
| Bis(2-Ethylhexl)phthalate | 17 | 400 | 0 |

NA – A drinking water standard (MCL) has not been established for these compounds.

Table 5-2: Summary of Radionuclide Occurrence Above Reference Levels in Area 1 Surface Samples

| Radiological Constituents | Background Value (mean + 2 std. dev.) | > Background but < Reference # Detects | Range | Reference Level | > Reference Level # Detects | Range |
|---|---|---|---|---|---|---|
| **Uranium – 238 Decay Series** | | | | | | |
| Uranium-238 | 2.24 | 1 | 2.33+/-0.54 | 7.24 | 2 | 87+/-7.2 to 147+/-38 |
| Thorium-234 | 2.76 | 0 | | 7.76 | 2 | 55.9+/-13.5 to 180+/-49 |
| Uranium-234 | 2.73 | 1 | 2.94+/-0.65 | 7.73 | 2 | 105+/- 22 to 154+/-40 |
| Thorium-230 | 2.45 | 1 | 2.67+/-0.76 | 7.45 | 2 | 7,850+/-1,470 to 57,000 +/-4,100 |
| Radium-226 | 1.30 | 1 | 1.32+/-0.24 | 6.3 | 2 | 109+/-5 to 910+/-93 |
| Lead-214 | 1.13 | 3 | 1.16+/-0.44 to 1.62+/-0.56 | 6.13 | 2 | 108+/-8 to 1,100+/-99 |
| Bismuth-214 | 1.61 | 0 | | 6.61 | 2 | 110+/-6 to 1,000+/-57 |
| Lead-210 | 3.77 | 0 | | 8.77 | 3 | 206+/-26 to 1,040+/-135 |
| **Uranium – 235 Decay Series** | | | | | | |
| Uranium-235/236 | 1.15 | 1 | 5.7+/-1.9 | 6.15 | 2 | 6.86+/-3.99 to 19.5+/-5.9 |
| Proactinium-231 | NE | NE | NE | 5 | 2 | 156+/-27 to 610+/-110 |
| Actinium-227 | NE | NE | NE | 5 | 2 | 118+/-14 to 305+/-33 |
| Radium-223 | NE | NE | NE | 5 | 2 | 113+/-NA to 939+/-76 |
| **Thorium – 232 Decay Series** | | | | | | |
| Thorium-232 | 1.55 | 0 | | 6.55 | 2 | 18.1+/-4.6 to 40+/-150 |
| Radium-228 | 2.37 | 0 | | 7.37 | 0 | |
| Thorium-228 | 1.33 | 1 | 1.96+/-1.14 | 6.33 | 0 | |
| Radium-224 | NE | NE | NE | 5 | 1 | 1,760+/-219 |
| Lead-212 | 2.26 | 0 | | 7.26 | 0 | |
| Bismuth-212 | NE | NE | NE | 5 | 0 | |
| Thallium-208 | 0.71 | 1 | 0.79+/-0.83 | 5.71 | 1 | 6.8+/-2.1 |

All values expressed as pCi/g.
NE = Not established, all background samples below minimum detectable activity. NA = 2 Sigma Error (+/-) is not available.
A total of 8 surface soil samples were collected in Area 1. One of the samples was split and analyzed at two different laboratories. For some of the radionuclides, the results from one of the laboratories were greater than the background or reference levels, while the results from the second laboratory were not.

Table 5-3: Summary of Radionuclide Occurrence Above Reference Levels in Area 1 Subsurface Samples

| Radiological Constituents | Background Value (mean + 2 std. dev.) | > Background but < Reference | | Reference Level | > Reference Level | |
|---|---|---|---|---|---|---|
| | | # Detects | Range | | # Detects | Range |
| **Uranium – 238 Decay Series** | | | | | | |
| Uranium-238 | 2.24 | 5 | 2.89+/-0.56 to 6.94+/-1.28 | 17.24 | 2 | 17.8+/-4.1 to 26.4+/-10.1 |
| Thorium-234 | 2.76 | 0 | | 17.76 | 0 | |
| Uranium-234 | 2.73 | 6 | 2.92+/-1.46 to 15.6+/-3.6 | 17.73 | 0 | |
| Thorium-230 | 2.45 | 6 | 2.47+/-1.26 to 7.52+/-1.65 | 17.45 | 6 | 23.2+/-4.9 to 1,500+/-240 |
| Radium-226 | 1.30 | 6 | 1.36+/-0.37 to 6.3+/-1.2 | 16.3 | 3 | 18.4+/-1 to 128+/-6 |
| Lead-214 | 1.13 | 12 | 1.13+/-0.33 to 7.0+/-0.76 | 16.13 | 3 | 19.9+/-1.6 to 110+/-7 |
| Bismuth-214 | 1.61 | 3 | 2.53+/-0.19 to 6.5+/-0.58 | 16.61 | 3 | 18.4+/-1.2 to 128+/-7.00 |
| Lead-210 | 3.77 | 2 | 5.1+/-1.0 to 17+/-4.0 | 18.77 | 2 | 83.4+/-12.4 to 212+/-28 |
| **Uranium – 235 Decay Series** | | | | | | |
| Uranium-235/236 | 1.15 | 1 | 1.46+/-0.57 | 16.15 | 0 | |
| Proactinium-231 | NE | NE | NE | 15 | 3 | 26.9+/-7.9 to 73.2+/-14.6 |
| Actinium-227 | NE | NE | NE | 15 | 3 | 15.0+/-2.6 to 43.8+/-5.8 |
| Radium-223 | NE | NE | NE | 15 | 3 | 16.1+/-NA to 44.3+/-NA |
| **Thorium – 232 Decay Series** | | | | | | |
| Thorium-232 | 1.55 | 4 | 1.64+/-0.56 to 10.3+/-3.5 | 16.55 | 0 | |
| Radium-228 | 2.37 | 0 | | 17.37 | 0 | |
| Thorium-228 | 1.33 | 1 | 1.55+/-1.48 | 16.33 | 0 | |
| Radium-224 | NE | NE | NE | 15 | 1 | 39.1+/-6.3 |
| Lead-212 | 2.26 | 0 | | 17.26 | 0 | |
| Bismuth-212 | NE | NE | NE | 15 | 0 | |
| Thallium-208 | 0.71 | 0 | | 15.71 | 0 | |

All values expressed as pCi/g.
NE = Not established, all background samples below minimum detectable activity. NA = 2 Sigma Error (+/-) is not available.
A total of 39 subsurface soil samples were collected in Area 1. Field and laboratory duplicates were prepared for several of the samples. Two of the samples were split and analyzed at two different laboratories. For some of the radionuclides, the results from one of the laboratories or from one of the duplicate samples were greater than the background or reference levels, while the results from the original sample or second laboratory were not.

Table 5-4: Summary of Radionuclide Occurrence Above Reference Levels in Area 2 Surface Samples

| Radiological Constituents | Background Value (mean + 2 std. dev.) | > Background but < Reference # Detects | Range | Reference Level | > Reference Level # Detects | Range |
|---|---|---|---|---|---|---|
| **Uranium 238 – Decay Series** | | | | | | |
| Uranium-238 | 2.24 | 3 | 3.1+/-0.7 to 4.17+/-1.04 | 7.24 | 2 | 134+/-42 to 294+/-92 |
| Thorium-234 | 2.76 | 0 | | 7.76 | 0 | |
| Uranium-234 | 2.73 | 3 | 3.18+/-1.06 to 4.05+/-1.02 | 7.73 | 2 | 216+/-67 to 575+/-180 |
| Thorium-230 | 2.45 | 4 | 2.91+/-0.82 to 5.35+/-1.14 | 7.45 | 9 | 8.63+/-2.62 to 29,240+/-5,290 |
| Radium-226 | 1.30 | 4 | 1.54+/-0.22 to 4.78+/-0.44 | 6.3 | 4 | 9.2+/-1.7 to 3,720+/-142 |
| Lead-214 | 1.13 | 5 | 1.28+/-0.28 to 5.26+/-0.49 | 6.13 | 4 | 8.8+/-1.0 to 3,190+/-277 |
| Bismuth-214 | 1.61 | 2 | 3.56+/-0.87 to 4.2+/-0.67 | 6.61 | 4 | 7.3+/-0.69 to 3,690+/-136 |
| Lead-210 | 3.77 | 0 | | 8.77 | 3 | 9.58+/-2.32 to 1,370+/-162 |
| **Uranium – 235 Decay Series** | | | | | | |
| Uranium-235/236 | 1.15 | 0 | | 6.15 | 2 | 49.7+/-16.5 to 251+/-79 |
| Proactinium-231 | NE | NE | NE | 5 | 4 | 5.22+/-2.32 to 2,030+/-301 |
| Actinium-227 | NE | NE | NE | 5 | 3 | 6.15+/-1.17 to 1,320+/-179 |
| Radium-223 | NE | NE | NE | 5 | 3 | 6.73+/-NA to 1,097+/-NA |
| **Thorium – 232 Decay Series** | | | | | | |
| Thorium-232 | 1.55 | 0 | | 6.55 | 4 | 6.73+/-1.36 to 127+/-23 |
| Radium-228 | 2.37 | 0 | | 7.37 | 0 | |
| Thorium-228 | 1.33 | 1 | 4.97+/-1.04 | 6.33 | 0 | |
| Radium-224 | NE | NE | NE | 5 | 2 | 4,330+/-628 to 6,580+/-1090 |
| Lead-212 | 2.26 | 0 | | 7.26 | 0 | |
| Bismuth-212 | NE | 0 | | 5 | 0 | |
| Thallium-208 | 0.71 | 0 | | 5.71 | 0 | |

All values expressed as pCi/g.
NE = Not established, all background samples below minimum detectable activity. NA = 2 Sigma Error (+/-) is not available.
A total of 15 surface soil samples were collected in Area 2. Three of the samples were split and analyzed at two different laboratories. For some of the radionuclides, the results from one of the laboratories were greater than the background or reference levels, while the results from the second laboratory were not.

Table 5-5: Summary of Radionuclide Occurrence Above Reference Levels in Area 2 Subsurface Samples

| Radiological Constituents | Background Value (mean + 2 std. dev.) | Background but < Reference | | Reference Level | > Reference Level | |
|---|---|---|---|---|---|---|
| | | # Detects | Range | | # Detects | Range |
| **Uranium – 238 Decay Series** | | | | | | |
| Uranium-238 | 2.24 | 7 | 2.61+/-0.64 to 11.4+/-3.8 | 17.24 | 3 | 60.7+/-12.4 to 287+/-47 |
| Thorium-234 | 2.76 | 1 | 13.2+/-15.7 | 17.76 | 2 | 24.5+/-15.8 to 140+/-25 |
| Uranium-234 | 2.73 | 6 | 2.9+/-0.4 to 12.5+/-4.0 | 17.73 | 3 | 45.4+/-9.7 to 527+/-87 |
| Thorium-230 | 2.45 | 28 | 2.72+/-1.45 to 17.29+/-3.4 | 17.45 | 18 | 18.2+/-3.3 to 83,000+/-530 |
| Radium-226 | 1.30 | 17 | 1.3+/-0.45 to 12.9+/-0.54 | 16.3 | 4 | 88.4+/-5.2 to 3,140+/-116 |
| Lead-214 | 1.13 | 23 | 1.14+/-0.24 to 12.5+/-0.9 | 16.13 | 4 | 85.9+/-6.4 to 2,200+/-170 |
| Bismuth-214 | 1.61 | 10 | 1.63+/-0.42 to 12.6+/-0.6 | 16.61 | 4 | 93.2+/-5.1 to 3,150+/-111 |
| Lead-210 | 3.77 | 7 | 4.02+/-1.6 to 9.83+/-2.56 | 18.77 | 6 | 22.4+/-3.5 to 1,300+/-157 |
| **Uranium – 235 Decay Series** | | | | | | |
| Uranium-235/236 | 1.15 | 0 | | 16.15 | 3 | 24+/-27 to 115+/-19 |
| Proactinium-231 | NE | NE | NE | 15 | 4 | 39.3+/-11.1 to 1,930+/-243 |
| Actinium-227 | NE | NE | NE | 15 | 4 | 25.8+/-4.2 to 1,180+/-138 |
| Radium-223 | NE | NE | NE | 15 | 4 | 30.2+/-NA to 5,270+/-359 |
| **Thorium – 232 Decay Series** | | | | | | |
| Thorium-232 | 1.55 | 4 | 1.76+/-1.07 to 3.84+/-0.9 | 16.55 | 3 | 106+/-19 to 180+/-65 |
| Radium-228 | 2.37 | 2 | 14.5+/-7.9 to 16.7+/-9.3 | 17.37 | 0 | |
| Thorium-228 | 1.33 | 2 | 1.5+/-0.80 to 4.59+/-0.91 | 16.33 | 0 | |
| Radium-224 | NE | NE | NE | 15 | 0 | |
| Lead-212 | 2.26 | 1 | 2.49+/-0.94 | 17.26 | 1 | 82+/-35 |
| Bismuth-212 | NE | NE | NE | 15 | 0 | |
| Thallium-208 | 0.71 | 3 | 1.13+/-0.78 to 7.9+/-3.7 | 15.71 | 0 | |

All values expressed as pCi/g.
NE = Not established, all background samples below minimum detectable activity. NA = 2 Sigma Error (+/-) is not available.
A total of 73 subsurface soil samples were collected in Area 2. Field and laboratory duplicates were prepared for several of the samples. Four of the samples were split and analyzed at two different laboratories. For some of the radionuclides, the results from one of the laboratories or from one of the duplicate samples were greater than the background or reference levels, while the results from the original sample or second laboratory were not.

Table 5-6: Summary of Background Radionuclide Levels at the West Lake Landfill Site

| Radionuclide | Detection Frequency | Mean | Standard Deviation | Minimum Value | Maximum Value | Mean Plus 2 Standard Deviations | Mean Plus 3 Standard Deviations | Variance |
|---|---|---|---|---|---|---|---|---|
| Uranium-238 Decay Series | | | | | | | | |
| Uranium-238 | 4/4 | 1.33 | 0.46 | 0.74+/-0.35 | 1.85+/-0.79 | 2.24 | 2.7 | 0.21 |
| Thorium-234 | 2/4 | 1.57 | 0.59 | 1.15+/-0.89 | 1.99+/-1.11 | 2.76 | 3.35 | 0.35 |
| Uranium-234 | 4/4 | 1.47 | 0.63 | 1.06+/-0.44 | 2.40+/-0.93 | 2.73 | 3.36 | 0.40 |
| Thorium-230 | 4/4 | 1.51 | 0.47 | 0.92+/-0.44 | 2.03+/-0.6 | 2.45 | 2.91 | 0.22 |
| Radium-226 | 4/4 | 1.06 | 0.12 | 0.95+/-0.22 | 1.19+/-0.22 | 1.30 | 1.41 | 0.01 |
| Lead-214 | 4/4 | 1.01 | 0.06 | 0.92+/-0.26 | 1.07+/-0.24 | 1.13 | 1.19 | 0.004 |
| Bismuth-214 | 2/4 | 1.09 | 0.26 | 0.90+/-0.31 | 1.27+/-0.4 | 1.61 | 1.87 | 0.07 |
| Lead-210 | 3/4 | 2.48 | 0.64 | 1.88+/-1.56 | 3.16+/-2.18 | 3.77 | 4.41 | 0.41 |
| Uranium-235 Decay Series | | | | | | | | |
| Uranium-235/236 | 4/4 | 0.39 | 0.38 | 0.02+/-0.08 | 0.91+/-0.57 | 1.15 | 1.54 | 0.15 |
| Uranium-235 | -- | -- | -- | -- | -- | -- | -- | -- |
| Protactinium-231 | -- | -- | -- | -- | -- | -- | -- | -- |
| Actinium-227 | -- | -- | -- | -- | -- | -- | -- | -- |
| Radium-223 | -- | -- | -- | -- | -- | -- | -- | -- |
| Thorium-232 Decay Series | | | | | | | | |
| Thorium-232 | 4/4 | 0.90 | 0.33 | 0.52+/-0.29 | 1.26+/-0.39 | 1.55 | 1.87 | 0.11 |
| Radium-228 | 2/4 | 1.65 | 0.36 | 1.39+/-0.4 | 1.90+/-0.47 | 2.37 | 2.73 | 0.13 |
| Thorium-228 | 4/4 | 0.68 | 0.33 | 0.43+/-0.27 | 1.16+/-0.37 | 1.33 | 1.66 | 0.11 |
| Radium-224 | -- | -- | -- | -- | -- | -- | -- | -- |
| Lead-212 | 4/4 | 1.29 | 0.48 | 0.80+/-0.31 | 1.94+/-0.29 | 2.26 | 2.74 | 0.23 |
| Bismuth-212 | -- | -- | -- | -- | -- | -- | -- | -- |
| Thallium-208 | 4/4 | 0.44 | 0.14 | 0.32+/-0.16 | 0.63+/-0.21 | 0.71 | 0.84 | 0.02 |

All values expressed as pCi/g, except detection frequency.

Four background samples were analyzed. Samples without detections were not used to calculate background statistics.

-- = Radionuclides were not detected above the Minimum Detectable Activity (MDA) in any of the four background samples.

**Table 7-1 Current Exposure Point Concentrations in Area 1 Soil**

| Analyte | 95% CL on the Arithmetic Mean | | Units |
|---|---|---|---|
| | Surface Soil | All Depths | |
| **Uranium Series** | | | |
| Uranium-238 + 2 dtrs | 118 | 16.6 | pCi/g |
| Uranium-234 | 122 | 16.9 | pCi/g |
| Thorium-230 | 8140 | 1060 | pCi/g |
| Radium-226 + 5 dtrs | 581 | 71.6 | pCi/g |
| Lead-210 + 2 dtrs | 680 | 88.6 | pCi/g |
| **Actinium Series** | | | |
| Uranium-235 + 1 dtr | 5.99 [a] | 0.84 [a] | pCi/g |
| Protactinium-231 + 8 dtrs | 365 | 47.3 | pCi/g |
| **Thorium Series** | | | |
| Thorium-232 + 10 dtrs | 25.8 | 4.14 | pCi/g |
| **Inorganic Chemicals** | | | |
| Arsenic | 139 | NE[b] | mg/kg |
| **Organic Chemicals** | | | |
| Aroclor-1254 | 0.70 | 0.48 | mg/kg |

[a] **Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium.**

[b] **"NE" indicates no exposure because the receptor is not exposed to subsurface soil.**

## Table 7-2 Current Exposure Point Concentrations in Area 2 Soil

| Analyte | 95% CL on the Arithmetic Mean | | Units |
|---|---|---|---|
| | Surface Soil | All Depths | |
| **Uranium Series** | | | |
| Uranium-238 + 2 dtrs | 83.5 | 27.1 | pCi/g |
| Uranium-234 | 156 | 46.0 | pCi/g |
| Thorium-230 | 8920 | 3730 | pCi/g |
| Radium-226 + 5 dtrs | 1130 | 338 | pCi/g |
| Lead-210 + 2 dtrs | 384 | 128 | pCi/g |
| **Actinium Series** | | | |
| Uranium-235 + 1 dtr | 5.99 [a] | 1.83 [a] | pCi/g |
| Protactinium-231 + 8 dtrs | 559 | 162 | pCi/g |
| **Thorium Series** | | | |
| Thorium-232 + 10 dtrs | 36.6 | 15.9 | pCi/g |
| **Inorganic Chemicals** | | | |
| Arsenic | 15.9 | NE[b] | mg/kg |
| Lead | 1176 | NE | mg/kg |
| Uranium | 250 [c] | NE | mg/kg |
| **Organic Chemicals** | | | |
| Aroclor-1254 | 1.02 | NE | mg/kg |

[a] **Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium.**

[b] **"NE" indicates no exposure because the receptor is not exposed to subsurface soil.**

[c] **The uranium238 isotope accounts for more than 99 percent of the mass of natural uranium. The mass concentration of uranium was calculated by dividing the uranium-238 activity in picocuries per gram (pCi/g) by its specific activity of 0.336 pCi/µg, resulting in a mass concentration of mg uranium per kg soil (mg/kg).**

## Table 7-3 Current Exposure Point Concentrations for the Ford Property Soil

| | 95% CL on the Arithmetic Mean | |
|---|---|---|
| **Analyte** | **Surface Soil** | **Units** |
| **Uranium Series** | | |
| Uranium-238 + 2 dtrs | 0.997 | pCi/g |
| Uranium-234 | 1.01 | pCi/g |
| Thorium-230 | 15 | pCi/g |
| Radium-226 + 5 dtrs | 1.08 | pCi/g |
| Lead-210 + 2 dtrs | 4.22 | pCi/g |
| **Actinium Series** | | |
| Uranium-235 + 1 dtr | 0.050 [a] | pCi/g |
| **Thorium Series** | | |
| Thorium-232 + 10 dtrs | 1.40 | pCi/g |

[a] **Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium.**

## Table 7-4 Future Exposure Point Concentrations for Area 1 Soil

| Analyte | 95% CL on the Arithmetic Mean | | Units |
|---|---|---|---|
| | Surface Soil | All Depths | |
| **Uranium Series** | | | |
| Uranium-238 + 2 dtrs | 118 | 16.6 | pCi/g |
| Uranium-234 | 122 | 16.9 | pCi/g |
| Thorium-230 | 8140 | 1060 | pCi/g |
| Radium-226 + 8 dtrs | 3224 | 417 | pCi/g |
| **Actinium Series** | | | |
| Uranium-235 + 1 dtr | 5.99 [a] | 0.84 [a] | pCi/g |
| Protactinium-231 + 8 dtrs | 365 | 47.3 | pCi/g |
| **Thorium Series** | | | |
| Thorium-232 + 10 dtrs | 25.8 | 4.14 | pCi/g |
| **Inorganic Chemicals** | | | |
| Arsenic | 139 | NE[b] | mg/kg |
| **Organic Chemicals** | | | |
| Aroclor-1254 | 0.70 | 0.48 | mg/kg |

[a] **Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium.**

[b] **"NE" indicates no exposure because the receptor is not exposed to subsurface soil.**

## Table 7-5 Future Exposure Point Concentrations for Area 2 Soil

| Analyte | 95% CL on the Arithmetic Mean | | Units |
|---|---|---|---|
| | Surface Soil | All Depths | |
| **Uranium Series** | | | |
| Uranium-238 + 2 dtrs | 83.5 | 27.1 | pCi/g |
| Uranium-234 | 156 | 46.0 | pCi/g |
| Thorium-230 | 8920 | 3730 | pCi/g |
| Radium-226 + 8 dtrs | 3853 | 1524 | pCi/g |
| **Actinium Series** | | | |
| Uranium-235 + 1 dtr | 5.99 [a] | 1.83 [a] | pCi/g |
| Protactinium-231 + 8 dtrs | 559 | 162 | pCi/g |
| **Thorium Series** | | | |
| Thorium-232 + 10 dtrs | 36.6 | 15.9 | pCi/g |
| **Inorganic Chemicals** | | | |
| Arsenic | 15.9 | NE[b] | mg/kg |
| Lead | 1176 | NE | mg/kg |
| Uranium | 250 [c] | NE | mg/kg |
| **Organic Chemicals** | | | |
| Aroclor-1254 | 1.02 | NE | mg/kg |

[a] **Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium.**

[b] **"NE" indicates no exposure because the receptor is not exposed to subsurface soil.**

[c] **The uranium-238 isotope accounts for more than 99 percent of the mass of natural uranium. The mass concentration of uranium was calculated by dividing the uranium-238 activity in picocuries per gram (pCi/g) by its specific activity of 0.336 pCi/µg, resulting in a mass concentration of mg uranium per kg soil (mg/kg).**

**Table 7-6 Future Exposure Point Concentrations for Ford Property Soil**

| Analyte | 95% CL on the Arithmetic Mean | |
|---|---|---|
| | Surface Soil | Units |
| **Uranium Series** | | |
| Uranium-238 + 2 dtrs | 0.997 | pCi/g |
| Uranium-234 | 1.01 | pCi/g |
| Thorium-230 | 15 | pCi/g |
| Radium-226 + 8 dtrs | 5.95 | pCi/g |
| **Actinium Series** | | |
| Uranium-235 + 1 dtr | 0.050 [a] | pCi/g |
| **Thorium Series** | | |
| Thorium-232 + 10 dtrs | 1.40 | pCi/g |

[a] **Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium.**

## Table 7-7 Future Exposure Point Concentrations in Air

| Analyte | 95% Confidence Limit on the Arithmetic Mean of Surface Soil x Mass Loading Factor of 50 μg/m³ | | | Units |
|---|---|---|---|---|
| | Area 1 | Area 2 | Ford Property | |
| **Uranium Series** | | | | |
| Uranium-238 + 2 dtrs | 5.89 E-3 | 4.18 E-3 | 4.99 E-5 | pCi/m³ |
| Uranium-234 | 6.10 E-3 | 7.80 E-3 | 5.03 E-5 | pCi/m³ |
| Thorium-230 | 4.07 E-1 | 4.46 E-1 | 7.50 E-4 | pCi/m³ |
| Radium-226 + 8 dtrs | 1.61 E-1 | 1.93 E-1 | 2.97 E-4 | pCi/m³ |
| Radon-222 | 1.89 E+1 [a] | 6.67 E+1 [a] | 3.98 E-2 [a] | pCi/m³ |
| **Actinium Series** | | | | |
| Uranium-235 + 1 dtr | 3.00 E-4 [b] | 2.99 E-4 [b] | 2.50 E-6 [b] | pCi/m³ |
| **Thorium Series** | | | | |
| Thorium-232 + 10 dtrs | 1.29 E-3 | 1.83 E-3 | 7.00 E-5 | pCi/m³ |
| **Inorganic Chemicals** | | | | |
| Arsenic | 6.97 E-3 | 7.93 E-4 | NA[c] | μg/m³ |
| Lead | NA | 5.88 E-2 | NA | μg/m³ |
| Uranium | NA | 1.25 E-2 | NA | μg/m³ |
| **Organic Chemicals** | | | | |
| Aroclor-1254 | 3.48E-05 | 5.10E-05 | NA | μg/m³ |

[a] **Calculated from the predicted radium-226 concentrations in soil.**

[b] **Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium.**

[c] **"ND" indicates the radionuclide was not detected.**

[d] **"NA" indicates not applicable. Preliminary screening removed the chemical from consideration in this area.**

## Table 7-8 Radiological Carcinogenic Slope Factors [a]

| Constituent | Inhalation Cancer Slope Factor $SF_i$ ($pCi^{-1}$) | Oral Cancer Slope Factor $SF_o$ ($pCi^{-1}$) | External Cancer Slope Factor $SF_e$ (g/pCi-y) |
|---|---|---|---|
| **Uranium Series** | | | |
| Uranium-238 + 2 dtrs | 1.24 E-8 | 6.20 E-11 | 5.25 E-8 |
| Uranium-234 | 1.40 E-8 | 4.44 E-11 | 2.14 E-11 |
| Thorium-230 | 1.72 E-8 | 3.75 E-11 | 4.40 E-11 |
| Radium-226 + 8 dtrs | 6.61 E-9 | 1.31 E-9 | 6.74 E-6 |
| Radium-226 + 5 dtrs | 2.75 E-9 | 2.96 E-10 | 6.74 E-6 |
| Radium-226 | 2.72 E-9 | 2.95 E-10 | 1.31 E-8 |
| Radon-222 + 4 dtrs | 7.57 E-12 | NA | NA |
| Radon-222 in Outdoor Air [b] | 7.3 E-13 | NA | NA |
| Lead-210 + 2 dtrs | 3.86 E-9 | 1.01 E-9 | 1.45 E-10 |
| **Actinium Series** | | | |
| Uranium-235 + 1 dtr | 1.30 E-8 | 4.70 E-11 | 2.65 E-7 |
| Protactinium-231+ 8 dtrs | 1.03 E-7 | 7.75 E-10 | 6.24 E-7 |
| **Thorium Series** | | | |
| Thorium-232 + 10 dtrs | 1.17 E-7 | 5.11 E-10 | 4.27 E-6 |

[a] EPA assumes all radionuclides are Class A carcinogens. Slope factors used are from EPA 1997 "Health Effects Assessment Summary Tables Update," unless noted.

[b] Radon daughters have not had enough time to appear before the released radon-222 reaches the exposure points selected in this risk assessment. To reflect this, the radon-222 slope factor (without daughter contributions) from EPA's March 1994 "Health Effects Assessment Summary Tables Update" was used for outdoor Rn-222 exposures

## Table 7-9 Chemical Carcinogenic Slope Factors [a]

| Constituent | Inhalation Cancer Slope Factor $SF_i$ [1/(mg/kg-d)] | Oral Cancer Slope Factor $SF_o$ [1/(mg/kg-d)] | Inhalation Tumor Site | Oral Tumor Site | Cancer Classification | Dermal Cancer Slope Factor $SF_d$ [1/(mg/kg-d)] |
|---|---|---|---|---|---|---|
| Aroclor-1254 | 2.00 E+0[b] | 2.00 E+0[b] | ND[c] | Liver | B2[b] | 2.22 E+0 |
| Arsenic | 1.54 E+1 | 1.50 E+0 | Respiratory tract | Skin, liver, lung, bladder | A | 1.58 E+0 |
| Lead | ND | ND | ND | Kidney | B2 | ND |
| Uranium | ND | ND | ND | ND | ND | ND |

[a] References: Integrated Risk Information System (EPA 2000), Health Effects Assessment Summary Tables (EPA 1997c).

[b] Slope Factors for polychlorinated biphenyls are given. Cancer slope factors for Aroclor-1254 are not available.

[c] ND signifies that no data were available.

## Table 7-10 Chemical Reference Doses [a]

| Constituent | Inhalation Reference Dose $RfD_i$ (mg/kg-d) | Oral Reference Dose $RfD_o$ (mg/kg-d) | Inhalation Target Organ | Oral Target Organ | Inhalation Uncertainty Factor | Oral Uncertainty Factor | Dermal Reference Dose $RfD_d$ (mg/kg-d) |
|---|---|---|---|---|---|---|---|
| Aroclor-1254 | ND[b] | 2.0 E-5 | ND | ND | ND | 3.0 E+2 | 1.8 E-5 |
| Arsenic | ND | 3.0 E-4 | ND | Skin, vascular system | ND | 3.0 E+0 | 2.9 E-4 |
| Lead | ND | ND | CNS[c] | CNS[c] | ND | ND | ND |
| Uranium [d] | ND | 3.0 E-3 | ND | Kidney | ND | 1.0 E+3 | 1.9 E-5 |

[a] References: Integrated Risk Information System (EPA 2000), Health Effects Assessment Summary Tables (EPA 1997c).

[b] ND signifies that no data were available.

[c] CNS signifies Central Nervous System.

[d] Values used are for soluble uranium salts, IRIS file no. 0421. No toxicity information is available from EPA on natural uranium, CASRN 7440-61-1, (IRIS file no. 0259). The RfD for soluble uranium was used, although this form of uranium is not expected to be found at this site.

**Table 7-11 Calculated Incremental Lifetime Cancer Risks for the Landfill Groundskeeper Scenario Area 1 – Future Conditions**

| Constituent | Exposure Route: Soil Ingestion | Inhalation | Dermal Absorption | Direct Radiation | All Routes |
|---|---|---|---|---|---|
| **Uranium Series** | | | | | |
| Uranium-238 + 2 dtrs | 1 E-8 | 2 E-8 | NE[a] | 2 E-8 | 5 E-8 |
| Uranium-234 | 1 E-8 | 2 E-8 | NE | 7 E-12 | 3 E-8 |
| Thorium-230 | 6 E-7 | 1 E-6 | NE | 8 E-10 | 2 E-6 |
| Radium-226 + 8 dtrs | 8 E-6 | 2 E-7 [b] | NE | 5 E-5 | 6 E-5 |
| **Actinum Series** | | | | | |
| Uranium-235 + 1 dtr | 6 E-10 | 8 E-10 | NE | 4 E-9 | 5 E-9 |
| Protactinium-231+ 8 dtrs | 6 E-7 | 4 E-7 | NE | 5 E-7 | 1 E-6 |
| **Thorium Series** | | | | | |
| Thorium-232 + 10 dtrs | 3 E-8 | 3 E-8 | NE | 3 E-7 | 4 E-7 |
| **Inorganic Chemicals** | | | | | |
| Arsenic | 2 E-7 | 1 E-8 | 5 E-9 | NE | 2 E-7 |
| **Organic Chemicals** | | | | | |
| Aroclor-1254 | 2 E-9 | 8 E-12 | 6 E-11 | NE | 2 E-9 |
| **Total Risk** | | | | | |
| Radiocarcinogenic | 1 E-5 | 2 E-6 | NE | 5 E-5 | 6 E-5 |
| Chemocarcinogenic | 2 E-7 | 1 E-8 | 5 E-9 | NE | 2 E-7 |

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

[b] Includes risks from inhalation of particulates and radon-222 gas

## Table 7-12 Calculated Incremental Lifetime Cancer Risks for the Landfill Groundskeeper Scenario Area 2 – Future Conditions

| Constituent | Exposure Route | | | | |
|---|---|---|---|---|---|
| | Soil Ingestion | Inhalation | Dermal Absorption | Direct Radiation | All Routes |
| **Uranium Series** | | | | | |
| Uranium-238 + 2 dtrs | 1 E-8 | 1 E-8 | NE[a] | 3 E-8 | 5 E-8 |
| Uranium-234 | 1 E-8 | 2 E-8 | NE | 2 E-11 | 4 E-8 |
| Thorium-230 | 7 E-7 | 2 E-6 | NE | 3 E-9 | 2 E-6 |
| Radium-226 + 8 dtrs | 1 E-5 | 3 E-7 [b] | NE | 2 E-4 | 2 E-4 |
| **Actinum Series** | | | | | |
| Uranium-235 + 1 dtr | 6 E-10 | 8 E-10 | NE | 9 E-9 | 1 E-8 |
| Protactinium-231+ 8 dtrs | 9 E-7 | 6 E-7 | NE | 2 E-6 | 3 E-6 |
| **Thorium Series** | | | | | |
| Thorium-232 + 10 dtrs | 4 E-8 | 4 E-8 | NE | 1 E-6 | 1 E-6 |
| **Inorganic Chemicals** | | | | | |
| Arsenic | 2 E-8 | 1 E-9 | 5 E-10 | NE | 3 E-8 |
| Lead | NS[c] | NS | NS | NE | - |
| Uranium | NS | NS | NS | NE | - |
| **Organic Chemicals** | | | | | |
| Aroclor-1254 | 2.0 E-9 | 1.0 E-11 | 9.0 E-11 | NE | 2.0 E-9 |
| **Total Risk** | | | | | |
| Radiocarcinogenic | 1 E-5 | 3 E-6 | NE | 2 E-4 | 2 E-4 |
| Chemocarcinogenic | 2 E-8 | 1 E-9 | 6 E-10 | NE | 3 E-8 |

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

[b] Includes risks from inhalation of particulates and radon-222 gas

[c] "NS" - Intake calculation is not applicable because EPA has not published a slope factor for use in quantifying the risk from this contaminant via this exposure route.

## Table 7-13 Calculated Incremental Lifetime Cancer Risks for the Landfill Adjacent Building User Scenario Area 1 – Future Conditions

| | Exposure Route | | | | | |
|---|---|---|---|---|---|---|
| Constituent | Soil Ingestion | Inhalation | | Dermal Absorption | Direct Radiation | All Routes |
| **Uranium Series** | | | | | | |
| Uranium-238 + 2 dtrs | NE[a] | NE | NE | NE | 3 E-9 | 3 E-9 |
| Uranium-234 | NE | NE | NE | NE | 1 E-12 | 1 E-12 |
| Thorium-230 | NE | NE | NE | NE | 2 E-10 | 2 E-10 |
| Radium-226 + 8 dtrs | NE | NE | NE | NE | 1 E-5 | 1 E-5 |
| **Actinum Series** | | | | | | |
| Uranium-235 + 1 dtr | NE | NE | NE | NE | 8 E-10 | 8 E-10 |
| Protactinium-231+ 8 dtrs | NE | NE | NE | NE | 1 E-7 | 1 E-7 |
| **Thorium Series** | | | | | | |
| Thorium-232 + 10 dtrs | NE | NE | NE | NE | 7 E-8 | 7 E-8 |
| **Inorganic Chemicals** | | | | | | |
| Arsenic | NE | NE | NE | NE | NE | 0 E+0 |
| **Organic Chemicals** | | | | | | |
| Aroclor-1254 | NE | NE | NE | NE | NE | 0 E+0 |
| **Total Risk** | | | | | | |
| Radiocarcinogenic | NE | NE | NE | NE | 1 E-5 | 1 E-5 |
| Chemocarcinogenic | NE | NE | NE | NE | NE | 0 E+0 |

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

## Table 7-14 Calculated Incremental Lifetime Cancer Risks for the Landfill Adjacent Building User Scenario Area 2 – Future Conditions

| Constituent | Exposure Route | | | | | |
|---|---|---|---|---|---|---|
| | Soil Ingestion | Inhalation | | Dermal Absorption | Direct Radiation | All Routes |
| **Uranium Series** | | | | | | |
| Uranium-238 + 2 dtrs | NE[a] | NE | NE | NE | 5 E-9 | 5 E-9 |
| Uranium-234 | NE | NE | NE | NE | 4 E-12 | 4 E-12 |
| Thorium-230 | NE | NE | NE | NE | 6 E-10 | 6 E-10 |
| Radium-226 + 8 dtrs | NE | NE | NE | NE | 4 E-5 | 4 E-5 |
| **Actinum Series** | | | | | | |
| Uranium-235 + 1 dtr | NE | NE | NE | NE | 2 E-9 | 2 E-9 |
| Protactinium-231+ 8 dtrs | NE | NE | NE | NE | 4 E-7 | 4 E-7 |
| **Thorium Series** | | | | | | |
| Thorium-232 + 10 dtrs | NE | NE | NE | NE | 3 E-7 | 3 E-7 |
| **Inorganic Chemicals** | | | | | | |
| Arsenic | NE | NE | NE | NE | NE | 0 E+0 |
| Uranium | NE | NE | NE | NE | NE | 0 E+0 |
| **Organic Chemicals** | | | | | | |
| Aroclor-1254 | NE | NE | NE | NE | NE | 0 E+0 |
| **Total Risk** | | | | | | |
| Radiocarcinogenic | NE | NE | NE | NE | 4 E-5 | 4 E-5 |
| Chemocarcinogenic | NE | NE | NE | NE | NE | 0 E+0 |

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

## Table 7-15 Calculated Incremental Lifetime Cancer Risks for the Landfill Storage Yard Worker Scenario Area 1 – Future Conditions

| Constituent | Exposure Route: Soil Ingestion | Inhalation | | Dermal Absorption | Direct Radiation | All Routes |
|---|---|---|---|---|---|---|
| **Uranium Series** | | | | | | |
| Uranium-238 + 2 dtrs | NE[a] | NE | NE | NE | 3 E-8 | 3 E-8 |
| Uranium-234 | NE | NE | NE | NE | 1 E-11 | 1 E-11 |
| Thorium-230 | NE | NE | NE | NE | 2 E-9 | 2 E-9 |
| Radium-226 + 8 dtrs | NE | NE | NE | NE | 1 E-4 | 1 E-4 |
| **Actinum Series** | | | | | | |
| Uranium-235 + 1 dtr | NE | NE | NE | NE | 8 E-9 | 8 E-9 |
| Protactinium-231+ 8 dtrs | NE | NE | NE | NE | 1 E-6 | 1 E-6 |
| **Thorium Series** | | | | | | |
| Thorium-232 + 10 dtrs | NE | NE | NE | NE | 7 E-7 | 7 E-7 |
| **Inorganic Chemicals** | | | | | | |
| Arsenic | NE | NE | NE | NE | NE | 0 E+0 |
| **Organic Chemicals** | | | | | | |
| Aroclor-1254 | NE | NE | NE | NE | NE | 0 E+0 |
| **Total Risk** | | | | | | |
| Radiocarcinogenic | NE | NE | NE | NE | 1 E-4 | 1 E-4 |
| Chemocarcinogenic | NE | NE | NE | NE | NE | 0 E+0 |

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

## Table 7-16 Calculated Incremental Lifetime Cancer Risks for the Landfill Storage Yard Worker Scenario Area 2 – Future Conditions

| | Exposure Route | | | | | |
|---|---|---|---|---|---|---|
| Constituent | Soil Ingestion | Inhalation | | Dermal Absorption | Direct Radiation | All Routes |
| **Uranium Series** | | | | | | |
| Uranium-238 + 2 dtrs | NE[a] | NE | NE | NE | 5 E-8 | 5 E-8 |
| Uranium-234 | NE | NE | NE | NE | 4 E-11 | 4 E-11 |
| Thorium-230 | NE | NE | NE | NE | 6 E-9 | 6 E-9 |
| Radium-226 + 8 dtrs | NE | NE | NE | NE | 4 E-4 | 4 E-4 |
| **Actinum Series** | | | | | | |
| Uranium-235 + 1 dtr | NE | NE | NE | NE | 2 E-8 | 2 E-8 |
| Protactinium-231+ 8 dtrs | NE | NE | NE | NE | 4 E-6 | 4 E-6 |
| **Thorium Series** | | | | | | |
| Thorium-232 + 10 dtrs | NE | NE | NE | NE | 3 E-6 | 3 E-6 |
| **Inorganic Chemicals** | | | | | | |
| Arsenic | NE | NE | NE | NE | NE | 0 E+0 |
| Uranium | NE | NE | NE | NE | NE | 0 E+0 |
| **Total Risk** | | | | | | |
| Radiocarcinogenic | NE | NE | NE | NE | 4 E-4 | 4 E-4 |
| Chemocarcinogenic | NE | NE | NE | NE | NE | 0 E+0 |

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

## Table 7-17 Calculated Incremental Lifetime Cancer Risks for the Groundskeeper Scenario Ford Property – Future Conditions

| Constituent | Exposure Route | | | | |
|---|---|---|---|---|---|
| | Soil Ingestion | Inhalation | Dermal Absorption | Direct Radiation | All Routes |
| **Uranium Series** | | | | | |
| Uranium-238 + 2 dtrs | 1 E-9 | 3 E-10 | NE[a] | 2 E-9 | 3 E-9 |
| Uranium-234 | 8 E-10 | 3 E-10 | NE | 8 E-13 | 1 E-9 |
| Thorium-230 | 1 E-8 | 6 E-9 | NE | 3 E-11 | 2 E-8 |
| Radium-226 + 8 dtrs | 1 E-7 | 1 E-9 [b] | NE | 2 E-6 | 2 E-6 |
| **Actinum Series** | | | | | |
| Uranium-235 + 1 dtr | 4 E-11 | 1 E-11 | NE | 5 E-10 | 6 E-10 |
| **Thorium Series** | | | | | |
| Thorium-232 + 10 dtrs | 1 E-8 | 4 E-9 | NE | 2 E-7 | 3 E-7 |
| **Total Risk** | | | | | |
| Radiocarcinogenic | 2 E-7 | 1 E-8 | NE | 2 E-6 | 2 E-6 |

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

[b] Includes risks from inhalation of particulates and radon-222 gas

## Table 7-18 Calculated Hazard Quotients and Hazard Index for All Future Scenarios

| Constituent | Exposure Route[a] Soil Ingestion | Inhalation | Dermal Absorption | Total |
|---|---|---|---|---|
| **Area 1 Grounds Keeper** | | | | |
| Aroclor-1254 | 0.0004 | NS | 0.000017 | 0.0004 |
| Arsenic | 0.0053 | NS | 0.00012 | 0.0054 |
| Total Hazard Index for Route | 0.0057 | NS | 0.00013 | |
| **Total Hazard Index for Area 1 Grounds Keeper** | | | | **0.0059** |
| **Area 2 Ground Keeper** | | | | |
| Aroclor-1254 | 0.00058 | NS | 0.000025 | 0.0006 |
| Arsenic | 0.0006 | NS | 0.000013 | 0.0006 |
| Lead | NS | NS | NS | |
| Uranium | 0.0010 | NS | NS | 0.0010 |
| Total Hazard Index for Route | 0.0021 | NS | 0.000038 | |
| **Total Hazard Index for Area 2 Grounds Keeper** | | | | **0.0022** |

[a] Complete exposure pathways do not exist for the Adjacent Building User and the Storage Yard Worker.

[b] "NS" - Risk calculation is not applicable because no reference dose is available to quantify risk.

## Table 7-19 Summary of Risks for Future Receptor Scenarios

| Risks | On-site | | | | | | Off-site |
|---|---|---|---|---|---|---|---|
| | Area 1 Grounds Keeper | Area 2 Grounds Keeper | Area 1 Adjacent Building User | Area 2 Adjacent Building User | Area 1 Storage Yard Worker | Area 2 Storage Yard Worker | Ford Property Grounds Keeper |
| Total Cancer Risks | 6 E-5 | 2 E-4 | 1 E-5 | 4 E-5 | 1 E-4 | 4 E-4 | 2 E-6 |
| Radionuclides | 6 E-5 | 2 E-4 | 1 E-5 | 4 E-5 | 1 E-4 | 4 E-4 | 2 E-6 |
| Chemicals | 2 E-7 | 3 E-8 | NE[a] | NE | NE | NE | NE |
| Hazard Index | 0.0059 | 0.0022 | NE | NE | NE | NE | NE |

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

## Table 7-20
**Summary of Exposure Pathways for Ecological Receptors**

| Taxa | Direct Contact | Ingestion Soils | Ingestion Vegetation | Ingestion Invertebrates | Ingestion Prey Mammals | Ingestion Prey Birds | Ingestion Water |
|---|---|---|---|---|---|---|---|
| Plants | X | | | | | | |
| Soil Invertebrates | X | | | | | | |
| White-footed Mouse | | X | X | X | | | X |
| Cottontail Rabbit | | X | X | | | | X |
| Red Fox | | X | X | X | X | X | X |
| American Robin | | X | X | X | | | X |
| American Woodcock | | X | | X | | | X |
| Red-tailed Hawk | | | | | X | X | X |

## Table 7-21

### SUMMARY OF RISK FINDINGS FOR THE PLANTS AND INVERTEBRATES, AREA 2

| Chemical | Plants | | | Invertebrates | | |
|---|---|---|---|---|---|---|
| | 95% CI Concentration (mg/kg) | Benchmark Concentration (mg/kg) | Hazard Quotient (HQ) | 95% CI Concentration (mg/kg) | Benchmark Concentration (mg/kg) | Hazard Quotient (HQ) |
| **Inorganics** | | | | | | |
| Arsenic | 3.50E+01 | 1.00E+01 | 3.50E+00 | 3.50E+01 | 6.00E+01 | 5.83E-01 |
| Beryllium | 2.20E+00 | 1.00E+01 | 2.20E-01 | 2.20E+00 | ND | ND |
| Cadmium | 6.30E+00 | 3.00E+00 | 2.10E+00 | 6.30E+00 | 2.00E+01 | 3.15E-01 |
| Chromium | 4.90E+01 | 1.00E+00 | 4.90E+01 | 4.90E+01 | 4.00E-01 | 1.23E+02 |
| Copper | 3.60E+02 | 1.00E+02 | 3.60E+00 | 3.60E+02 | 5.00E+01 | 7.20E+00 |
| Lead | 2.20E+03 | 5.00E+01 | 4.40E+01 | 2.20E+03 | 5.00E+02 | 4.40E+00 |
| Mercury | 2.70E-01 | 3.00E-01 | 9.00E-01 | 2.70E-01 | 1.00E-01 | 2.70E+00 |
| Nickel | 6.80E+02 | 3.00E+01 | 2.27E+01 | 6.80E+02 | 2.00E+02 | 3.40E+00 |
| Selenium | 3.80E+01 | 1.00E+00 | 3.80E+01 | 3.80E+01 | 7.00E+01 | 5.43E-01 |
| Uranium | 8.75E+02 | 5.00E+00 | 1.75E+02 | 8.75E+02 | ND | ND |
| Zinc | 4.00E+02 | 5.00E+01 | 8.00E+00 | 4.00E+02 | 2.00E+02 | 2.00E+00 |
| **Organics** | | | | | | |
| Acetone | 3.80E-02 | ND | ND | 3.80E-02 | ND | ND |
| Bis(2-ethylhexyl)phthalate | 7.70E+01 | ND | ND | 7.70E+01 | 2.00E+02 | 3.85E-01 |
| Di-n-octylphthalate | 1.20E+01 | 2.00E+02 | 6.00E-02 | 1.20E+01 | 2.00E+02 | 6.00E-02 |
| 1,4-Dichlorobenzene | 6.50E-03 | ND | ND | 6.50E-03 | 2.00E+01 | 3.25E-04 |
| Fluoranthene | 8.50E+00 | ND | ND | 8.50E+00 | 3.00E+01 | 2.83E-01 |
| Xylenes | 1.20E-02 | ND | ND | 1.20E-02 | ND | ND |
| **Pesticides/PCBs** | | | | | | |
| Aldrin | 1.70E-03 | ND | ND | 1.70E-03 | 2.20E+00 | 7.73E-04 |
| Aroclor 1254 | 1.60E+00 | 4.00E+01 | 4.00E-02 | 1.60E+00 | ND | ND |
| 4,4'-DDD | 7.60E-03 | ND | ND | 7.60E-03 | 2.00E+03 | 3.80E-06 |
| 4,4'-DDT | 9.30E-03 | ND | ND | 9.30E-03 | 2.00E+03 | 4.65E-06 |
| **Totals:** | | | 3.47E+02 | | | 1.44E+02 |

## Table 7-22

**SUMMARY OF RISK FINDINGS FOR WILDLIFE WITH SMALL HOME RANGES, AREA 2**

| Chemical | White-footed Mouse | | | Cottontail Rabbit | | | American Robin | | |
|---|---|---|---|---|---|---|---|---|---|
| | Intake (mg/kg/day) | Benchmark Value (mg/kg/day) | Hazard Quotient (HQ) | Intake (mg/kg/day) | Benchmark Value (mg/kg/day) | Hazard Quotient (HQ) | Intake (mg/kg/day) | Benchmark Value (mg/kg/day) | Hazard Quotient (HQ) |
| **Inorganics** | | | | | | | | | |
| Arsenic | 1.11E+01 | 1.36E-01 | 8.19E+01 | 8.80E+00 | 5.00E-02 | 1.76E+02 | 4.19E+01 | 5.10E+00 | 8.21E+00 |
| Beryllium | 1.02E-02 | 1.32E+00 | 7.70E-03 | 3.18E-02 | 4.90E-01 | 6.50E-02 | 3.89E-02 | ND [1] | ND |
| Cadmium | 9.31E+01 | 1.93E+00 | 4.83E+01 | 4.47E+01 | 7.09E-01 | 6.31E+01 | 3.20E+02 | 1.45E+00 | 2.20E+02 |
| Chromium | 3.72E+01 | 5.47E+03 | 6.81E-03 | 6.85E-01 | 2.01E+03 | 3.41E-04 | 1.07E+02 | 1.00E+00 | 1.07E+02 |
| Copper | 6.10E+02 | 3.04E+01 | 2.01E+01 | 6.42E+02 | 1.12E+01 | 5.73E+01 | 2.50E+03 | 4.70E+01 | 5.32E+01 |
| Lead | 1.56E+03 | 1.60E+01 | 9.74E+01 | 2.95E+02 | 5.88E+00 | 5.01E+01 | 4.76E+03 | 3.85E+00 | 1.24E+03 |
| Mercury | 1.29E+00 | 2.60E+00 | 4.97E-01 | 5.14E-02 | 9.60E-01 | 5.35E-02 | 3.76E+00 | 4.50E-01 | 8.35E+00 |
| Nickel | 3.01E+01 | 7.99E+01 | 3.77E-01 | 1.66E+01 | 2.94E+01 | 5.63E-01 | 9.74E+01 | 7.74E+01 | 1.26E+00 |
| Selenium | 1.57E+02 | 3.99E-01 | 3.94E+02 | 1.98E+02 | 1.47E-01 | 1.35E+03 | 6.84E+02 | 5.00E-02 | 1.37E+04 |
| Uranium | 1.09E+00 | 3.26E+00 | 3.34E-01 | 1.24E+01 | 1.20E+00 | 1.03E+01 | 4.14E+00 | 1.60E+01 | 2.59E-01 |
| Zinc | 1.09E+00 | 3.20E+02 | 3.41E-03 | 1.24E+01 | 1.18E+02 | 1.05E-01 | 4.14E+00 | 1.45E+01 | 2.86E-01 |
| **Organics** | | | | | | | | | |
| Acetone | 6.44E-02 | 2.00E+01 | 3.22E-03 | 8.05E-02 | 7.30E+00 | 1.10E-02 | 2.79E-01 | ND | ND |
| Bis(2-ethylhexyl)phthalate | 8.91E+00 | 1.98E+01 | 4.50E-01 | 1.10E+00 | 7.30E+00 | 1.50E-01 | 2.59E+01 | 1.10E+00 | 2.35E+01 |
| Di-n-octylphthalate | 2.18E+00 | ND | ND | 1.50E-01 | ND | ND | 6.27E+00 | ND | ND |
| 1,4-Dichlorobenzene | 6.99E-04 | 4.73E+01 | 1.48E-05 | 1.90E-04 | 1.25E+01 | 1.53E-05 | 2.15E-03 | ND | ND |
| Fluoranthene | 9.70E-01 | 1.08E+00 | 8.98E-01 | 1.24E-01 | 4.00E-01 | 3.10E-01 | 2.82E+00 | ND | ND |
| Xylenes | 1.31E-03 | 2.27E+00 | 5.78E-04 | 4.10E-04 | 8.35E-01 | 4.90E-04 | 4.09E-03 | ND | ND |
| **Pesticides/PCBs** | | | | | | | | | |
| Aldrin | 1.91E-04 | 3.99E-01 | 4.79E-04 | 6.92E-05 | 1.47E-01 | 4.71E-04 | 6.08E-04 | ND | ND |
| Aroclor 1254 | 2.03E-01 | 6.10E-02 | 3.33E+00 | 2.08E-02 | 2.20E-02 | 9.47E-01 | 5.87E-01 | 1.80E-01 | 3.26E+00 |
| 4,4'-DDD | 9.65E-04 | 1.60E+00 | 6.03E-04 | 9.90E-05 | 5.90E-01 | 1.68E-04 | 2.79E-03 | 3.00E-03 | 9.29E-01 |
| 4,4'-DDT | 1.23E-03 | 1.60E+00 | 7.71E-04 | 1.19E-04 | 5.90E-01 | 2.02E-04 | 3.56E-03 | 3.00E-03 | 1.19E+00 |
| **Totals:** | | | 6.47E+02 | | | 1.70E+03 | | | 1.53E+04 |

[1] ND = Insufficient data to calculate value.

## Table 7-23
### SUMMARY OF RISK FINDINGS FOR WILDLIFE WITH LARGE HOME RANGES, OPERABLE UNIT 1

| Chemical | Red-tailed Fox | | | American Woodcock | | | Red-tailed Hawk | | |
|---|---|---|---|---|---|---|---|---|---|
| | Intake (mg/kg/day) | Benchmark Value (mg/kg/day) | Hazard Quotient (HQ) | Intake (mg/kg/day) | Benchmark Value (mg/kg/day) | Hazard Quotient (HQ) | Intake (mg/kg/day) | Benchmark Value (mg/kg/day) | Hazard Quotient (HQ) |
| **Inorganics** | | | | | | | | | |
| Antimony | 1.34E-02 | 3.60E-02 | 3.73E-01 | NA [1] | ND [2] | NA | 2.73E-11 | ND | ND |
| Arsenic | 8.08E-01 | 3.60E-02 | 2.24E+01 | 3.72E+00 | 5.10E+00 | 7.29E-01 | 4.62E-04 | 5.10E+00 | 9.06E-05 |
| Beryllium | 1.54E-02 | 3.50E-01 | 4.41E-02 | 3.59E+00 | ND | ND | 1.77E-10 | ND | ND |
| Cadmium | 3.57E+01 | 5.09E-01 | 7.01E+01 | 3.94E+01 | 1.45E+00 | 2.72E+01 | 3.12E-01 | 1.45E+00 | 2.15E-01 |
| Chromium | 1.10E+00 | 1.45E+03 | 7.60E-04 | 2.61E+01 | 1.00E+00 | 2.61E+01 | 3.75E-03 | 1.00E+00 | 3.75E-03 |
| Copper | 2.26E+01 | 8.00E+00 | 2.83E+00 | 8.36E+01 | 4.70E+01 | 1.78E+00 | 2.14E+00 | 4.70E+01 | 4.56E-02 |
| Cyanide | 3.08E-03 | 3.41E+01 | 9.03E-05 | NA | ND | NA | NA | ND | NA |
| Lead | 2.88E+01 | 4.22E+00 | 6.83E+00 | 1.08E+03 | 3.85E+00 | 2.80E+02 | 1.57E-01 | 3.85E+00 | 4.08E-02 |
| Mercury | 8.73E-03 | 6.90E-01 | 1.26E-02 | 8.31E-01 | 4.50E-01 | 1.85E+00 | 1.98E-04 | 4.50E-01 | 4.39E-04 |
| Nickel | 1.24E+01 | 2.11E+01 | 5.86E-01 | 7.19E+01 | 7.74E+01 | 9.29E-01 | 4.46E-02 | 7.74E+01 | 5.76E-04 |
| Selenium | 4.98E+00 | 1.06E-01 | 4.70E+01 | 3.82E+00 | 5.00E-02 | 7.65E+01 | 5.95E-01 | 5.00E-02 | 1.19E+01 |
| Thallium | 3.36E-03 | 4.00E-03 | 8.41E-01 | 2.04E-03 | ND | ND | 2.94E-07 | ND | ND |
| Uranium | 9.52E-01 | 8.62E+00 | 1.10E-01 | 1.88E+02 | 1.60E+01 | 1.18E+01 | 1.13E-07 | 1.60E+01 | 7.09E-09 |
| Zinc | 9.76E+01 | 8.45E+01 | 1.16E+00 | 1.88E+02 | 1.45E+01 | 1.30E+01 | 1.13E-07 | 1.45E+01 | 7.83E-09 |
| **Organics** | | | | | | | | | |
| Acetone | 3.56E-02 | 5.30E+00 | 6.72E-03 | 2.38E-03 | ND | ND | 1.01E-08 | ND | ND |
| Bis(2-ethylhexyl)phthalate | 3.03E-01 | 5.20E+00 | 5.82E-02 | 6.52E+00 | 1.10E+00 | 5.92E+00 | 4.45E-04 | 1.10E+00 | 4.05E-04 |
| Butyl benzyl phthalate | 5.04E-01 | 6.79E+01 | 7.43E-03 | NA | ND | NA | 2.25E-05 | ND | ND |
| Chlorobenzene | 7.00E-03 | 2.69E+00 | 2.61E-03 | NA | ND | NA | 1.58E-08 | ND | ND |
| Di-n-butylphthalate | 2.80E-02 | 1.57E+02 | 1.78E-04 | NA | 1.10E-01 | NA | 1.91E-06 | 1.10E-01 | 1.74E-05 |
| 2,4-Dimethylphenol | 5.46E-05 | 9.41E-01 | 5.80E-05 | 1.64E-04 | ND | ND | 1.58E-05 | ND | ND |
| Di-n-octylphthalate | 3.15E-01 | ND | ND | 1.57E+00 | ND | ND | 2.39E-02 | ND | ND |
| 1,2-Dichlorobenzene | 2.80E-06 | 3.66E+01 | 7.65E-08 | NA | ND | NA | 1.44E-11 | ND | ND |
| 1,4-Dichlorobenzene | 7.02E-03 | 8.02E+00 | 8.75E-04 | 9.64E-04 | ND | ND | 4.34E-08 | ND | ND |
| Ethyl benzene | 5.60E-02 | 4.14E+01 | 1.35E-03 | 4.80E-06 | ND | ND | 6.88E-07 | ND | ND |
| Fluoranthene | 2.86E-02 | 2.90E-01 | 9.85E-02 | 6.96E-01 | ND | ND | 3.97E-05 | ND | ND |
| Fluorene | 1.01E-03 | 2.90E-01 | 3.48E-03 | NA | ND | NA | 1.62E-08 | ND | ND |

## Table 7-23 (Cont.)

### SUMMARY OF RISK FINDINGS FOR WILDLIFE WITH LARGE HOME RANGES, OPERABLE UNIT 1

| Chemical | Red-tailed Fox Intake (mg/kg/day) | Red-tailed Fox Benchmark Value (mg/kg/day) | Red-tailed Fox Hazard Quotient (HQ) | American Woodcock Intake (mg/kg/day) | American Woodcock Benchmark Value (mg/kg/day) | American Woodcock Hazard Quotient (HQ) | Red-tailed Hawk Intake (mg/kg/day) | Red-tailed Hawk Benchmark Value (mg/kg/day) | Red-tailed Hawk Hazard Quotient (HQ) |
|---|---|---|---|---|---|---|---|---|---|
| 2-Methylnaphthalene | 1.23E-02 | 2.90E-01 | 4.25E-02 | NA | ND | NA | 3.50E-11 | ND | ND |
| Methylene Chloride | 7.56E-03 | 3.10E+00 | 2.44E-03 | NA | ND | NA | 1.89E-09 | ND | ND |
| Naphthalene | 1.32E-02 | 2.90E-01 | 4.54E-02 | NA | ND | NA | 9.26E-08 | ND | ND |
| Phenanthrene | 2.55E-03 | 2.90E-01 | 8.79E-03 | NA | ND | NA | 6.44E-08 | ND | ND |
| Pyrene | 2.38E-03 | 2.90E-01 | 8.21E-03 | NA | ND | NA | 1.87E-07 | ND | ND |
| Toluene | 8.12E-02 | 7.40E+00 | 1.10E-02 | NA | ND | NA | 1.59E-07 | ND | ND |
| Xylenes | 6.33E-01 | 6.00E-01 | 1.05E+00 | 9.16E-04 | ND | ND | 5.28E-06 | ND | ND |
| **Pesticides/PCBs** | | | | | | | | | |
| Aldrin | 4.53E-04 | 1.06E-01 | 4.28E-03 | 1.15E-04 | ND | ND | 2.25E-09 | ND | ND |
| Aroclor 1242 | 7.28E-03 | 4.70E-02 | 1.55E-01 | NA | 4.10E-01 | NA | 1.55E-06 | 4.10E-01 | 3.78E-06 |
| Aroclor 1254 | 8.31E-03 | 9.60E-02 | 8.66E-02 | 1.64E-01 | 1.80E-01 | 9.09E-01 | 3.37E-05 | 1.80E-01 | 1.87E-04 |
| 4,4'-DDD | 6.67E-05 | 4.20E-01 | 1.59E-04 | 6.93E-04 | 3.00E-03 | 2.31E-01 | 1.60E-07 | 3.00E-03 | 5.32E-05 |
| 4,4'-DDE | 9.52E-06 | 4.20E-01 | 2.27E-05 | NA | 3.00E-03 | ND | 1.32E-09 | 3.00E-03 | 4.41E-07 |
| 4,4'-DDT | 2.08E-04 | 4.20E-01 | 4.96E-04 | 8.84E-04 | 3.00E-03 | 2.95E-01 | 3.91E-07 | 3.00E-03 | 1.30E-04 |
| Dieldrin | 1.18E-04 | 1.10E-02 | 1.07E-02 | NA | 7.70E-02 | ND | 3.43E-09 | 7.70E-02 | 4.45E-08 |
| Endosulfan I | 4.76E-06 | 8.00E-02 | 5.95E-05 | NA | 1.00E+01 | ND | 3.35E-11 | 1.00E+01 | 3.35E-12 |
| Endrin | 2.60E-05 | 2.60E-02 | 1.00E-03 | NA | 1.00E-02 | ND | 3.14E-09 | 1.00E-02 | 3.14E-07 |
| Beta BHC | 4.76E-05 | 2.10E-01 | 2.27E-04 | NA | ND | NA | 4.45E-10 | ND | ND |
| **Totals:** | | | 1.54E+02 | | | 4.42E+02 | | | 1.22E+01 |

[1] NA = Not applicable.

[2] ND = Insufficient data to calculate value.

## Table 12-1 Capital Cost Estimate for the Selected Remedy - Regrading of Areas 1 and 2 (fill to minimum slope of 2%) and Installation of Landfill Cover

| Description | Quantity | Units | Unit Rate | Estimated Cost |
|---|---|---|---|---|
| **Estimated Capital Costs:** | | | | |
| Work Plan | 1 | ea | 50,000 | 50,000 |
| Surveying (site layout) | 14 | day | 1,000 | 14,000 |
| Secure access/easements | 1 | LS | 10,000 | 10,000 |
| Silt fence | 9,600 | ft | 2.00 | 19,200 |
| Geotechnical testing of borrow materials | 1 | ea | 20,000 | 20,000 |
| Perimeter drainage | | | | |
| Drainage channels | 1,600 | lin ft | 4.41 | 7,056 |
| Area 2 berm regrading (800 feet) adjacent to buffer zone | 20,000 | cu yd | 16.83 | 336,600 |
| Area 1 - Soil fill to achieve minimum 2% grades | | | | |
| Clearing/grubbing/regrading/preparation | 10.4 | acre | 5,800 | 60,000 |
| Deliver, place and compactsoil | 23,467 | cu yd | 16.83 | 395,000 |
| Survey control | 5 | day | 1,000 | 5,000 |
| Materials testing equipment during construction | 0.25 | month | 2,000 | 1,000 |
| Area 2 Soil fill to achieve minimum 2% grades | | | | |
| Clearing/grubbing/regrading/preparation | 34.8 | acre | 5,800 | 202,000 |
| Deliver, place and compactsoil | 88,289 | cu yd | 16.83 | 1,486,000 |
| Survey control | 18 | day | 1,000 | 18,000 |
| Materials testing equipment during construction | 1 | month | 2,000 | 2,000 |
| Place cover over Areas 1 and 2 | | | | |
| Deliver and place 2' of 6" diameter rock | 172,735 | cu yd | 9.90 | 1,710,000 |
| Deliver and place soil to fill voids between rock (35% of rock volume) | 60,457 | cu yd | 16.83 | 1,017,000 |
| Deliver, place and compact 2' of $10^5$ compactedsoil | 243,008 | cu yd | 16.83 | 4,090,000 |
| Deliver, place 1' vegetative growth layer | 124,648 | cu yd | 24.46 | 3,049,000 |
| Fertilize/seeding/mulching | 45.2 | acre | 1,500 | 68,000 |
| Survey control | 122 | day | 1,000 | 122,000 |
| Materials testing equipment during construction | 7 | month | 2,000 | 14,000 |
| Monitoring during construction | | | | |
| Continuous monitoring/recording of air flow | 1 | LS | 20,000 | 20,000 |
| Meteorological | 12 | month | 2,000 | 24,000 |
| Radiological (radon, particulates, and radioisotopes) | 9 | month | 16,000 | 144,000 |
| Health and safety monitoring | 9 | month | 7,222 | 65,000 |
| Misc. sitework | 1 | LS | 50,000 | 50,000 |
| Surveying ("record drawings") | 10 | day | 1,000 | 10,000 |
| Construction Completion Report | 1 | LS | 50,000 | 50,000 |
| Health & safety surcharge for CERCLA site contractor | 10 | % | 930,000 | 93,000 |
| **Estimated Construction Costs - Subtotal** | | | | **13,152,000** |
| Contractor Markup, Mob/demob, Insurance | | % | 10 | 1,315,000 |
| Engineering, Permitting and Construction Management | | % | 20 | 2,630,000 |
| Regulatory Oversight | | % | 2.5 | 329,000 |
| **Estimated Project Capital Costs - Subtotal** | | | | **17,426,000** |
| Contingency | | % | 25 | 4,357,000 |
| **Estimated Project Capital Costs - Total** | | | | **21,780,000** |

**Table 12-1 Capital Cost Estimate for the Selected Remedy (Cont.) - Monitoring**

| Description | Quantity | Units | Unit Rate | Estimated Cost |
|---|---|---|---|---|
| **Estimated Capital Costs:** | | | | |
| Planning documents | 1 | LS | 10,000 | 10,000 |
| Secure easements | 1 | LS | 1,000 | 1,000 |
| Install/develop new groundwater monitoring wells S-8, I-62, D-83 | 180 | feet | 60 | 10,800 |
| Install radon and landfill gas monitoring probes, 20' deep each | 12 | ea | 650 | 7,800 |
| Estimated Capital Costs - Subtotal | | | | 30,000 |
| Contingency | | % | 25 | 8,000 |
| **Estimated Project Capital Costs - Total** | | | | **38,000** |